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Executive Summary

Signed in 1979 by President Carter and Premier Deng Xiaoping, the U.S.-China Agreement on Cooperation in Science and Technology (the S&T Agreement) began an era of robust government-to-government science and technology (S&T) collaboration between the two countries. The Agreement is among the longest-standing U.S.-China accords and has been broadly endorsed by U.S. Federal agencies through their participation in cooperative exchanges. These exchanges have helped advance cooperative research in an incredibly diverse range of fields, including fisheries, earth and atmospheric sciences, basic research in physics and chemistry, a variety of energy-related areas, agriculture, civil industrial technology, geology, health, and disaster research.

As in 2002, State finds no direct evidence that the S&T Agreement has contributed to the development of China's military capabilities in a significant way. Any derived benefits to the Chinese military establishment resulting from government-to-government scientific cooperation would be overshadowed by the overall value of the program to U.S. scientific interests and the window it provides into Chinese science. There is no denying that China seeks to improve its military capabilities, but the vast majority of military technologies acquired by China from abroad are from sources other than the U.S. As amply documented in the 1998 Cox Report, instances of militarily-sensitive transfer of U.S. technology to China have indeed occurred, and while State has not identified any clearly military-related transfers that have taken place in the course of S&T cooperation under the 1979 Agreement, a small minority of programs were deemed to pose some degree of risk of transfer of militarily-sensitive dual use technology. No direct link between any of the entities involved in these projects and the People's Liberation Army (PLA) has been established. However, given the complex nature of Chinese societal, business, and military networks, civil-military linkages cannot be ruled out entirely.

PRC military capabilities have undoubtedly benefited indirectly from China's overall economic and scientific expansion and transformation, to which the S&T Agreement has made some small contribution. Any improvement in the level of Chinese science as a result of U.S.-China S&T cooperation and exposure to U.S. scientific standards and practices quite likely also has had some benefit for the PRC military. With the exceptions cited above, however, State's examination of the voluminous data supplied by the U.S. technical agencies involved in S&T cooperation has not pinpointed any specific instances of transfer of U.S. dual use technology to China in violation of stringent export controls.

China has many alternative means of acquiring military and industrial technologies that are of far greater significance than the S&T Agreement. Among these is a network of Chinese agreements for military, commercial, industrial and S&T cooperation with virtually every advanced industrial nation.

Many of the latter are eager to sell, license, share or otherwise transfer their technologies to China. The lure of China's potentially gigantic consumer market also attracts massive private foreign investment from around the globe. Many U.S. firms are among those seeking to establish footholds in the Chinese market. While China committed to eliminating technology transfer requirements as a condition of foreign investment, many local governments and individual firms continue to apply great pressure on foreign partners to share technology. (However, state-owned enterprises are still allowed to require technology transfers per WTO accession rules. For example, the PRC government imposed a requirement for 100% technology transfer as a condition for the sale of nuclear power reactors.) U.S. firms, in general, remain willing to pay this price for admission and as such have become a major source of advanced technology for the PRC. China successfully employs these and other approaches to garner scientific data, as well as industrial and military technologies from industrial nations around the globe, including the U.S. Compared to other technology-gathering tools at China's disposal, however, the 1979 S&T Agreement, in State's estimation, does not represent a significant threat to protecting U.S. technological advantage.

This is true in no small part because the United States also has benefited significantly from this interaction. The U.S. research establishment – academia, industry and public research institutions – relies on educated scientific and engineering talent from overseas to make up for the shortage of young Americans graduating in the sciences. China is one of the leading sources for this indispensable foreign brainpower without which U.S. research and development would slow, posing significant consequences for U.S. competitiveness and economic prosperity. The tens of thousands of Chinese students, scholars, researchers and skilled technicians who work in U.S. laboratories throughout the academic and private sectors make an enormous and vital contribution to U.S. research efforts across the entire scientific spectrum. While these students and researchers represent a powerful tool that the PRC can exploit to gather information on virtually every sector of U.S. science and technology development, they also form an important avenue for the U.S. in turn to exert influence on the PRC and advance social change in China.

As China continues to advance technologically, growing domestic technology innovation could profoundly influence China's economic growth and military modernization efforts. This is clearly one goal of China's S&T policies. But activities under the S&T Agreement have not been the primary thrust behind China's recent transformation into an emerging science and technology power. China's national efforts to promote research and development plans in strategic advanced technologies, implement market-oriented reforms of its S&T infrastructure, generate large numbers of highly-skilled scientists, engineers and researchers, and attract capital and technological know-how from foreign companies have been the driving forces behind China's rapid advancement in science and technology.

While the U.S.-China S&T Agreement itself has had only a minor and ancillary role in contributing to China's remarkable economic buildup, it clearly provides the context for numerous mutually beneficial exchanges of information, ideas, data and scientific personnel and continues to facilitate such exchanges. Benefits to the U.S. resulting from activities under the S&T Agreement include: sharing of data, e.g. satellite, meteorological, climate, and seismic; enhanced nuclear power plant safety in China; access to joint 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 CFC's 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 US environmental monitoring technologies and agricultural market analysis. Collaboration under the Agreement has set the stage for U.S. entry into China's 207-million-person cellular telephone market, potentially significant U.S. access to deposits of mineral resources and rare earths crucial to today's high-tech industries, access for American companies to China's developing petroleum and natural gas industry, creation of market opportunities for U.S. energy suppliers of renewable energy technologies in China and the introduction into U.S. society and subsequent acceptance of traditional Chinese alternative medicines, such as acupuncture. As China's technological capacity continues to catch up with advanced nations, U.S. scientists will increasingly find it beneficial to use the complementary strengths of their Chinese counterparts through bilateral cooperation, thereby leveraging U.S. investments in research and development.

More broadly, over the past two decades, the 1979 Agreement has exerted a stabilizing influence on the U.S.-China relationship. It has provided an avenue for rational dialogue and communication regardless of other tensions in the often-volatile bilateral political relationship, while giving an influential segment of Chinese society – the science community -- a stake in maintaining a peaceful, constructive relationship with the U.S.

This report is based on information requested by State from all the U.S. technical agencies identified as having conducted bilateral S&T cooperation with China during 2002-2003. The legislative mandate for this report stated its scope to be 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. The entire submission in response to the Congressional request 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.

1. 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 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 huge 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. 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 commerce 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.

2. Statement of the 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 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.
2. An estimate of the annual cost to the United States to administer the Agreement. (These are found in the compendium of unclassified attachments.)
3. An assessment of how the Agreement has influenced the policies of the PRC toward S&T cooperation with the U.S.
4. An analysis of the involvement of Chinese specialists in nuclear weapons, intelligence, and military affairs in the activities of the Joint Commission.
5. 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.
6. 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.

3. U.S.-China Science and Technology Cooperation

The Agreement between the Government of the United States of America and the Government of the People's Republic of China on Cooperation in Science and Technology (S&T) was signed in Washington, DC on January 31, 1979.

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) focus on key themes in U.S.-China S&T cooperation and chart 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 2002 in Beijing, while the last ESM was held in November 2002 in Guilin, China. The emergence of SARS in China in 2003 interfered with the scheduling of an ESM in that year. Planning is underway for a JCM to be held in Washington, DC in October 2004, with an ESM to be held sometime in 2005. Minutes and other documentation from the last JCM and ESM are included at Tab 2.

History of the Agreement

The 1979 U.S.-China S&T Agreement was an outgrowth of President Nixon's bold decision to open relations with China. The Agreement was one of China's first efforts to cooperate in science and technology with nations outside the Communist block, although China has subsequently built a network of S&T cooperative agreements with nearly the entire industrial world. 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 most recently renewed in April 2001 by exchange of diplomatic notes.

Protocols

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.

Table 1. LIST OF ACTIVE PROTOCOLS, AGREEMENTS, MEMORANDA OF UNDERSTANDING, AND ANNEXES, ETC. OPERATIVE FROM 2002-2003

DEPARTMENT OF ENERGY		
	High Energy Physics Implementing Accord	
	Protocol on Nuclear Physics and Controlled Magnetic Fusion Research	
	Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization	
		Annex 1: Rural Energy Development
		Annex 2: Wind Energy Development
		Annex 3: Energy Efficiency
		Annex 4. Renewable Energy Business Development
		Annex 5: Development of Electric Drive and Fuel Cell Vehicle Technologies
		Annex 6: Geothermal Production and Use
		Annex 7: Renewable Energy Policy and Planning

	Fossil Energy Protocol	
		Project Annex I: Cooperation in the Area of Power Systems
		Project Annex II: Cooperation in the Area of Clean Fuels
		Project Annex III: Cooperation in the Areas of Oil and Gas
		Project Annex IV: Cooperation in the Areas of Energy and Environmental Technologies
		Project Annex V: Climate Science
	Agreement on Peaceful Uses of Nuclear Technologies	
	The U.S.-China Energy and Environment Technology Center	
	Green Olympics Protocol for the 2008 Olympic Games	
DEPARTMENT OF THE INTERIOR		
National Park Service		
Fish and Wildlife Service		
	The Protocol on Cooperation and Exchanges in the Field of Conservation of Nature	Annex 9
U.S. Geological Survey		
	Earth Sciences Protocol	
		Annex 1. Sediment-Hosted Gold Deposits of the U.S. and China

		Annex 2. Collaborative Studies of the Major Mineral Deposits, Metallogenesis and Tectonics of Northeast China
		Annex 3. Collaborative Studies of the Human Health Impacts of Domestic Coal Use in China and the U. S.
		Annex 4: Global Mineral Resources Assessment
	The Earthquake Studies Protocol	
		Annex 1: Investigations of Premonitory Phenomena and Techniques for Earthquake Prediction.
		Annex 2. Investigations of Intra-plate Active Faults and Earthquakes.
		Annex 3. Cooperative Research on Earthquake Engineering and Hazards Mitigation.
		Annex 4. Cooperative Research Projects on Deep Crustal Structure.
		Annex 5. Cooperative Research Projects on Laboratory Studies in Rock Mechanics.
		Annex 6. Deployment of Very Long Period Seismograph Stations and Cooperative Research.

		Annex 7. Exchange of Data and Films of Seismograms.
	The Protocol for Scientific and Technical Cooperation in Surveying and Mapping Studies	
		Project Annex 1: Scientific and Technical Cooperation in Surveying and Mapping Studies Concerning Developing Geographic Information Systems
		Project Annex 2: Surveying and Mapping Studies in the Application of Remote Sensing Information.
		Project Annex 3: Scientific and Technical Cooperation in the Management and Technology of Surveying and Mapping.
		Project Annex 4: Scientific and Technical Cooperation in the Application of Geodetic and Geophysical Data to Mapping, Charting and Geodetic Programs.
	The Surface-Water Hydrology Protocol	
		Project Annex 1. Interchange of Scientific and Technical Information on Hydrology and Analytical Techniques of Water Resources Study.

		Project Annex 2. Hydrologic Measurement Procedures, Instruments and Equipment
		Project Annex 3. Cooperative Project on Hydrologic Extremes
		Project Annex 4. Cooperative Project on Sediment Transport.
		Project Annex 5. Flood Forecasting
		Project Annex 6. Cold Regions Hydrology.
		Project Annex 7. Water Quality
DEPARTMENT OF TRANSPORTATION		
DEPARTMENT OF COMMERCE		
National Oceanic and Atmospheric Administration		
	Protocol on Cooperation in the Field of Marine and Fisheries Science and Technology	
	Protocol on Cooperation in the Field of Atmospheric Science and Technology	
National Technical Information Service		
National Institute of Standards and Technology	Protocol on Cooperation in the Fields of Metrology and Standards	

Technology Administration	Protocol on Cooperation in Civil Industrial Technology and Scientific and Technical Information and Policy	
ENVIRONMENTAL PROTECTION AGENCY	Memorandum of Understanding on Scientific and Technical Cooperation in the Field of Environment	
		Annex 1: Air Pollution
		Annex 2: Water Pollution
		Annex 3: Pollution from Persistent Organic Pollutants and Other Toxic Substances
DEPARTMENT OF AGRICULTURE		
	Protocol on Cooperation in Agriculture Science and Technology	
	Memorandum of Understanding on Cooperation in Agriculture and Related Fields	
	Memorandum of Understanding on Cooperation in the Fields of Water Resources	
Foreign Agricultural Service		
	Memorandum of Understanding on Agricultural Exchange	
Agricultural Research Service		

	Joint Operating Agreement on Biological Control	
U.S. Forest Service		
	Memorandum of Understanding on Forestry Cooperation	
NUCLEAR REGULATORY COMMISSION		
	Protocol on Cooperation in Nuclear Safety Matters	
NATIONAL SCIENCE FOUNDATION		
	The Earthquake Studies Protocol	Annex 3: Cooperative Research on Earthquake Engineering and Hazards Mitigation
	Memorandum of Understanding on Ocean Drilling	
DEPARTMENT OF HEALTH AND HUMAN SERVICES		
	Protocol for Cooperation in the Science and Technology of Medicine and Public Health	
	Memorandum of Understanding on AIDS Cooperation	
Centers for Disease Control and Prevention		

Food and Drug Administration		
National Institutes of Health	Memorandum of Understanding on Cooperation in the Basic Biomedical Sciences	

4. Current Agency Activities Under the 1979 Science and Technology Agreement

The following is a synopsis of ongoing activities as reported by the agencies. Detailed information, including costs, is found in the referenced Tab.

Department of Energy
(See Tab 4)

High Energy Physics Implementing Accord

The objective of this accord is to establish a framework for cooperation in high energy physics, including theoretical and experimental research, accelerator design and construction techniques, and related technology. The cooperation between the U.S. and the PRC in high energy physics research seeks a better understanding of the fundamental constituents of matter and the interactions among them. This agreement between DOE and the State Scientific and Technological Commission (now the Ministry of Science and Technology) of the People's Republic of China was last renewed on April 25, 2001 for five years, through April 2006.

During the period under consideration, cooperation under this accord has involved exchange of information on scientific and technical developments, exchange of personnel for collaboration on scientific experiments, and visits of technical teams for exchange of information about and training in the application of technological developments.

All of the work carried out under this accord and the Protocol on Nuclear Physics and Controlled Magnetic Fusion Research (see below) is unclassified and unrestricted. Results from this work are published in the open literature and discussed at open national and international conferences. Both protocols deal only with areas of science and technology that do not involve sensitive technology and are not of direct potential military application. DOE is aware of the concerns about potential technology transfer to China for military applications and continues to consult, as appropriate, with responsible DOE offices to prevent any such transfers.

The Program of Cooperation in High Energy Physics is a modest part of the U.S. high energy physics research program, but it is beneficial to both participants and to the scientific field.

The Chinese government recently decided to underwrite a major upgrade of the Beijing Electron-Positron Collider (BEPC) and its dedicated detector (BES). These upgrade projects, which are now under way, are currently the principal foci of the cooperative program. The program is planned to continue at its current level throughout 2004-2010.

Protocol on Physics and Controlled Magnetic Fusion Research

This protocol was renewed on April 25, 2001 for another five years, through April 2006. The long-term objective was to develop and utilize fusion as an energy source. To date, cooperation has taken place under the Protocol in the general form of scientist-to-scientist collaborations, exchanges of data and open literature, and visits to each other's facilities for information exchange.

The U.S. benefits significantly from the science learned in these joint and collaborative experiments. The existing and potential new physics experiments and the potential to perform tests of materials and blanket behavior in Chinese test facilities make bilateral activities of continuing interest.

For the 2002-2003 bilateral program, there were a total of 26 exchanges, and 65% of these exchanges were completed by December 2003. Both sides are preparing preliminary proposals for 2004-2005 coordinated tasks that will include plasma physics, fusion technology, power plant studies, and materials research at a modest level of activity of about 20-30 exchanges. Also included will be cooperation associated with the new HT-7U project, a Tokamak to be located at the Institute of Plasma Physics, Chinese Academy of Sciences (ASIPP) in Hefei.

In addition, General Atomics (GA) in San Diego, CA, and ASIPP have agreed to collaborate on GA's DIII-D Tokamak and China's HT-7U Tokamak. This collaboration drew on the DIII-D physics and operating experience to provide technical support for the HT-7U design. The Chinese plan to finish the construction of the device by the end of 2004. Recently, GA and ASIPP have expanded collaboration between the DIII-D Program at GA and the EAST Tokamak Program at ASIPP. The collaboration, which is in planning and approval stages, includes joint work on design and fabrication of Tokamak components and plasma control systems that would benefit both programs. The collaboration would also include scientific participation in the DIII-D and EAST experiments.

Under the framework of the U.S.-PRC fusion protocol, the Fusion Research Center (FRC) at the University of Texas of Austin entered into an agreement to subcontract with ASIPP for engineering, design and fabrication of the new DOE HELIMAK project at the FRC. The HELIMAK device met all design requirements and was installed in 2002 at the FRC and continues to operate successfully.

Future work involving the DIII-D/ASIPP collaboration on the DIII-D Tokamak at GA and on the EAST Tokamak (the new name for China's HT-7U, a large superconducting Tokamak) will take place at ASIPP. A MOU was recently signed between GA and ASIPP outlining future fusion energy cooperation. DOE anticipates that work similar to that which has been underway will continue as there are many areas of mutually beneficial cooperation and exchange.

Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization

The objectives under this Protocol are to establish the framework for specific collaboration in order to promote renewable energy business development between the U.S. and China, and increased use of renewable energy.

<u>Annex 1: Rural Energy Development</u>

The focus of this annex to the protocol is the use of village-scale renewable energy technologies to provide energy or electricity for rural areas in China. The scope of cooperation under this protocol includes biomass, solar, small wind, and small hydropower technologies. The objectives are to promote sustainable development in rural areas by accelerating the deployment of renewable energy with the support of U.S. industry, and to demonstrate the technical and economic feasibility of renewable energy technology for rural populations in China.

The National Renewable Energy Laboratory (NREL) co-organized a workshop on a sustainable village biogas energy system in order to develop a system that meets the needs of a planned 100-household village in Guanghan, Sichuan. NREL also co-authored a hybrid systems project development training manual for the Chinese context. DOE has also finished the first phase of the Greenstar micro-enterprise project to help generate income and improve quality of life in Pang Do Village in Tibet. In this village 1.6kW of PV has been installed and plans are underway to use 400 watts for educational and battery charging applications. The micro-enterprise phase, in which solar-powered internet communications will help villagers increase local incomes through export of digital art and music, will begin after the Spring thaw in Tibet.

This annex is scheduled to remain effective for five years from June 2000 until 2005. From 2004 until 2010, the projected focus will include capacity building for rural energy projects with an emphasis on institutional and programmatic approaches that lead to sustainable rural electrification.

Annex 2: Wind Energy Development

This annex, signed by DOE and the former Ministry of Electric Power (now State Power Corporation of China), focuses on accelerating sustainable, large-scale development of wind power in both grid-connected and off-grid village power applications in China. The scope of cooperation includes resource assessment, utility wind power plant analysis, finance workshops, wind/hybrid mini-grid analysis, project development and personnel exchanges in training programs. Although the Wind Energy Development annex was renewed in 2002, last year the State Power Corporation was dismantled. The wind power development tasks thereafter have been continued under Annex 7.

CD-ROMs of wind maps and measurement data from a southeast China wind resource assessment and mapping project were completed. DOE/NREL and the State Power Corporation of China developed a pilot project using a wind/diesel/battery system to electrify 120 households on Xiao Qing Dao island in the Yellow Sea off Shandong Province, resulting in an increase in power usage of 40% from 2001. Also, in both 2002 and 2003, NREL trained two Chinese engineers in a 2-3 month training program on various topics including: wind resource assessment, hybrid systems modeling, and wind utility interconnection modeling.

From 2002-2010, it is anticipated that projected activities will include capacity building for wind resource assessment and wind farm operation and management.

Annex 3: Energy Efficiency

The objectives of this annex are to develop and enhance energy efficiency strategies in China, and to introduce technically feasible and cost-effective energy efficiency technologies with the support and participation of U.S. industry and other U.S. organizations. In addition, it aims to assist China in achieving energy efficiency targets while simultaneously advancing environmental protection and stimulating trade in energy efficiency technology.

The only activity to report for the 2002-2003 period is the Beijing Energy Efficient Demonstration Project. The objective of the project is to promote the use of energy efficient and renewable energy technologies in commercial buildings in China. The U.S. and China agreed to study the potential for an energy efficient building demonstration project under a statement of work (SOW) in 1998. The groundbreaking for the building occurred in 2002 and the building was completed in January 2004. The energy savings for this building compared with that of a regular building in China is about 35%.

Annex 4. Renewable Energy Business Development

This annex focuses on assisting China meet its energy demands and promote and accelerate commercialization of renewable energy in China. Activities under this annex will create market opportunities for suppliers of renewable energy products and services in both the U.S. and China, and will encourage investment and other participation in renewable energy projects. This annex was renewed in 2002.

NREL and The Chinese Renewable Energy Industries Association helped provide one-on-one assistance to U.S. companies interested in the China market. U.S. companies received specialized business support such as customized market research, excellent contacts, introductions to key industry and government representatives, and facilitation of business deals. More than a dozen U.S. companies and organizations benefited from this program.

In other projects, information for U.S. companies on promising Chinese and multi-lateral opportunities, as well as policy and market facts, were assembled in seven fact sheets. A guide to U.S. renewable energy manufacturers, system integrators, and component suppliers was also updated.

Follow-on activities include facilitation of U.S./China business partnerships with linkages to Chinese government and program officials as well as companies and financiers. A business development workshop and a study tour with linkages to the Beijing Olympic games are planned for 2004.

Annex 5: Development of Electric Drive and Fuel Cell Vehicle Technologies (formerly known as Exploratory Research for Advanced Batteries and Ultracapacitors—Electric Vehicle and Hybrid-Electric Vehicle Development)

There were no activities between 2002-2003 under the Exploratory Research Annex and it has been replaced by a new Annex entitled “Development of Electric-Drive and Fuel Cell Vehicle Technologies” signed on October 29, 2003.

The purpose of this new annex is to establish a framework for specific collaboration, including demonstrations to promote large-scale deployment in the PRC of electric and hybrid vehicles, including light duty passenger and business vehicles and electric buses, as well as other forms of electric transportation.

Annex 6: Geothermal Production and Use

This annex is inactive.

Annex 7: Renewable Energy Policy and Planning

Activities conducted under this Annex will help develop a framework to assist China develop national policies and plan for sustainable future renewable energy development. In addition to renewable energy policy and plans, the Annex supports the Brightness Rural Electrification Program, China's largest program to electrify 450,000 home systems and 500 village systems in its first phase. It is anticipated that implementation of this Annex will assist China meet its energy demand in the near future and will promote and accelerate the commercialization of renewable energy in China.

Activities include training Chinese officials in renewable energy planning, renewable energy design and rural electrification optimization software. Among other activities DOE is also establishing a training certification program for solar home systems; completing training manuals on renewable village power systems; developing biomass and wind policy initiatives and policies for Chinese law; and identifying Chinese villages for data acquisition monitoring.

Follow-on activities include assistance to the National Development and Reform Commission and provincial level commissions in analyzing China's energy situation, developing plans and policies to promote use of renewable energy, and assistance to China's largest renewable energy rural electrification program for villages. Specifically, NREL will support the biomass and wind sections of the new renewable energy law, and will organize a workshop on productive uses of renewable energy that was postponed last year because of SARS.

Fossil Energy Protocol (formerly known as the Protocol for Cooperation in the Fields of Fossil Energy Technology Development and Utilization)

Under this protocol, clean coal technologies would be reviewed, as would integrated gasification combined cycle (IGCC) systems. China is a leader in experimentation with new fossil technologies, such as coal liquefaction and IGCC plants, in addition to modeling, analysis, and information exchanges in power plant improvements and electricity grid enhancements for stability, reliability and growth planning. Fuel cells and turbine/fuel cell hybrid systems and concepts are part of the mix of studies, as is the integration of power plants with carbon sequestration. These studies are relevant to concerns with global climate change.

Between 2002 and 2003, 180 Chinese utility personnel were trained in U.S. technologies and practices for flue gas desulfurization (FGD). The Chinese FGD market is estimated at $13 billion over the next 6 years. Chinese personnel were also trained in U.S. coal bed methane technologies and natural gas.

This Protocol includes five annexes:

<u>Project Annex I: Cooperation in the Area of Power Systems</u>

Briefings and training under this annex included electricity grid modeling, U.S. Integrated Gasification Combined Cycle power technologies, and a training course for 180 Chinese utility personnel, on the design and operation of U.S. flue gas desulfurization technologies.

Projected activities between 2004-2012 include two technology briefings which will familiarize Chinese personnel with commercially available U.S. plant optimization software packages and fuel cell technologies.

<u>Project Annex II: Cooperation in the Area of Clean Fuels</u>

No projects were conducted under this Annex in 2002-2003.

Between 2004-2012, studies will be conducted on coal co-production and the impacts of a major coal liquefaction plant on the regional environment and economy.

<u>Project Annex III: Cooperation in the Areas of Oil and Gas</u>

Training workshops on natural gas and coal bed methane technologies were conducted.

In future activities, a technical briefing will introduce Chinese personnel to DOE oil and gas reservoir simulation software.

<u>Project Annex IV: Cooperation in the Area of Energy and Environmental Technologies</u>

Major Chinese power producers and 9 U.S. vendors of emissions control equipment were represented at a NO_x and SO_2 control workshop. A total of 105 Chinese were present.

Between 2004 and 2012, a joint study will analyze the use of ammonium scrubbing on flue gas to capture CO_2, and assistance will be provided in the development of a mercury emissions inventory in China.

Project Annex V: Climate Science

Projects under this annex reconstruct Chinese climate data, compare original climate models to climate data sets, measure atmospheric greenhouse gas emissions and analyze the interplay between climate and human activity.

Included in the joint research inventory are four models needing investigation: an analysis of general circulation models; climate data preparation and analysis; atmospheric trace constituents; and the effect and impact of climate change on human and natural systems.

Projects during the 2002-2003 period will continue in 2004 and 2005.

Agreement on Peaceful Uses of Nuclear Technologies

The objective of the agreement is to advance a non-proliferation agenda with China that includes nuclear reactor power plant safety, safeguards and physical protection practices, and nuclear export control, while laying the groundwork for Materials Protection Control and Accounting-type (MPC&A) “threat reduction” research initiatives, and re-establishing technical arms control and nonproliferation discussions. From December 1998 until 2001, due to, among other things, allegations of diversion of sensitive technologies, the Chinese were reluctant to proceed with the implementation of the Peaceful Uses of Nuclear Technology Agreement (PUNT). However, after an invitation by the Chairman of China’s State Development Planning Commission (SDPC), now the National Development and Reform Commission, more than 90 U.S. and Chinese government officials, scientists, and researchers participated in the first Joint Coordinating Committee (JCC) from July 31 to August 2, 2002, in Beijing, China. Although SDPC is the signatory agency, China's overall nuclear programs mainly reside in the China Atomic Energy Authority, CAEA.

A technical workshop was also held at the JCC and covered the areas of nuclear technology (nuclear plant aging management and life extension, severe accident phenomenology and mitigation, advanced reactor development, and export controls of nuclear materials, equipment, and technology), nuclear safety (emergency planning and preparedness, plume modeling, emergency exercises and training), and high level waste management (high-level waste disposal, spent nuclear fuel management, and environmental management). All of these planned activities in FY 2003 were stalled because of the SARS outbreak and visa issues. But the 2^{nd} JCC and Workshops (Export Control, Physical Protection, Nuclear Energy, Nuclear Emergency Management and Safety, and

High-Level Waste Management) were held at the Sandia National Laboratory in 2004.

In addition, in September 2003, DOE and CAEA signed a Statement of Intent (SOI) on exchange of nonproliferation assurances required for transfer of nuclear technology. The recent understandings removed the impediments that had prevented most U.S. firms from obtaining and using authorizations under DOE regulations (10 Code of Federal Regulations Part 810) to provide technology and services to the Chinese nuclear power program.

In September 2003, the State Department and the Ministry of Foreign Affairs also exchanged diplomatic notes on the Tsinghua-MIT Modular Pebble (High-Temperature Gas-Cooled) Bed Reactor Technology Transfer. Building primarily on German technological experience, China has built an experimental pebble bed reactor—one of only three in the world, and perhaps the most advanced. No new nuclear plants have been ordered in the U.S. in a generation, and U.S. nuclear engineers and regulators are extremely interested in new reactor designs that have been built in China such as the pebble bed reactor.

Under the auspices of the nuclear safety cooperation provisions of the S&T agreement, U.S. government scientists are learning about the state of Chinese technology through visits to Chinese nuclear plants. Such visits provide transparency and contribute to cogent review and analysis of the possibility of a Chernobyl-like disaster affecting Hong Kong, Taiwan, Korea, Japan or even the continental U.S.

In upcoming activities, DOE is cooperating with the International Atomic Energy Agency (IAEA) on MPC&A in China by hosting a joint CAEA-DOE-IAEA training course that is scheduled for May 2004.

The U.S.-China Energy and Environment Technology Center

Because China will have to meet much of its growing energy demand with coal, DOE, together with China's Ministry of Science and Technology, established the Energy and Environment Technology Center at Tsinghua University in 1997 to transfer clean fossil energy technology to meet China's environmental needs and generate exports for U.S. businesses.

The EETC is maintained outside the U.S.-China S&T Agreement. DOE also helped establish the Beijing Energy Conservation Center, housed at China's Energy Research Institute.

Cooperation under the protocol has provided the following results:

- The sale of Hydrocarbon Technology Inc. (HTI) coal liquefaction technology to the Shenhua Group for $750,000.

- Two American firms are on the four-firm short list to supply technology for an integrated gasification combined cycle (IGCC) project, valued at $300 - $400 million, being developed by the Shandong Power Company.

- Two industrial partners' workshops were attended by over 40 U.S. firms. The workshop focused on opportunities in the Chinese market for U.S. firms with offerings related to coal-fired power generation. Substantial networking between U.S. and Chinese firms has taken place, and this has led to privately funded market development activities.

- Activities were initiated for the introduction of U.S. combustion optimization and NOx control technologies to the China marketplace.

Ongoing dialogue with the City of Beijing has resulted in a project, using both U.S. and Chinese expertise, to develop a plan to manage coal quality in Beijing under the city's new Olympic Energy Sub-plan. Future activities include continuing work in Beijing on development of the city's coal quality management plan and implementation of a U.S. combustion optimization software project to demonstrate the technology for the Chinese utility sector.

Green Olympic Protocol for the 2008 Olympic Games in Beijing

In preparation for the 2008 Summer Olympic Games in Beijing, both the national and municipal governments of China, the Beijing Municipal People's Government (BMPG) in particular, intend to use clean energy technologies to improve Beijing's environmental quality to an acceptable level by 2008 and to present the event as a magnificent "high-tech" sports meet.

For that reason, a Statement of Intent between DOE and the BMPG was signed on September 10, 2002, that focused on assisting BMPG develop clean energy technologies, and energy and environmental policies in preparation for the 2008 Summer Olympic Games.

Eleven areas of cooperation were identified by a U.S.-China Joint Working Group (JWG) Meeting including: the efficient use of natural gas; fuel cell, hydrogen, and electric vehicles; a green building rating system; energy and resources planning for the Olympic Green; urban traffic and transportation; energy efficient demonstration buildings; air quality (monitoring, management, and integrated environmental strategies); weather (monitoring and forecasting); water (water quality monitoring, animal waste treatment, wastewater reuse, and water efficiency and conservation); clean coal technologies; and Beijing-Chicago "Friendship Cities Initiatives."

Energy Secretary Spencer Abraham joined China's Science and Technology Minister Xu and Beijing's Vice Mayor Fan on January 12th, 2004 to sign the Green Olympic Protocol for the 2008 Olympic Games in Beijing. Two joint working group meetings were successfully held in Beijing in 2002 and 2003, leading to new proposals for cooperation.

Projected activities include leading a trade mission of U.S. firms to China, designing and making operational a sustainable development center in Beijing, coordinating a workshop on integrated resource planning and completing “Green Building” guidelines,” the clean water/wastewater demonstration project, demonstration of “smart” transit systems, and the demonstration of a hybrid “hy-thane” bus.

In the future, DOE will begin to publicize the work of the JWG to U.S industry and will work with the Foreign Commercial Service in Beijing to facilitate interactions between the teams, end-users, and suppliers of technologies. Another JWG will take place in the U.S. in autumn 2004.

Department of Interior
(See Tab 5)

The activities conducted at the Departmental level are under a Memorandum of Understanding (MOU) between the Department of the Interior and the Ministry of Land and Resources to Promote Cooperation on Natural Resources. This was signed on June 22, 2000. The MOU is subject to the Science and Technology Agreement signed in 1979 as extended and amended.

The only project in 2003 was arrangements for a trip to the U.S. in October by Professor Fang Keding and three officials of the Ministry to study the organization of the Department of the Interior, and its methods of coordinating and integrating efforts in implementing strategies and programs.

National Park Service
(See Tab 6)

In 1998, the National Park Service (NPS) and the Chinese National Parks Agency (NPA) negotiated a five-year program of technical exchange and cooperation. A new two-year work plan was signed in November 2002 and the parties agreed to renew the MOU for another five years.

Since 1998, two U.S. delegations have visited China, one Chinese delegation visited U.S. national parks in Summer 2001, and a delegation of 20 Chinese national park managers visited the U.S. in Spring 2002. The Chinese tours of NPS sites include formal training components. In 2002, a senior member of China's NPA, Li Rusheng, spent several months with a NPS regional office studying park management policies and practices used in field units. Adapting NPS concessions and planning policies, this Chinese senior staffer drafted policies applicable to all Chinese provinces which were formally adopted into law by the Chinese State Supreme Council in late 2003. In the PRC, the central government designates national scenic areas, akin to U.S. national park units, but it is the various Chinese provincial governments that actually administer the units within their municipalities. Further joint workshops on concessions and planning will be held between the NPS and the NPA in the future.

U.S. Fish & Wildlife Service
(See Tab 7)

Protocol on Cooperation and Exchanges in the Field of the Conservation of Nature

This Protocol focuses on cooperation and exchanges in the fields of wildlife conservation and protected natural areas. It includes the establishment and management of protected natural areas, migratory bird banding, the regulation of the importation and export of threatened and endangered species of wild flora and fauna. It further includes conservation, propagation, research and rational use of wild flora and fauna, as well as the management of wildlife habitats.

In 2002-2003, the U.S. provided guidance to Chinese personnel on wetlands, river and floodplain management through exchanges. Grants funded a delegation to a transboundary elephant management meeting in Yunnan Province, the establishment of corridors and new protected areas for the protection of the Amur tiger and assessment of the conservation status of the Black Crested Gibbon in Yunnan Province, China.

For 2004-2005, the U.S. Department of the Interior and the PRC State Forestry will meet again in 2005 to plan cooperation for 2005-2006 under the Protocol on Cooperation and Exchanges in the Field of the Conservation of Nature. Grants will continue to benefit the conservation of Asian elephants, tigers and gibbons in China.

U.S. Geological Survey
(See Tab 8)

The U.S. Geological Survey anticipates that the level of cooperative actions under the U.S.-China S&T Agreement will fluctuate somewhat over the next five years because USGS cooperative activities are driven mostly from the bottom (scientific researcher level) upward through its internal system, by the availability of funding for such scientific cooperative projects, and by the fact that the cooperative activities that USGS undertakes with the Chinese must clearly demonstrate that they support its domestic programs in earth sciences, earthquakes, surveying and mapping, and water resources. The USGS anticipates renewal of the existing protocols upon their expiration. The USGS also anticipates negotiating an additional protocol with the Chinese Academy of

Sciences in the discipline of biology. The USGS does not conduct S&T cooperation with China outside of the S&T Agreement or the Protocols.

Earth Sciences Protocol

This protocol was originally signed on January 24, 1980 with the then Chinese Ministry of Geology. It has been renewed at approximately five-year intervals, and remains in force until April 25, 2006. The focus of this protocol is to compile, synthesize, interpret and publish comprehensive databases and analyses on specific mineral resources, metallogenesis, geologic frameworks and the tectonics of particular regions or specific deposits. Earth science fields covered by this protocol include mineral resources, energy resources, ground water resources, engineering geology, marine geology, geotectonics, stratigraphy, paleontology, geophysics and geochemistry.

Annex 1. Sediment-Hosted Gold Deposits of the U.S. and China

This annex focuses on sediment-hosted gold resources of both countries. The objectives of this annex are to 1) compile, synthesize, interpret, and publish a comprehensive database on the sediment-hosted gold resources, metallogenesis, geologic framework, and tectonics of sediment-hosted gold deposits; 2) organize scientific and technical exchanges between interested segments of the earth-science communities and private sectors of the U.S. and China; and 3) perform, in conjunction with U.S. and Chinese university investigators, detailed studies of specific minerals deposits, such as the Great Wall deposit in Hebei Province, and Dian-Qian-Gui, Northwestern Sichuan metallogenic belts for mineral deposit development.

Annex 2. Collaborative Studies of the Major Mineral Deposits, Metallogenesis and Tectonics of Northeast China

In addition to the general requirements of this protocol as listed above, the objectives of the annex are to perform detailed studies of specific mineral deposits and metallogenic belts for mineral deposit development. Voluminous amounts of publicly available mineral data have been compiled, interpreted, and published through the USGS publication system. This project was completed in 2002.

Annex 3. Collaborative Studies of the Human Health Impacts of Domestic Coal Use in China and the United States

The foci of this annex are to collect systematically and thoroughly analyze coal samples from areas in China where domestic coal combustion has contributed to the occurrence of endemic arsenism, fluorosis, selenosis, iodine deficiency, *inter alia*, and to encourage biomedical researchers to collaborate and study the epidemiologic effects of domestic coal combustion. Another objective is to collect and analyze coal samples from the major coal producing areas in both countries.

Annex 4: Global Mineral Resources Assessment

In addition to the general objectives of this protocol as listed above, the objectives of the annex are to a) exchange information concerning the collection, storing, and dissemination of national and international mineral data; b) investigate the changing patterns of global mineral production and consumption and the implications of increasing mineral consumption for mineral supply, recycling, and environmental impacts; c) review the role of mineral statistics in public decision-making and the types of analysis that are undertaken in support of that activity; d) compile, synthesize, interpret, and publish comprehensive assessment of identified and undiscovered mineral resources of China and the United States, with an initial emphasis on copper, platinum-group metals, zinc, lead, chromium, manganese, and potash; e) compile, synthesize, interpret, and publish a regional metallogenic, geologic, and tectonic analysis.

The Earthquake Studies Protocol

This protocol was originally signed on January 24, 1980. It has subsequently been renewed four times at approximately five-year intervals, with the last renewal on January 24, 2000. The objectives of this protocol included the installation and operation of geophysical instruments and the processing and interpretation of this data for the study of earthquakes; the application of geologic mapping and tectonic analysis to the study of faults, earthquake source zones, and geologic conditions that affect the propagation of seismic waves; installation and operation of instrumentation for the study of strong ground shaking that is required for progress in earthquake engineering, laboratory, theoretical and numerical studies of the geological processes preceding, accompanying and following earthquakes; post-earthquake damage surveys; theoretical, analytical, numerical and experimental studies of structural and soil responses during earthquake excitation.

During the 2002-2003 period, seven annexes were in force under this Protocol:

Annex 1: Investigations of Premonitory Phenomena and Techniques for Earthquake Prediction.

Annex 2: Investigations of Intra-plate Active Faults and Earthquakes.

Annex 3: Cooperative Research on Earthquake Engineering and Hazards Mitigation.

Annex 4: Cooperative Research Projects on Deep Crustal Structure.

Annex 5: Cooperative Research Projects on Laboratory Studies in Rock Mechanics.

Annex 6: Deployment of Very Long Period Seismograph Stations and Cooperative Research.

Annex 7: Exchange of Data and Films of Seismograms.

The Protocol for Scientific and Technical Cooperation in Surveying and Mapping Studies

The objectives of this Protocol are: 1) development of geographical information systems; 2) application of remote sensing information to cartography; 3) exchange of scientists, specialists, technical consultants, delegations, and of scientific and technical information; 4) joint basic research and applications projects that engage the core scientific and technical capabilities of the State Bureau of Surveying and Mapping (SBSM) and USGS in areas of mutual interest to the U.S. and PRC; 5) exchange of technical results, and other appropriate materials, such as maps and geodetic control to assist in this protocol and other protocols under the Science and Technology Agreement; and 6) joint organization of scientific conferences, symposia and lectures.

During 2003-2006, the mapping protocol will emphasize cooperative research in the areas of geospatial applications for invasive species research, land cover mapping research and applications, and mapping support for the 2008 Beijing Olympics.

A joint Annex 3 visit to the United States by three SBSM scientists is planned in early calendar 2004. The SBSM delegation will pay its own in-country expenses. Also planned in calendar 2004 is a visit to China by three USGS mapping and remote sensing scientists to conduct field work related to joint land cover mapping and invasive species research, and to participate in a June 8-11 international conference in Beijing on the economic and environmental threats posed by invasive species.

During 2001-2006, there are four Project Annexes in force under this Protocol:

Project Annex 1: Scientific and Technical Cooperation in Surveying and Mapping Studies Concerning Developing Geographic Information Systems (GIS).

There are six activities under this annex: a) Digital Cartographic Data Collection; b) Spatial Data Base Management Systems; c) Digital Terrain Model; d) Techniques of Digital map revision; e) Land Use Mapping; and f) applications of GIS.

Project Annex 2: Surveying and Mapping Studies in the Application of Remote Sensing Information.

There are five cooperative activities under this annex, including: 1) Techniques of geometric and radiometric rectification of remote sensing data; 2) Application of remote sending data to map revision; 3) Application of remote sensing data to thematic mapping using enhancement and classification techniques; 4) Integration of remote sensing data from various sources with other types of data for land use mapping and related applications; 5) research on the techniques of geometric and radiometric rectification, enhancement, classification, interpretation and application of remote sensing data, including radar data.

Project Annex 3: Scientific and Technical Cooperation in the Management and Technology of Surveying and Mapping.

There are five cooperative activities under this annex. The five are concerned with the management of mapping, including organizational structures, laws, regulations, planning, production, and financial affairs.

Project Annex 4: Scientific and Technical Cooperation in the Application of Geodetic and Geophysical Data to Mapping, Charting and Geodetic Programs.

This annex focuses on the development of an Accurate Earth Gravity Model and cooperation in global positioning system surveys.

The Surface-Water Hydrology Protocol

This protocol was originally signed on October 17, 1981, between the U.S. Geological Survey and the Chinese Ministry of Water Conservancy, and has subsequently been renewed four times, the last being in January 2003. The objectives of this Protocol are the exchange of scientists, specialists, delegations, and scientific and technical information; cooperative research on the design and operation of data collection networks, automated storage and retrieval of hydrologic data, techniques of hydrologic and hydraulic analysis, hydrological forecasting, and the application of space technology to hydrology and water resources; joint organization of scientific conferences, symposia and lectures.

There were seven project annexes under this protocol between 2002-2003:

<u>Project Annex 1: Interchange of Scientific and Technical Information on Hydrology and Analytical Techniques of Water Resources Study.</u>

<u>Project Annex 2: Hydrologic Measurement Procedures, Instruments and Equipment</u>

<u>Project Annex 3: Cooperative Project on Hydrologic Extremes.</u>

<u>Project Annex 4: Cooperative Project on Sediment Transport</u>

Projects have included a study of a) total sediment transport, b) debris flows and hyper concentrated flows, and c) geomorphic and hydrologic processes in upland areas.

<u>Project Annex 5: Flood Forecasting.</u>

<u>Project Annex 6: Cold Regions Hydrology. (Currently inactive)</u>

<u>Project Annex 7: Water Quality</u>

This annex is the major focus for activity under the protocol. The most recent activity resulted in publication of Professional Paper 1647, “Comparative Water-Quality Assessment of the Hai He River Basin the People’s Republic of China and Three Similar Basins in the United States.” The publication was prepared in cooperation with the Hai He River Water Conservancy Commission, the Tangshan Water Resources Bureau, and the Ministry of Water Resources of the PRC, in cooperation with the USGS National Water-Quality Assessment Program.

A joint study of reservoir eutrophication in the Hai He River is currently being conducted to 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. Upon completion of chemical, isotopic, and loading studies, a plan will be developed by the Hai He River Commission to reduce the loadings of nutrients to the reservoir through a series of land use changes or regulatory actions. The study is planned to be a model effort at understanding watershed loadings of nutrients or other contaminants, and the development of strategies to reduce those loads in order to restore the planned beneficial uses of surface water systems.

Department of Transportation

The Department of Transportation did not engage in any science and technology activities under the 1979 S&T Agreement from 1996-2000.

Federal Railway Administration (FRA)

Protocol on Cooperation in Railroad Science and Technology

The most recent agreement between the Federal Railway Administration and the Ministry of Railroads was signed in June 2000. It called for continued cooperation and organized a trade assessment trip to China in 2001 with the purpose of assessing U.S. rail related company interest in (1) establishing joint manufacturing ventures in China and (2) purchasing U.S. rail related equipment and supplies to overcome chronic rolling stock shortages. There were no activities under the S&T Agreement in 2003.

Federal Aviation Administration (FAA)

The FAA does not have any activities with China that fall under the S&T Agreement.

Volpe National Transportation Systems Center

The Center has no S&T cooperation activities with China.

Department of Commerce

National Oceanic and Atmospheric Administration (NOAA)
(See Tab 9)

Protocol on Cooperation in the Field of Atmospheric Science and Technology

The protocol is administered by the National Weather Service (NWS), National Oceanic and Atmospheric Administration (NOAA) for the United States, and the Chinese Meteorological Administration (CMA) for China. The purpose of the Protocol on Atmospheric Sciences is to promote the advancement of meteorological science for the benefit of the public. The principal goal of the Protocol is to improve weather forecasting. Activities under the Protocol involve public domain information. There are no activities or personnel exchanges that involve sensitive or security issues.

The five activities under the Protocol are: 1) climate and monsoon studies; 2) mesoscale model development;t 3) satellite meteorology; 4) meteorological modernization; and 5) training and participation. This Protocol was renewed without change in 1999 for five more years.

Six visiting CMA scientists worked or trained in the following areas: (1) thunderstorm forecasting; (2) fog monitoring and warning; (3) providing customers operational Weather Element Forecast Guidance; (4) developing various codes for the Meteorological Development Laboratory; and (5) working on the Interactive Forecast Preparation Systems and Local Data Acquisition or Dissemination Sub-systems of the Advanced Weather Interactive Processing System.

Protocol on Cooperation in the Field of Marine and Fisheries Science and Technology

Currently, there are six general areas of cooperation under the protocol.

- Data and Information exchange
- Marine Environmental Services
- Understanding the Role of the Oceans in Climate Change
- Living Marine Resources
- Marine and Coastal Management
- Polar Sciences

In data and information exchange, a joint coordination panel agreed to cooperate in the following areas: 1) continued cooperation and data exchange between SOA/NMDIS (Chinese State Oceanic Administration/National Marine Data Information Service) and NOAA/NESDIS (U.S. National Oceanic and Atmospheric Administration/National Environmental Satellite Data and Information Service); 2) oceanographic data processing, assimilation, and quality control; 3) cooperative research on data and information management and coastal monitoring; 4) marine geological and geophysical data exchange; and 5) publication exchange.

In living marine resources, the U.S. and China intend to continue collaborative activities to optimize integrated aquaculture and fisheries technologies by promoting new concepts of integrated aquaculture (marine polyculture) systems; adopt environmentally-friendly aquaculture practices to help sustain and increase seafood supply; and advance our understanding of biosecure systems, bioremediation techniques, and biotechnology applications that are mutually beneficial for both countries. U.S.-China cooperation in living marine resources helps U.S. scientific and commercial sectors benefit from access to large scale fisheries and Chinese aquaculture production technologies.

In marine and coastal management, the U.S. and China cooperate in the fields of biodiversity protection, ecosystem monitoring and sea area use. Both sides confirmed a work plan for 2004-2005 in the following areas: marine protected area management; harmful algal blooms (HAB) research; Xiamen (China) marine ecosystem restoration; sea area use management; marine biodiversity conservation; development of a twinning program (Bohai Sea, Manila Bay, Chesapeake Bay, Seto Inland Sea); marine policy and management training; participating in the Ocean Expo 2005 in China; hosting a conference on aquaculture in the context of marine ecosystem management; and a joint conference on legislation and law enforcement in the coastal zone.

Since 1994, U.S.-China cooperation in coupled ocean/atmosphere climate research became dormant primarily due to a shift in China's research priorities and the lack of funding at the Chinese State Oceanic Administration. Climate events, such as the 1997/98 El Nino event, which resulted in significant human and economic impacts in both the U.S. and China, rekindled interest in furthering cooperation on coupled ocean/climate observations. Not only has China's increased investment in climate change science attracted the attention of U.S. scientists, but gaining access to China's historical climate data sets is a topic of increasing interest to U.S. ocean/atmosphere modelers and to the data and information community. NOAA will pursue the possibility of rejuvenating the U.S.-China Joint Coordination Panel for the Role of the Oceans in Climate

Change Cooperation in order, at the 16th Joint Working Group Meeting of the U.S.-China Marine and Fisheries Science and Technology Agreement in Beijing in 2004, to promote a partnership between the two countries to expand ocean observation coverage/capabilities.

Cooperation in the polar sciences in aimed toward understanding the significant atmospheric, oceanic, and terrestrial changes that have occurred in the Arctic and how these changes will impact climate and the economies of the U.S. and China. Interests and activities under the polar sciences category include 1) measurement of aerosol and carbon cycle gases; 2) impacts of Arctic climate on the Northern Hemisphere mid-latitude climate regimes; 3) sea-ice-air mass and energy exchange in the polar regions; 4) convening a workshop in China on climate forecasting, atmospheric observation and carbon cycle gas measurements; 5) impacts of climate and other physical change on ecosystems in the Chukchi Sea and Bering Seas; 6) investigation of oceanographic variability and modification of the Pacific water as it flows across the Chukchi Sea and Canadian Basin; 7) ice conditions in the Arctic and sub-Arctic seas, physical and biogeochemical measurements over the shelf-slope-deep basin regions of the western Arctic; 8) continental shelf processes in the Chukchi Sea and Bering Seas, 9) investigation of cross-shelf transport of plankton and seasonal variability in the western Arctic; 10) study of haze and carbon sink in the Arctic regions; 11) carbon biogeochemical cycles in the Arctic Ocean; 12) paleoenvironmental and paleoclimate evolution of the Arctic and Sub-Arctic regions, and 13) a long term observatory at the pole.

The United States and China also have an ongoing bilateral dialogue on climate change, managed by the U.S. Department of State, that in addition to the two Protocols, provides a forum for exchanging the results of climate specific research endeavors. Since the U.S. and China experience similar climate patterns, both countries recognize the importance of cooperation to better understand the impact of climate on society. NOAA's cooperation with China on climate change focuses on joint research and applications, including expanding access to environmental data from China and encouraging China to be a partner in international climate observation programs. Cooperating with China in these areas is an important step towards improving global climate data coverage and, subsequently, climate forecasts.

National Technical Information Service (NTIS)

NTIS has no current programs with China.

National Institute of Standards and Technology (NIST)
(See Tab 10)

In December 2003, the State Administration of Inspection and Quarantine (AQSIQ) and the Department of Commerce signed a protocol allowing for exchange of scientific and technical information, exchange of experts, joint research and development, and exchange of samples and materials. Activities will be carried out in the fields of metrology, documentary standards, accreditation and information technology.

NIST has traditionally welcomed visitors from China to discuss non-sensitive, non-proprietary information. NIST is also authorized to accept foreign researchers to work in NIST facilities. NIST is committed to protecting sensitive and proprietary information, therefore, visitors do not have access to any sensitive or proprietary information and NIST staff is trained to protect such information in their interactions with any non-NIST employee. Proposed research projects for foreign guest researchers are carefully defined and made clear to both parties. Foreign guest researchers are not permitted to work on cooperative research and development projects between NIST staff and U.S. industry, nor can they have access to any sensitive proprietary information during their tenure at NIST.

AQSIQ typically sends two or three delegations to NIST each year to meet with NIST staff. NIST considers these visits very important to their mission of promoting the use of U.S. measurements and standards internationally. 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.

NIST hosted 211 visitors from China in FY 2002 and 230 in FY 2003. Eighty-seven guest researchers also visited NIST during fiscal years 2002 and 2003 in order to work collaboratively with NIST on research projects of mutual interest. The majority of the travel to China by NIST staff is to attend international meetings and conferences. During these trips the NIST staff may use this opportunity to visit laboratories and learn more about China's measurement capabilities and their ongoing research efforts. These visits are informal and no U.S. proprietary information is discussed. Workshops and conferences addressed wireless standards, semiconductors, micro-electro mechanical systems, encryption and general information security standards, and international MPEG and JPEG standards, among other subjects. NIST staff also visited

Chinese science agencies and universities to explore potential areas for cooperation.

Technology Administration
(See Tab 11)

Standards workshops and training sessions held in both the U.S. and China were sponsored by TA.

Environmental Protection Agency
(See Tab 12)

An Environmental Protection Protocol under the Agreement was concluded in May 1980. It was renewed in 1985 for a second five-year term, but was not subsequently extended or amended beyond 1990. In the mid-1990's, EPA's cooperative agenda with China was subsumed under the U.S.-China Forum for Environment and Development. Project-specific understandings were undertaken on an ad hoc basis, without reference to the 1980 Protocol or the 1979 S&T Agreement.

Under the aegis of the Montreal Protocol on Substances that Deplete the Ozone Layer, EPA helped China develop and popularize CFC-free refrigerators. In April 1999, EPA signed 10 statements of intent with Chinese counterparts to provide technical assistance in the following areas:

- Sulfur dioxide emissions trading
- Coal mine methane market development
- Air quality management
- Natural gas utilization
- Air pollution and public health
- Industrial pollution prevention and energy efficiency
- Cleaner air and cleaner energy technology
- Effects of particulate matter on children's lungs
- Air pollution and asthma
- Energy efficient buildings

Most of these projects are still ongoing, but they are not under the 1979 S&T Agreement.

EPA also has activities in energy efficient labeling of appliances, economy-environmental health modeling, transportation demand modeling, air quality modeling, development of an air quality monitoring network, water quality management and establishment of a Wind Technology Partnership to promote wind power generation in China. Research activities include studying the health effects of arsenic, development of a membrane system for industrial wastewater treatment and development of a water quality monitoring system on the Yellow River.

Future EPA cooperative activities with China are summarized below.

Memorandum of Understanding on Scientific and Technical Cooperation in the Field of Environment

In December 2003, EPA and SEPA concluded a Memorandum of Understanding (MOU) on Scientific and Technical Cooperation in the Field of Environment. The MOU outlines a broad range of potential areas for cooperation, but places the immediate focus of activities on the prevention and management of air pollution, water pollution, and pollution from persistent organic pollutants (POPs) and other toxic substances. Each of these three areas is the subject of a separate annex to the MOU.

The first new initiative under the MOU is the EPA-SEPA Strategy for Clean Air and Energy Cooperation. The goal of this strategy is to address China's severe local and regional air pollution problems and to reduce emissions that contribute to transboundary air pollution, as well as regional and global climate impacts. The strategy provides a framework that will coordinate activities in two directions: 1) strengthening regional coordination of clean air and energy management; and 2) prioritizing source categories affecting air, environment and public health.

In 2004-2005, new activities are anticipated that will address the World Summit for Sustainable Development (WSSD) Partnership on Clean Fuels and Vehicles, the WSSD Partnership on Indoor Air, the United Nations Environment Program (UNEP) global initiative on mercury, and the Stockholm Convention on POPs.

Department of Agriculture
(See Tab 13)

USDA has a very extensive program of cooperation with China under the 1979 S&T Agreement, including an exchange agreement under the aegis of the International Cooperation and Development Area of the Foreign Agricultural Service, a protocol on cooperation in agriculture science and technology, a memorandum of understanding in water resources and agriculture fields, and a joint operating agreement with the Agricultural Research Service. The collaborative S&T activities of other elements of the Department—the Natural Resource and Conservation Service, the Cooperative State Research, Education and Extension Service, and the Economic Research Service—are included in this section. The Animal and Plant Health Inspection Service and the Food Safety and Inspection Service did not contribute to the effort. The projects are clearly mutually beneficial; indeed the success of many of them will be critical to certain aspects of the future of U.S. agriculture.

Foreign Agricultural Service (FAS)
(See Tab 14)

Additional cooperation has been arranged to solve problems in many important subject areas, including improving resistance to aflatoxin contamination in peanuts, analyzing impacts of land-use management on tropical agricultural soils, examining antimicrobial resistance of Campylobacter from retail chickens, applications of crop sensor-based nitrogen management, and establishment of two U.S.-China joint research centers in natural resource management. Integral to this agreement is the exchange of agricultural personnel. The original agreement called for between 500-700 Chinese students to come to the U.S. in 1978-79. Short-term exchange visits in 2002-2003 have addressed issues such as agricultural products safety and quality control; animal disease management; promoting local and organic agricultural production; animal biotechnology; animal drug management; pest risk analysis; water management; global agricultural information, animal products processing and marketing; and agricultural aviation, among others.

Agricultural Research Service (ARS)
(See Tab 15)

The Joint Operating Agreement between the Chinese Academy of Agricultural Sciences in the PRC Ministry of Agriculture and the Agricultural Research Service focuses on the development of live biological controls for agricultural pests. Such cooperative research promises to be extremely useful, particularly in light of the development of pests' resistance to chemical insecticides and herbicides. These controls may include natural enemies of plant diseases, insects and weeds. One area of research aims to provide resistance to a wide variety of plant viruses, including the development of broad-spectrum virus resistance in wheat, maize (corn), melon and rice. Other biotechnology activities include molecular breeding to develop new hybrids of cotton, providing ongoing assistance in diagnosing avian influenza in poultry species, using non-GMO biotechnology to develop foods enhanced in selenium, and development of hazelnut cryopreservation techniques. ARS has over 50 proposed activities that are currently in the planning phase, including soil and wind erosion, water quality modeling, agricultural management, plant genetics, impacts of global climate change on vegetation and agricultural technology and other areas.

The Chinese Ministry of Science and Technology has said that it may consider the establishment of a new special fund to support the Sino-U.S. collaboration in Agricultural Science and Technology. For the U.S. side, existing budget appropriations will cover the expenses of the selected collaborative projects in the priority areas agreed upon in the signed Protocol.

Economic Research Service
(See Tab 16)

The China Emerging Market Project invites Chinese government agricultural analysts and economists to train in market analysis on grain crops, corn, oilseed crops and livestock products. Chinese officials were also trained in economic analysis of changes in China's rural consumption. The training has resulted in multiple publications by trained Chinese analysts including a rice industry handbook and a market analysis report on the production, consumption, industrial use, and trade of wheat, rice, corn and livestock products from China. These publications provided information about the Chinese agricultural sector that was previously unavailable to U.S. agricultural analysts.

U.S. Forest Service
(See Tab 17)

The Memorandum of Understanding on Forestry Cooperation between the Forest Service and the State Forestry Administration of the PRC intends to deal with a panoply of forest related issues, including biodiversity, forest regeneration, fire suppression, prevention, planning and fire management, pests, diseases, water and soil conservation, conservation and sustainable use, urban forestry, natural resource policy and economics and forest education.

Nuclear Regulatory Commission
(See Tab 18)

Protocol on Cooperation in Nuclear Safety Matters

In 1981, the protocol was signed between the Nuclear Regulatory Commission and the State Science and Technology Commission of the PRC on Cooperation in Nuclear Safety Matters. This protocol was renewed twice. With the implementation of the U.S.-China Agreement for Cooperation on the Peaceful Uses of Nuclear Technology on March 19, 1998, the NRC and its Chinese counterpart, the National Nuclear Safety Administration (NNSA) signed an expanded Protocol on Cooperation in Nuclear Safety Matters in September 1998. This protocol was renewed during the visit of NRC Chairman Diaz to Beijing in April 2004. This Protocol is outside of the U.S.-China S&T Agreement. However, cooperation in nuclear safety matters is carried out in the spirit of the original S&T Agreement, as illustrated below.

The safety documents, lectures, and on-the-job training opportunities provided by the NRC have assisted the Chinese nuclear regulatory body to develop a clearer picture of nuclear safety (culture) as it is practiced in the U.S. The protocol has facilitated close contact between the nuclear safety personnel in the U.S. and China, and provided a dialogue with China at times when relations between our two nations were under strain.

During the years 2002 and 2003, safety exchanges took place under the terms of the Protocol at a minimal cost to NRC. The activities included providing technical lectures on power reactor design review, construction and operation inspection, plant operation, radiation protection and nuclear materials safety and providing regulatory guides and standards, training information and other publicly available safety information.

NRC also has an active Assignee Program that places fellow regulators at NRC on a temporary 6-12 month basis for hands-on training. Three Chinese regulators are scheduled to train at NRC in 2004 on regulatory requirements for digital instrumentation and control systems, regulation and inspection of material licensees and source registration and tracking, and the decommissioning process.

The NRC and the NNSA are currently exploring the possibility of drafting a cooperative research agreement under the terms of the NRC-NNSA Protocol. It would allow NRC access to the fuel burn-up data of the high-temperature gas-cooled (modular pebble bed) reactor (HTGR) located at the Institute of Nuclear

Energy Technology (INET), Tsinghua University. In exchange, NRC would invite NNSA to participate in the NRC Code Applications and Maintenance Program (CAMP) and Cooperative Severe Accident Research Program (CSARP).

National Aeronautics and Space Administration (NASA)
(See Tab 19)

NASA does not have any agreements with China under the U.S. China S&T Agreement. NASA's cooperation with China has been extremely limited due to missile technology proliferation and other factors, including the June 1989 sanctions that placed China on the proscribed country list of International Traffic in Arms Regulations.

Presently, NASA has an agreement with China for earth science research. Signed in 1992 and amended in 1996, this agreement—entitled the Dynamics of the Solid Earth Program—is between NASA and the Chinese Academy of Sciences and allows for limited project-specific activities in plate tectonics and geodynamics research. Additionally, NASA has nine reimbursable agreements with Chinese entities under NASA's Small Self-Contained Payload program. Due to MTCR concerns, however, these nine agreements have been on an indefinite hold since 1998. Two of the nine agreements were cancelled on September 2003 with the remaining seven still on hold.

NASA has two agreements with U.S. entities that include indirect Chinese participation. In 2000, NASA provided a grant to the California Institute of Technology (Caltech) to study pre-Cambrian microfossils in the Doushanto Formation in Yunnan Province, China with the Nanjing Institute of Paleontology. As a result of this grant Caltech concluded a collaborative research agreement with the Nanjing Institute of Paleontology in China on January 2002 and research is ongoing. In addition, NASA has an agreement with the U.S. Department of Energy on the Alpha Magnetic Spectrometer, a high-energy particle physics space experiment using the International Space Station. Sixteen countries in all are participating in this endeavor, including China.

At present, there are no new NASA cooperative initiatives with China being contemplated. Regarding future activities with China, NASA is awaiting direction from the Administration on guidelines for civil space cooperation with China before undertaking any new initiatives.

National Science Foundation
(See Tab 20)

The Basic Sciences Protocol

Although this protocol formally lapsed in 2000, cooperative activities continue as before. These activities include what is probably the most eclectic collection of joint projects under the S&T Agreement umbrella. This cooperation resulted in 21 activities between 2002 and 2003. Seven of these projects were related to earth science. There were three social science projects, while chemistry and information technology each had two projects. There was one project each in water pollution, physics, technology management, materials science, robotics and software development. One interdisciplinary workshop introduced physicists and chemists to relevant problems in biology.

The NSF has also supported ongoing science policy forums since the signing of the S&T cooperation agreement. The principal objective of the science policy dialogues is to explore issues facing the United States and China that have significant implications for the vitality of science and engineering in the borderless, knowledge-based economy of the 21st century. The most recent science policy bilateral forum discussed basic science research policy and was held on February 2004.

The Earthquake Studies Protocol

This protocol, a joint project between the U.S. Geological Survey and NSF, has been an academic, basic and applied research bonanza in all its aspects. China has pursued the elusive grail of earthquake prediction for over a millennium, frequently using unique low technology methods, while the United States leads in the development and use of high technology aimed at the same goals. Both countries share similar tectonic relationships, with devastating quakes occasionally resulting from the collisions of huge oceanic and continental plates. As a result, the research carried out under this protocol is mutually beneficial. Furthermore, 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.

There have also been extensive research projects in the Earth Sciences under this protocol using a variety of high technology methods. These have run the gamut from projects aimed at measuring deformation of the earth's crust using GPS (global positioning systems), both offshore beneath the Chinese continental shelf and onshore in Northwest China and Tibet, to investigations into paleomagnetism and mineralization in China. These studies continue to make significant contributions to basic geological research and could aide in the discovery of oil, natural gas, and economically valuable minerals. They may also provide crucial seismological data on the Tien Shan Mountain Range, the largest and most active intra-continental mountain range in the world. Several of these joint projects involve not only China and the United States, but Kazakhstan, Kyrgyzstan, and India. Research under the protocol includes not only geology, geophysics and paleontology, but also health monitoring and damage detection of civil infrastructure.

Annex 3: Cooperative Research on Earthquake Engineering and Hazards Mitigation

Memorandum of Understanding on the Participation of the People's Republic of China in the Ocean Drilling Program

NSF also conducts scientific activities with China in ocean drilling under a special Memorandum of Understanding, separate and distinct from the S&T Agreement. The ocean drilling protocol is mutually valuable for both the U.S. and China. This truly multinational effort takes core samples from rigorously selected parts of the deep ocean floor in various parts of the globe. Since the 1960s, foreign scientists from most of the world's coastal nations have participated in coring the deep sea floor to improve their understanding of the earth's history. Holding a fixed position and drilling in deep water are the two main technologies involved. This know-how will help China avoid blow outs and oil spills when drilling begins on its outer continental shelf. In addition to purely academic interest, cores taken seaward of the continental shelf of a coastal state can reveal much about the geologic history of the region and thus give useful information regarding the location of potential oil and natural gas deposits. Doubtless, Chinese participation in coring off its coast will eventually prove beneficial to the definition of their total petroleum reserve picture. If U.S. oil companies participate as well, it will ultimately benefit the U.S. economy.

Department of Health and Human Services
(See Tab 21)

Protocol for Cooperation in the Science and Technology of Medicine and Public Health

There is an agreement between DHHS and the Ministry of Health of the PRC to facilitate cooperation in disease control and prevention, public health, biomedical research, health services and health policy research, and health administration and finance. In the biomedical research area, NIH participates in exchange of scientists, joint seminars and meetings, and joint research projects.

The U.S. - China Health Protocol, most recently renewed in November 2003 and originally signed in 1979, is an example of the length and strength of our mutual work on health over the past twenty-five years. In 2003, the U.S. Department of Health and Human Services (HHS) funded over $34 million worth of research and technical assistance with China under this Protocol. This includes $28,472,000 in funds to 86 grants and 5 contracts from the National Institutes of Health (NIH), and $5,574,970 in funds to 32 activities from the Centers for Disease Control and Prevention (CDC). These activities cover a wide range of topics including studies on the prevention of birth defects; HIV/AIDS treatment, prevention and control efforts; training activities aimed at strengthening the Chinese public health system; genetics research on osteoporosis, hypertension, and schizophrenia; and studies examining environmental and dietary factors in the etiology of cancer. In addition to these activities, in 2003 HHS supported five full time staff in Beijing – two working with HIV/AIDS; one focused on hepatitis prevention and research; one assigned to the Peking University Medical Center coordinating a large cohort birth defects study; and one assigned to the World Health Organization working on immunization practices in China. In 2004, this footprint will expand to include two staff coordinating the Field Epidemiology Training Program, an activity based on the Epidemiological Intelligence Service (EIS) of CDC, but with an in-country focus; a Health Attaché assigned to the U.S. Embassy in Beijing; and one person from NIH assigned to work on the NIH HIV/AIDS research activities with China

Memorandum of Understanding on AIDS Cooperation

Agreement to cooperate in the fields of AIDS prevention, research, treatment and care.

Food and Drug Administration (FDA)

FDA met with 75 official visitors in 18 delegations from China in FY 2003. These meetings were requested by a variety of Chinese government agencies and organizations for the purpose of learning FDA's policies and regulatory requirements for foods, drugs, biologicals, animal drugs and botanical products. FDA staff also traveled to China to participate in scientific meetings concerning FDA's regulatory approaches to herbal drugs, Good Clinical Practices (GCP) and seafood safety. FDA staff also provided training to SFDA officials on U.S. regulatory requirements for medical devices. Thirty FDA staff made thirteen inspection and regulatory trips to twenty-nine cities in China.

Centers for Disease Control (CDC)

Since its inception in 1998, nine fellows from China have participated in HHS/CDC's Emerging Infectious Disease International Laboratory Fellowship Program. In this program doctoral level scientists work at HHS/CDC on a one-year project that allows them to enhance and develop skills needed to address emerging infectious diseases in their home country. HHS/CDC has collaborated with Chinese officials on influenza surveillance since 1988, and assists in research and program implementation in childhood immunizations, prevention of hepatitis B virus infection and sequelae, and the prevention of birth defects.

National Institutes of Health (NIH)
(See Tab 22)

Memorandum of Understanding on Cooperation in the Basic Biomedical Sciences

Since 1983, the NIH has had an agreement with the Chinese Academy of Sciences (CAS) for cooperation in the basic biomedical sciences. The Fogarty International Center serves an Executive Agent for the U.S. side, and the Bureau of Foreign Affairs, CAS, for the Chinese side.

NIH funded investigators have also initiated health research on topics ranging from hepatitis B, to influenza surveillance, to hookworm and mental health issues. The most recent activities include the NIH funded Comprehensive International Research Program of Research on AIDS (CIPRA) involving multiple institutions in two Chinese provinces. The HIV Prevention Trials Network (HPTN) of HHS/NIH also has field sites in two additional provinces.

5. Assessment of how the Agreement has influenced foreign and domestic policies of the PRC, and policy of the PRC toward Science and Technology cooperation with the U.S.

The U.S.-China S&T Agreement has provided China with some benefits that have helped close some of its scientific and technological development gaps. At the same time, the Agreement has helped moderate the bilateral relationship, given the U.S. access to the Chinese market and labor pool, and 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. This analysis of various aspects of the Agreement's implementation has not identified any signs of a significant diversion of high tech information that would be of use to China's military and defense industries.

The Agreement – A Steadying Bilateral Influence

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 and in the 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 (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.

We also believe that this U.S.-China S&T cooperation has played a consistent stabilizing role in U.S.-China relations. 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 U.S.-China S&T relationship has remained a largely stable pillar of the bilateral relationship, allowing a continuance of cooperative activities in science and technology at levels determined more by scientific accomplishment, 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 scientific relationship, perceived by both countries as beneficial, has thus constituted a very constant and stable element in U.S.-China bilateral relations in the recent past.

U.S.-Educated Scientists: A Force for Good Relations, Openness

The Chinese science community, many of whose prominent members have been educated in the U.S., is well-represented in China's leadership. Contacts with returning Chinese scientists suggest most are likely to remain pro-American.

Table 2: Chinese Students Awarded Doctorates in the United States in the Sciences and Engineering, 1993-2002. (Total of 24,511)

Year	Degrees Awarded
1993	2,227
1994	2,531
1995	2,751
1996	2,954
1997	2,288
1998	2,413
1999	2,182
2000	2,358
2001	2,412
2002	2,395

Experience in the U.S. has generally left an indelibly positive impression on most scientists in this group, and many 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 Communist block, 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. From this position of strength, 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 like 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 in dealing with the U.S. among China’s governing and other senior sectors. This has led toward 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. The value that both countries place on these cooperative links is illustrated by the fact that in April 2001, at the height of the EP-3 incident, the U.S. and China quietly renewed the S&T Agreement despite the severe chill in political dialogue resulting from that diplomatic confrontation. Throughout the crisis, rational scientific dialogue between U.S. and Chinese scientists continued normally, regardless of the deterioration in other bilateral areas of the relationship. As illustrated by this example, State believes the U.S.-China Agreement has exercised a steadying, moderating influence on overall bilateral relations, while also providing significant S&T-related benefits to both countries.

S&T Cooperation Leading to PRC Domestic Policy Reforms

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. For example, 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, Politburo members 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 Politburo 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.

In another example, 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.

As cited earlier, 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.

A Rapidly-Evolving Relationship

China is a 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[1]. 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 has 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.

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

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.

China's Information Technology Capabilities

Once considered a backwater industry, China's information technology (IT) sector now forms the core of the Chinese S&T enterprise. In its Tenth Five-Year Plan, Chinese leaders stated that information technology is a focal point for China's economy, national safety and social development, and that the IT industry would become the leading industry in the Chinese economy by 2005. China's IT market is one of the fastest growing IT markets worldwide and is now the second largest in the Asia-Pacific region, behind Japan. The Chinese market for IT products and services was $22 billion in 2002 and is expected to exceed $40.2 billion by 2006, representing a 16.3% compound annual growth rate during these years. Since 1997, the government has doubled its expenditure to $13 billion to promote information technology research and development, compared to the previous five-year period[2]. Chinese companies are matching most if not all of the current trendlines for advanced telecommunications systems and are providing the full range of telecommunications equipment[3].

China's Software Development Capabilities

China could also become a significant player in software development. As of 1993, China already had more software professionals than any other country besides the United States[4]. China's Ministry of Information predicts that software and systems integration product sales from China's 2200+ software companies should climb 30% in 2004 to reach U.S. $25 billion, with software exports reaching $1.8 billion in 2003[5]. With computer and communication hardware becoming increasingly complex, software developers worldwide are encountering severe problems in devising reliable systems. According to experts, U.S.-China cooperation efforts to resolve some of these fundamental difficulties could be highly productive for both parties[6].

[2] U.S. Department of Commerce. ExportIT China. Telecommunications and Informational Technology Market Opportunities for Small and Medium-Sized Enterprises. April 2003.
[3] James Mulvenon. Digital Triangle: A New Defense-Industrial Paradigm?.
[4] The Military Potential of China's Commercial Technology.1999.
[5] Zhong, Wu. IT Sales tipped to soar 30pc. The Standard. January 28, 2004.
[6] U.S. Embassy Beijing. U.S.-China Science and Technology Cooperation: Joint Commission Reports for 2002. December 2002.

China's Biotechnology Capabilities

China also bears watching on biotechnology, especially in the area of genetic engineering. The Chinese government has promoted biotechnology since the 1980s through multiple ambitious research programs. Current Chinese research areas in biotechnology include agricultural biotechnology, genomic sequencing, biochips, leveraging leads provided by traditional Chinese medicine, bioinformatics, stem cell research, biomanufacturing and toxicology testing[7]. Several recent accomplishments highlight China's advances in biotechnology. The Beijing Genomics Institute's stunning ability to decode the rice genome in a matter of months has made it a world leader in the field. A team of Beijing scientists has also grown dog-bladder tissue on a mouse's back, a prelude to human tissue engineering applications. Chinese efforts in agricultural biotech focuses on developing crops that have higher yield, greater nutritional value, and increased resistance to disease—a critical goal considering that China has 20% of the world's population with only 7% of the world's arable land. On the medical front, the epicenter of China's biopharmaceutical industries, Shanghai's Zhangjiang High-tech Park, China's leading regional center for biopharmaceutical research and manufacturing, has continued to attract large foreign multinational firms to set up research centers there.

Biotech research, which was traditionally concentrated in universities and state research facilities, has also spun-off into startup companies comprising a booming Chinese biotech market. China's biotech market is currently about $3 billion, and is forecasted to grow at 13.5% annually to reach $9 billion in 2010[8]. The Chinese government spends between $500-600 million per year on biotechnology through research institutes and academic centers[9]. 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.

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[7] 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.
[8] 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.
[9] 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's Nanotechnology Capabilities

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[10]. 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[11]. 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. The Chinese Ministry of Science reports that there are 50 universities, 20 institutes and 100 enterprises focused on furthering nanotechnology in China. 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[12].

Advancements in Chinese S&T capabilities in key research areas can provide multiple opportunities for the U.S. S&T enterprise. Using the expertise, initiative and money of foreign partners like China can help the U.S. retain its competitive advantage and technological superiority. The free exchange of scientific information and the growing S&T capabilities of developing countries around the world will mean that the key to future U.S. science and technology leadership will not depend upon hording high-tech secrets from other countries. Instead, it will depend upon effectively mobilizing a network of foreign partners that creates a distributed information network from which springs global innovation and discovery.

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

6. 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.

7. A determination of the extent to which the activities conducted under the Agreement have enhanced the military and industrial base of the PRC and an assessment of the impact of projected activities, including transfers of technology, on China's economic and military capabilities.

Over the period 1979-2002 during which the U.S.-China S&T Agreement has been in force, China has made enormous strides, both economically and in terms of its military capabilities. Certainly, cooperative activities under the agreement have 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). As outlined in the final section of this report, economic benefits to the U.S. derived from this cooperation also have been considerable.

The degree to which cooperative S&T activities conducted under the Agreement may have contributed to China's economic growth is difficult to assess. 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 produced goods valued at $335 billion, increasing 30 percent annually[13]. High-technology exports from China and Hong Kong exceeded $100 billion a year and 19% of China's total exports are now high-technology products[14]. 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:

[13] Beijing Embassy. China's S&T Reforms: From Communism to Capitalism. March 22, 2004.
[14] 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.

- 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 technologies

S&T Reforms of China's High-Tech Enterprises

In 1985, a report by the Communist Party Central Committee on "The Reform of the S&T Management System" guided restructuring of the S&T system. The restructuring reformed funding allocations and cut state budgets for research institutes and universities; it also encouraged them to launch their own commercial ventures. The strategy was to downsize bloated R&D institutes, transform individual institutions into manufacturing or engineering corporations with in-house research capabilities, increase profit-seeking motives and competition in state-owned firms and "spin-off" new nongovernmental technology enterprises[15]. Universities contracted their services to businesses, foreign investors and other research institutes and played host to many R&D centers of multinational corporations. The Chinese Academy of Sciences (CAS), the center of many successful Chinese S&T enterprises during the 1980s[16], spun off 13 commercial enterprises which had a cumulative income of $295 million in 2002.

These initial reforms opened the door for many more institutional reforms that were modeled on the S&T policies of advanced nations, resulting in improved coordination between government bureaus, universities, research institutes and companies. China established the National Natural Science Foundation in 1986 to promote basic research in new areas and coordinate research programs. Another important reform was the establishment of the National Engineering Research Center in 1992, which promotes applied research and engineering in priority industrial sectors by linking research in CAS institutes to manufacturing processes and production. Changes in the S&T management structure included transparent hiring practices and merit-based competition for awarding research funding, which places all research faculty on contracts instead of "iron rice bowls"--permanent job security.

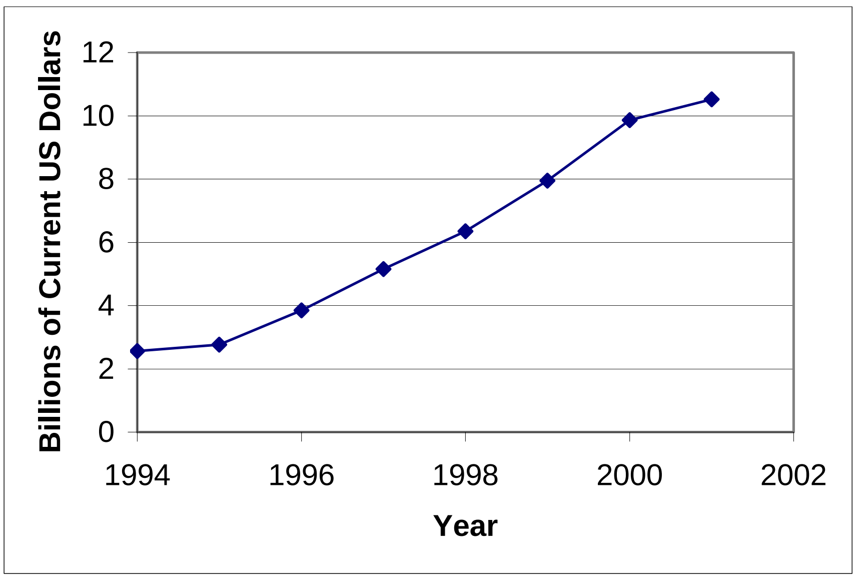
Following the early S&T infrastructure reforms of the 1980's, China embarked on multiple long-term S&T research and development plans like the 863 Program, Torch Program, and the Five-year Plans. These programs set national S&T targets, encouraged cooperation between research and production units, and significantly increased funding for the development of key technologies critical to economic development and national security. The Five-year Plan for 2001-2005

[15] Gu Shulin, China's Industrial Technology: Market Reform and Organizational Changes. (New York: Routledge, 1999).
[16] Erik Baark, "High Technology Innovation at the Chinese Academy of Science," Science and Public Policy. April 15, 1998, no. 2, 85.

funds multiple key technology projects, especially in information technology. The 863 Program funds China's strategic basic and advanced applied R&D across a host of disciplines including biotechnology, aerospace, energy, information technology, lasers, new and advanced materials and marine technology. The majority of funds for the 5,200 863 projects in 1999 are believed to have gone to biotechnology, new materials and information technology[17]. The Torch Program emphasizes high-technology commercialization and applied research and supported 2,742 projects using over $3 billion in funds by 1999[18].

Another significant factor in China's scientific and technological advancement has been the influence of foreign direct investment. In exchange for access to China's growing market, foreign companies, many from the U.S., have poured capital, technologies and know-how into China's commercial sector. From 1994 to 2001 the cumulative investments of U.S. multinational corporations 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.

Figure 1: US Foreign Direct Investment in China (1994-2001)



Source: U.S. Bureau of Economic Analysis, Survey of U.S. Direct Investment Abroad, Washington DC, annual series.
http://www.bea.doc.gov/bea/di/di1usdbal.htm

Multinational companies are encouraged to invest in R&D activities in China by attractive tax-based incentives, with foreigners paying only 17% tax on R&D-related investments while domestic firms pay 33%. Many Chinese research

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[17] The Digital Triangle: A New Defense-Industrial Paradigm?
[18] U.S. Embassy Beijing. Evaluation of China's Science and Technology System and its Impact on the Research Community. Summer 2002.

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.

Another important factor in China's technological transformation is the availability of a large pool of cheap, technologically sophisticated workers. The lure of well-educated engineers, researchers and scientists has drawn many foreign multinational companies to invest in research and development activities in China. Both Beijing University and Tsinghua University are world-renowned for the quality of the science and engineering students that they graduate. What sets China apart from advanced nations is its ability to produce such large numbers of scientists, engineers and researchers. In 1999, there were 1.6 million scientists and engineers in China, according to the Ministry of Science and Technology. And by 2000, there were over 3.3 million students enrolled as undergraduates in science, engineering, agriculture, and medicine in China[19]. 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. Furthermore, although China has long suffered from a "brain drain" to the U.S., an increasing number of China's top students are choosing to return to China after receiving graduate degrees abroad. The government attracts talented, foreign-educated Chinese students by offering them higher salaries, generous housing packages and even putting entire research teams at their disposal[20].

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. 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[21]. China's S&T enterprise still has its weaknesses. 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

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

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

[21] Adam Segal. Prospects for "Spin-On" from the Commercial Side of Chinese R&D. Council on Foreign Relations. March 19, 2004.

much bigger economy)[22]. But its growing S&T sophistication in high-tech industries has been the pillar of China's economic growth and is likely to continue to be in the future.

While S&T Agreement-related joint activities may have provided some ancillary economic benefits to China, the trendlines 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.

S&T Infrastructure Reforms and China's Military Modernization

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 market-driven dynamism of the commercial sector to advance Chinese IT technologies to the benefit of all parties involved. 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

[22] 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.

command headquarters and operational units and between inland areas and border and coastal areas[23].

Government investment in strategic technologies, market-based reforms of China's S&T infrastructure and the infusion of foreign capital and investment, all of which fall beyond the scope of the Agreement, have served as the primary engines of change that have raised China's technological capacity and thereby benefited both China's economic and military development. In our estimation, when viewed in the overall context of China's economic and military gains, any contributions derived from activities under the S&T Agreement are unlikely to have had any significance.

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 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 (see discussion below), 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. China's economy will doubtless continue to grow under the effects of economic liberalization by the PRC and expanding foreign investment, while the PRC's military capabilities will be enhanced by technologies acquired from abroad and, increasingly, by home-grown innovation arising from the growing sophistication of China's science community. In this context, economic and military benefits China might possibly glean from S&T cooperation under the Agreement will have even less impact on China's overall economic and military posture.

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

[23] Evan Medeiros. The Digital Triangle: A New Defense-Industrial Paradigm?

8. 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 (see discussion below), 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 enhancement of China's military and industrial capabilities. Therefore, it is not clear to State that there is a compelling need for greater monitoring of S&T activities under the Agreement other than the routine oversight provided by State's Office of Science and Technology Cooperation (OES/STC). 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, formed this year, will also help 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.

9. Observations and Conclusions

Economic Transformation

Over the past two decades the PRC has embarked on an intensive campaign of modernization that has wrought far-reaching changes in China's economic, industrial and military capabilities. The progressive introduction of capitalism and free market economic principles to the PRC economy has had a profound effect, stimulating rapid economic growth in the previously centrally-planned economy. Private ownership of property, entrepreneurship, the opening of stock markets, and other free-market mechanisms have marked a sharp departure from the previous state-planned economic model, unleashing market forces that have produced a powerful stimulus and dramatic economic growth. China's hybrid economy, now somewhere between the extremes of totally centralized planning and completely open free markets, continues to grow strongly and to evolve towards the Western economic model.

The PRC's decision to join the World Trade Organization (WTO) denoted a further step in this economic transformation, but China's implementation of its WTO commitments in its two years as a WTO member has been mixed. Full and timely implementation of its WTO commitment will make China's trade regime more predictable and transparent and would create incentives for both domestic innovation and foreign direct investment.

Private Sector Investment, Unleashed Native Entrepreneurship: Key Roles

Accompanying the structural metamorphosis of China's economy was a decision by the PRC leadership to greatly expand China's economic contacts with the outside world. China's progressive integration into the world economy over recent decades has brought massive investment, both foreign and domestic, into the manufacturing sector, making China a hub for low-cost manufacturing under contract to innumerable international firms, whether from North America, Europe, Japan, or elsewhere in Asia, including Taiwan. 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. As mentioned before, private sector capital has poured into China, which has proven itself a source of highly productive, low-cost labor, as well as a fast-growing domestic market for Western goods.

Another crucial factor in China's economic flowering has been the empowerment of indigenous entrepreneurial talent. Once the fundamental decision was made to allow market forces to operate in China, a great wave of domestic investment flowed into the market. A very high domestic savings rate, together with the removal of economic distortions and inefficiencies induced by central planning, combined to propel the Chinese economy rapidly ahead. The swift transformation of China's economy from centralized socialism to an emerging industrial-technological giant and magnet for Western capital investment is not a random event, but rather the result of systematic policies introduced and pursued by the PRC. The twin decisions to: a) allow free-market forces and mechanisms to operate in China; and b) open the Chinese economy to investment from and interaction with the global economy, have combined to produce dramatic changes that have fundamentally transformed China's economic landscape over recent decades. Foreign direct investment has been an important driver of this remarkable economic growth. 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 world.

S&T Cooperation – A Bit Part

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 cooperative agreements with other governments such as 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. And given that China 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 most likely played some contributory role in China's economic development – it is difficult, however, to quantify this role – S&T cooperation with the U.S. under the 1979 Agreement was only one part of a much larger overall effort by China.

A Worldwide Search for Technologies

Another factor in the rapid rise of Chinese S&T abilities is the PRC's continuing effort to acquire technologies from the West. For decades the PRC has worked assiduously to import both civilian and military technologies from advanced industrial nations around the globe, seeking to boost the country's S&T capabilities in leapfrog fashion by capitalizing on technology developed elsewhere. Acquiring foreign technology allows China to quicken the pace of economic development, to advance rapidly in certain areas of science and technology, and to strengthen its military capabilities. 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. 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."[24]

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, in State's view, 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. The recently released report of the U.S. Economic and Security Review Commission on China also does not provide any indication that direct government-to-government technology cooperation has played a significant role in China's overall technological growth.

Multiple Sources for Technology

There is no doubt that the United States has been and continues to be a major source country for the Chinese technology acquisition effort. This should not obscure the fact, however, that the PRC continues to scour the entire planet for available technologies. 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.

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

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	92
Ukraine	55	22		73	73	73	73	78	73	113	633	6
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	0
USA	1						31				32	0
UK						16	10				26	0
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.[25] The over $2 billion Chinese arms purchases, annually, from Russia is expected to continue in 2004. 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[26]. 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[27]. 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[28]. The EU this year has indicated it is considering lifting the arms embargo entirely. Some say that this has turned U.S. restrictions into "a unilateral and ineffective restraint on China's ability to acquire advanced technology"[29]. The

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

final EU decision will likely be driven more by a desire to capitalize on China's lucrative market than by concerns over any contribution to China's military development.[30]

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[31]. 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 U.S. is thus only one among many industrial nations that the Chinese have successfully targeted for the acquisition of military and industrial technologies. When considering what technologies China might have gained from cooperation conducted under the U.S.-China S&T Agreement, the very real possibility must be kept in mind that China may have acquired similar technologies from other countries, particularly given that many of China's other S&T partner countries have less stringent technology safeguards and are often less reticent to share or sell their technologies than is the U.S.

In other words, 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.

Students, Scholars and Researchers – Vital to U.S Economy, Also China's Principal Window on U.S. Technology

Within U.S. science policy circles, it has long been a source of concern that the number of native-born graduates with diplomas in the sciences 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

[30] James Lewis. Testimony before the U.S. China Economic and Security Review Commission, January 17, 2002

[31] John Frankenstein. Globalization of Defense Industries: China. Senior Fellows Publication. February 2003.

establishment which is 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 deficit in science, technology and engineering has been made up through the integration of large numbers of overseas students, scholars, researchers and high-tech workers into all sectors of the U.S R&D establishment. Of these, Chinese are the largest component, followed by Indians. The degree to which U.S. academia and industry are becoming dependent on skilled brainpower from abroad is indeed worrisome.

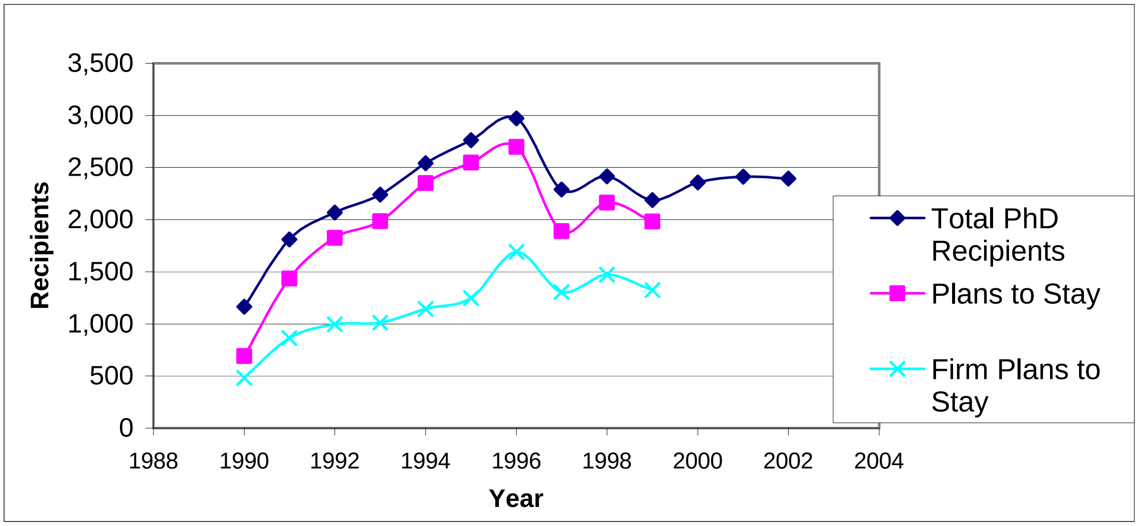
The size and configuration of the U.S. college and university system is predicated upon the assumption of a regular annual flow-through of very large numbers of foreign students. Academic research laboratories rely heavily on this low-cost but highly productive source of talent, along with substantial numbers of post-doctorate or more established scholars and researchers. A substantial 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 laboratories, both academic and private sector. U.S. high-tech industry, similarly, 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 the vast number of Chinese students annually present throughout 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., easily finding work in U.S. high-tech industry, or remaining in academia. Figure 1 shows the total number of U.S.-educated Chinese Ph.D. recipients in science and engineering from 1990 to 2002. A large majority of the thousands of Chinese Ph.D. students intend to stay in the United States after graduation, and roughly half have firm plans to remain within the country. 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.[32]

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



Links between U.S. and Chinese academic research institutions typically grow 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. As noted above, the U.S. has become increasingly reliant on foreign (including Chinese) expertise to keep its technological industries supplied with skilled manpower. 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 U.S. Embassy and consulates in China issued a total of 6,528 H1-B visas to Chinese during FY2002 and FY 2003). China was among the top six countries of origin of foreign-born scientists and engineers employed in the U.S., as of 2001[33]. As seen in Figure 2, Chinese-born

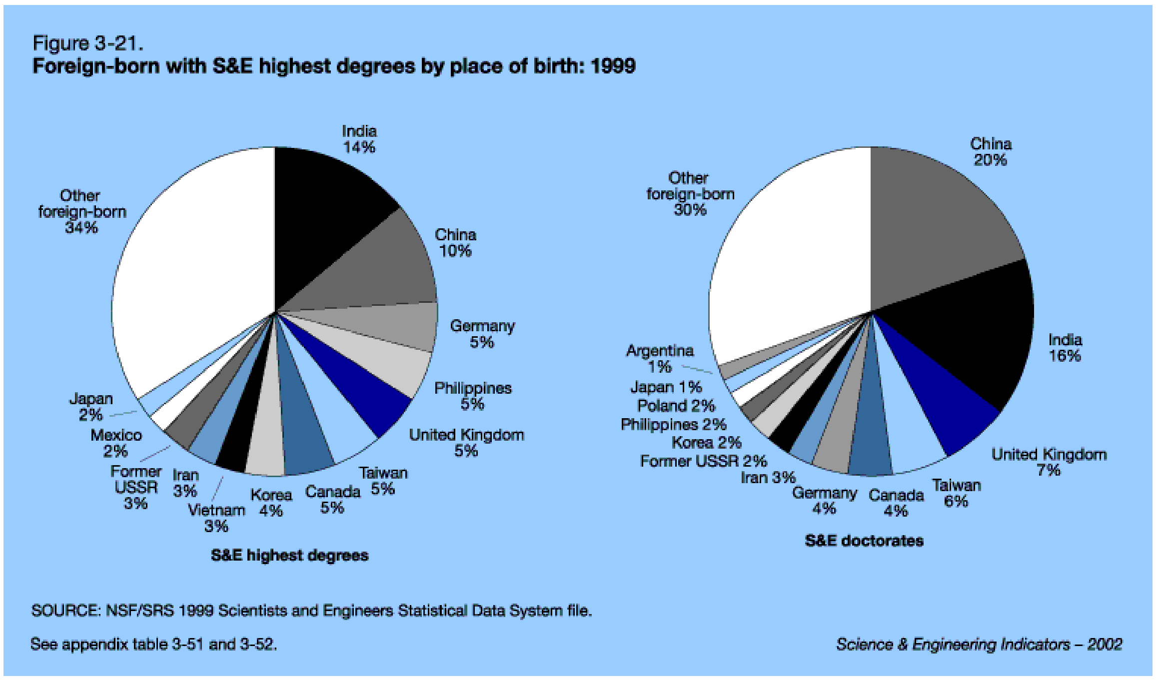
[32] U.S. Embassy Beijing. Bringing the PRC Students Home: Why They Stay, Why They Return, February 1997.

[33] Jean Johnson. Human Resource Contributions to U.S. Science and Engineering from China. National Science Foundation. January 12, 2001

graduates comprise a significant section of U.S. scientists and engineers according to 1999 statistics from the NSF[34].

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.[35]

Figure 4: U.S. Foreign-Born Scientists and Engineers with Science and Engineering Highest Degrees by Place of Birth: 1999



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 much valuable information on U.S. S&T developments filters back to China through this mass of individuals. It is State's belief that 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.

[34] National Science Board, Science and Engineering Indicators 2002, http://www.nsf.gov/sbe/srs/seind02/c3/fig03-21.htm, accessed February 19, 2004.
[35] Annalee Sanexian. Silicon Valley Immigrants Forging Local and Transnational Networks. Public Policy Institute of California. April 2002.

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.

China's Investment Strategy – Technology Transfer has been the Price of Market Access

The rapidly 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 themselves early in China, forecast to eventually become the world's largest consumer market. 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 lure 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 and electronics, including 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 source code to Windows[36]. 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 still may be a condition for government procurement.

A 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. There are estimated to be more than 400 research and development branches of multinational corporations in China, including companies like Motorola, IBM, Lucent, GE, DuPont, P&G, GM, Volkswagen and Intel[37]. Majority-owned affiliates of U.S. parent companies in China performed $506 million in R&D spending in 2000, compared to $7 million

[36] "The Digital Triangle": A New Defense-Industrial Paradigm?
[37] China Economic Review. China: Research and Development: Barriers to Entry, Comment and Analysis. August 6, 2003. Pg. 15

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%).[38] U.S. companies attempting to gain a foothold 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.

The minor transfers of technology that may have taken place in the context of S&T cooperation carried out under the 1979 Agreement, are, we think, inconsequential by comparison.

Too Many Other Options

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. A worldwide network of formal S&T cooperative agreements, military and industrial agreements with nearly every advanced industrial nation – U.S. included - has gained access for China to a wide range of technologies that partners other than the U.S. have been eager to transfer or sell. Scores of thousands of Chinese nationals work throughout the U.S. research 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

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[38] 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

such lesser importance as to be nearly invisible. While the Agreement has unquestionably been of benefit to China both economically and scientifically – as it has been also to the U.S. – in the overall context of China's acquisition of U.S. and Western technology, the Agreement has been a very tiny contributing component.

Beneficial to Both Countries

It is abundantly clear that S&T cooperation under this Agreement has brought benefits to both China and the United States. Some of the areas in which China has gained include:

- 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, a 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 both 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.

The Benefits to the United States Are Very Significant as Well

- In the case of China, data are especially important. Some of our most important collaborations, therefore, involve the sharing of data, e.g., 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 low-cost, well-trained and well-equipped researchers which U.S. scientists can use for cooperative research to meet U.S. scientific goals. For instance, while the average cost of a chemist in a U.S. contract laboratory would cost about $200,000 a year to do research, an equivalent Chinese scientist would only require about $50,000[39].

- 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 and helps create stability in the East Asian region. Both the U.S. and China want to avoid any Chernobyl-like disasters, potentially affecting Hong Kong, Taiwan, Korea, Japan, and, if the wind is right, the U.S. mainland itself.

- 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

[39] Testimony of Lee Zhong. 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.

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 have less adverse effects on global warming and climate change.

- 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. Successful transition away from polluting technologies in the U.S. will be meaningless if China continues to accelerate the rate it pollutes the environment. 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 transboundary 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.

- S&T cooperation with China has brought substantial benefits to U.S. agriculture. Much of the grass currently growing on U.S rangelands is in fact derived from Chinese varieties acquired by USDA in the course of collaboration.

- 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, 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 scientists 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 has 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.

Bottom Line

Examination of the S&T relationship between the U.S. and China under the 1979 S&T Agreement shows that cooperation undertaken in the context of this Agreement 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.