SECTION 3: CHINA'S SCIENCE AND TECHNOLOGY ACTIVITIES AND ACCOMPLISHMENTS

"The Commission shall investigate and report on—

"ECONOMIC TRANSFERS—The qualitative and quantitative nature of the transfer of United States production activities to the People's Republic of China, including the relocation of high technology, manufacturing, and research and development facilities, the impact of such transfers on United States national security, the adequacy of United States export control laws, and the effect of such transfers on United States economic security and employment.

"REGIONAL ECONOMIC AND SECURITY IMPACTS—The triangular economic and security relationship among the United States, [Taiwan], and the People's Republic of China (including the military modernization and force deployments of the People's Republic of China aimed at [Taiwan]), the national budget of the People's Republic of China, and the fiscal strength of the People's Republic of China in relation to internal instability in the People's Republic of China and the likelihood of the externalization of problems arising from such internal instability.

"UNITED STATES-CHINA BILATERAL PROGRAMS—Science and technology programs, the degree of non-compliance by the People's Republic of China with agreements between the United States and the People's Republic of China on prison labor imports and intellectual property rights, and United States enforcement policies with respect to such agreements."

China's Fifteen-Year Plan for Science and Technology

In February 2006, the State Council, China's highest executive body, publicly announced its first long-term plan for the twenty-first century, which intends to bolster China's science and technology (S&T) progress through 2020.[239] This Fifteen-Year Plan also is China's first long-term plan since its accession to the World Trade Organization (WTO).[240]

Premier Wen Jiabao served as chair of the committee representing several government ministries that developed the new S&T plan.[241] In contrast to the process by which previous S&T plans and programs were developed, preparations for the 2006–2020 plan occurred, at least in the early stages, in a remarkably open environment, with foreign scholars among the 2,000 research-

ers contributing to the policy development process.[242] However, the environment later changed as bureaucrats, attempting to strike compromises with each other over controversial portions of the plan, made revisions in secret until the final version was released.[243]

Since 1956, technological research and development (R&D) in China has been guided by Five-Year Plans.[244] Technology transfers from the Soviet Union in the early years of the People's Republic of China (PRC) aided China in its development of some of its strategic weapons. However, centralized S&T planning—epitomized by the Five-Year Plans—hampered overall technological and scientific development and innovation.[245] In addition, the Cultural Revolution (1966–1976) hurt Chinese S&T development, as universities were closed, and professors and students were killed, jailed, or sent to the countryside to work on farms. An entire generation of Chinese researchers and expertise was lost.[246]

When Deng Xiaoping came to power in 1978, he initiated a number of policies that would advance China's S&T capabilities. Science and technology composed one of Deng's well-known "four modernizations." [247] One of Deng's mottos, "science is the first productive force," remains a guiding principle for Chinese development today.[248]

In the 1980s and 1990s, macro-level research and development efforts such as the "863 Program" and the "973 Program" were initiated.[249] Funds allocated to these programs are directed toward various high-tech projects, particularly defense-related research institutes under the China Electronic Technology Group Corporation (CETGC), the PLA General Staff Department, and other defense industrial entities.[250] The 863 and 973 Programs, known officially as "High Tech Research and Development Program of China" and "National Basic Research Program of China," respectively, were both designed to aid China's scientific and technological advancement.[251] Each program takes a slightly different approach. The goals of the 863 program are broad, aiming to obtain technology, sometimes through international sources, to close the gap between China and developed countries. This program covers civilian technologies, but gives emphasis to military and dual-use technologies. The 973 program is specifically designed to provide funding to small and medium-sized companies in China, with the goal of fostering a more technologically advanced indigenous scientific and manufacturing base. Both programs give particular attention to international outreach and cooperation in exchanging expertise.[252]

The new Fifteen-Year Plan builds on past plans and policy initiatives, and incorporates them in a single, coherent approach to S&T. It differs from some older initiatives, such as the 863 Program, in that it no longer seeks only to attain parity with western S&T, but instead seeks to surpass the technological prowess of the West.[253] Previously, imports from foreign suppliers were central to China's S&T modernization. This new plan focuses on promoting indigenous innovation and creating an innovation-oriented society. It also promotes "leapfrogging," whereby the development of Chinese technologies improves established foreign technologies, and bypasses intermediate domestic R&D steps. This speeds product development and saves China the time and cost of accomplishing the intermediate steps.[254]

S&T Areas and Programs for Development Identified in China's Fifteen-Year Science Plan[255]

Key Areas

Agriculture
Energy
Environment
Information technology industry and modern services
Manufacturing
National defense
Population and health
Public securities
Transportation
Urbanization and urban development
Water and mineral resources

Frontier Technology

Advanced energy
Advanced manufacturing
Aerospace and aeronautics
Biotechnology
Information
Laser
New materials
Ocean

Engineering Megaprojects

Advanced numeric-controlled machinery and basic manufacturing technology
Control and treatment of AIDS, hepatitis, and other major diseases
Drug innovation and development
Extra large scale integrated circuit manufacturing techniques
Large advanced nuclear reactors
Manned aerospace and Moon exploration
Large-scale oil and gas exploration
High-definition earth observation systems
Core electronic components, high-end generic chips, and basic software
Genetically modified new-organism variety breeding
New-generation broadband wireless mobile telecommunications
Large aircraft
Water pollution control and treatment

Science Megaprojects

Development and reproductive biology
Protein science
Nanotechnology
Quantum research

Experts vary in their assessment of the plan and its potential to transform China's S&T capabilities. Some experts, such as Mr. Cong Cao, researcher at the University of Oregon; Dr. Richard P. Suttmeier, professor of political science at the University of Oregon; and Dr. Denis Simon, provost and vice president for academic affairs at the State University of New York's Levin Institute, writing in *Physics Today*, expressed their assessment that China's Fifteen-Year Plan for S&T will have a major effect on Chinese capabilities in the future. They predict that, if China reaches its R&D spending goals, it will become a global scientific center.[256] Some view the plan as a sort of grand experiment, in which the plan's

architects take into account the significance of institutional and cultural reforms. However, experts also believe the plan has flaws, including that it gives little attention to the role of market forces and instead assumes that innovation can be decreed "from above."[257]

The extent to which Chinese science and technology may benefit from the policies set forth in the new S&T plan has yet to be determined. It certainly is possible, and is China's intent, that increases in R&D funding and an emphasis on indigenous innovation will bring Chinese S&T into a new era that is less reliant on foreign technology, and one in which China can contribute more significantly to international S&T efforts. The plan, however, still upholds high-level political control over R&D decisions by ministries such as the Ministry of Science and Technology (MOST). Some scientists in China think these decisions should be in the hands of researchers.[258] In addition, accountability and government oversight continue to be problems for Chinese S&T, and frequent allegations of fraud and scientific misconduct continue to plague China's S&T administrators.[259] Nonetheless, the new Fifteen-Year S&T Plan represents a strategy to overcome many of these obstacles and to ensure China's long-term competitiveness in the rapidly changing world of science and technology.

China's S&T Progress and Accomplishments

The National Science Foundation recently reported that China's S&T activities, along with those of other East Asian nations, are gaining strength and capability, and that China is emerging as a regional S&T leader. The report further indicates that the S&T investment and effort of these nations are beginning to produce commercial victories for them in the marketplace, where they are wresting high-technology product market share away from the United States and other nations:

> *A range of indicators traces a trend that shows growing competitive strength in the Asian region outside. . . . Japan, chiefly in China, South Korea, Malaysia, Singapore, and Taiwan. Scientists based in those countries produce a growing share of the S&T articles appearing in the world's leading journals, and development of regional scientific collaboration (centered on China) is apparent. These Asian economies have an expanding world market share of high-technology production. In exports of high-technology products, they are gaining market share on all major industrial nations including the United States.*[260]

Chinese Expenditures on Research and Development

According to its new S&T plan, China's R&D expenditures will increase to 2.5 percent of gross domestic product (GDP) by 2025—up from 1.34 percent in 2005.[261] Yet, even before initiation of this plan, R&D expenditures had been rising.[262] In 2006, China's R&D expenditures surpassed those of Japan for the first time,[263] and now are second only to those of the United States. Even though other top R&D countries have been increasing R&D expenditures,

the rapid pace at which Chinese R&D is growing has caused other countries, including the United States, to see declines in their global shares of R&D spending. (This phenomenon is discussed in more detail in Chapter 1, Section 3, "The Impact of Trade with China on the U.S. Defense Industrial Base.")

Figure 2.2 China's Gross Expenditures on R&D 1998–2005

Source: Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China 15-year Science and Technology Plan," Physics Today, December 2006, 39, citing National Bureau of Statistics and Ministry of Science and Technoloy, China Statistical Yearbook on Science and Technology, (China Statistics Press, Beijing), various years; national Bureau of Statistics, China Statistical Abstract 2006, (China Statistics Press, Beijing), 2006.

Dr. James Mulvenon, Deputy Director of the Center for Intelligence Research and Analysis at Defense Group, Incorporated, testified to the Commission that R&D plays an important role as one of the three vertices of what he described as the "digital triangle."[264] The digital triangle is a paradigm shift in which Chinese military modernization is facilitated by cooperation among the military, commercial civilian information technology (IT) companies, and R&D institutes and funding sources.[265] Therefore, it is not surprising that the rise in R&D expenditures in China's S&T plan corresponds with China's military modernization goals, particularly indigenous innovation and civil-military integration. As the quality, sophistication, and ambition of China's R&D activities increase, both the PLA and Chinese IT companies gain access to more advanced technologies.

From 1994 to 2004, the share of business investment in China's R&D funding increased from 30 percent to 64 percent.[266] This change indicates a dramatic shift in thinking about who should bear R&D responsibility and the role that the market can play in developing new technologies. This shift also has been beneficial for the development of military platforms and for China's "national champions," as Dr. Mulvenon explains:

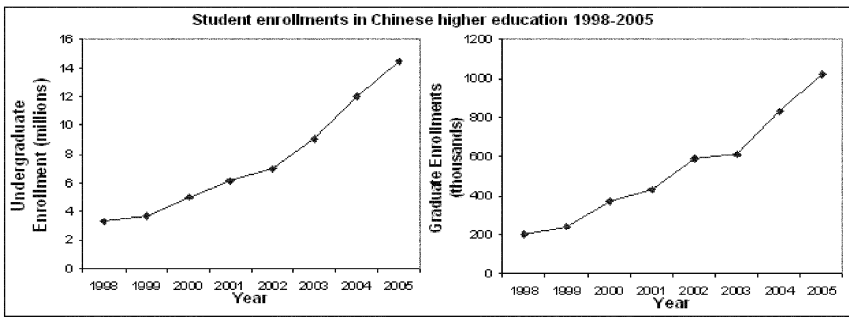
> *[T]he Chinese IT sector, backed by state R&D funding and national labs, has moved beyond the mere importation of Western technology to co-development with foreign firms and even indigenous development of near state-of-the-art*

technology. The result is significant levels of military access to cutting edge [commercial off-the-shelf] information technology, fueling a [command, control, communications, computers, and intelligence] revolution in the armed forces. Moreover, these IT "national champions" are now aggressively pursuing markets abroad, particularly in the third world regions such as Africa that have been conspicuously avoided by Western firms.[267]

Accompanying this shift in funding, China's state-led research institute sector, which for so long was predominant in China's S&T pursuits, has been shrinking. In 1991, nearly 6,000 research institutes employed approximately one million employees. By 2004 approximately 4,000 research institutes employed 560,000 employees-representing a loss of nearly half the workforce among such institutes over a 13-year period.[268] The shift in approaches appears to have produced significant positive dividends for China. During approximately the same period, Chinese worldwide patent applications increased sharply over the same period, from about 15,000 in 1991 to over 150,000 in 2004. These applications represent a mix of Chinese and non-Chinese companies and individuals filing from China. Between 1995 and 2005, applications submitted from China by Chinese companies and individuals increased 834 percent; and applications submitted from China by non-Chinese companies and individuals increased 819 percent.[269]

Universities also have been taking responsibility for a larger percentage of R&D in China. While research institutes continue to enjoy greater R&D funding than universities, this gap is closing as both graduate and undergraduate enrollments swell.[270]

Figure 2.3 Student Enrollment in Chinese Higher Education 1998–2005



Source: Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China 15-year Science and Technology Plan," Physics Today, December 2006, 40, citing National Bureau of Statistics and Ministry of Science and Technoloy, China Statistical Yearbook on Science and Technology, (China Statistics Press, Beijing), various years; national Bureau of Statistics, China Statistical Abstract 2006, (China Statistics Press, Beijing), 2006.

Ensuring the Availability of Qualified Scientists and Engineers

China is now home to about one million scientists and engineers, second in the world only to the United States.[271] China boasts of world-class R&D in several fields, including life sciences, nano-

science, and space technology. Chinese scientists increasingly are being published in international scientific journals and Chinese cities are chosen more frequently as locations for international science and technology (S&T) conferences and exhibitions.[272] As China pursues S&T growth, it must ensure that qualified scientists and engineers will be available both in the near term and also in the more distant future. In the 1990s, China relied on foreign scientists and engineers for technical and consulting advice on weapons development projects. It tapped their expertise via academic exchanges and professional conferences in order to obtain data and information needed by the Chinese defense industry.[273] Even today, China must recruit foreign scientists, in part because many of China's own best scientists and engineers pursue career opportunities abroad. China would prefer to meet its needs for scientists and engineers with its own population.

Among the reasons why China has been forced to import scientific and technological expertise in the past is that, for many years, the quality of the education available from most of China's top universities lagged behind what was available from top universities in leading Western nations, such as the United States and the United Kingdom. Chinese leaders realized that to remain competitive, especially in fields related to science and engineering, China must enable its best students to study in universities of the highest quality. The problem was different for the second tier of Chinese college students, who would not qualify to attend or be able to arrange financing to attend the top Western schools. Chinese post-secondary educational facilities had insufficient capacity to meet the demand, so China arranged for many of these students, as well, to attend other colleges and universities around the world.

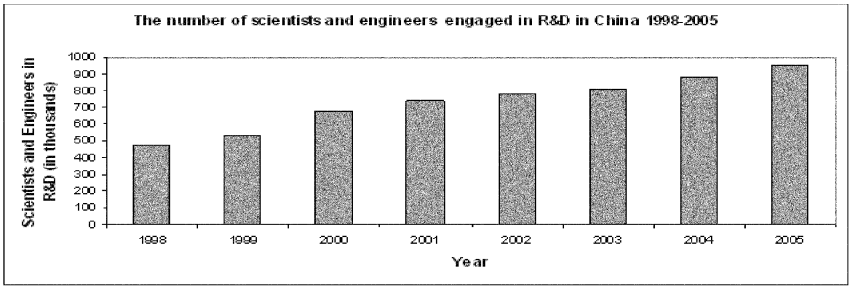
Many students who studied abroad chose not to return to China, and sought and obtained employment in the nations where they had studied. Particularly the brightest and most skilled Chinese students usually found it easy to do this. They were joined abroad by some scientists and engineers who had obtained their advanced degrees in China but found the work and living situations in Western nations more appealing. In China, the absence of an effective patents system and intellectual property rights culture has meant that researchers and their institutions have received little or no reward from the exploitation of their work.[274] (See Chapter 1, Section 1 for more details about China's failure to implement an effective mechanism for protecting copyrights, trademarks, and patents.) They knew they would enjoy and benefit from Western nations' strong intellectual property protections and enforcement.

China has had difficulty in attracting Chinese-born scientists and engineers living outside China to return to China to live and work, although it offers an array of incentives to those whose skills and abilities it wants to acquire. These incentives were noted in the National Science Foundation's Science and Engineering Indicators 2004 report:

> *[China has] in place, or [is] instituting, policies and incentives to retain their highly trained personnel, attract expatriates, or otherwise benefit from their nationals working abroad, chiefly in the United States.*[275]

Recently, however, the number of Chinese-born persons educated abroad who return to live and work in China has begun to increase. The Chinese have coined a term for the returnees—"hai gui," or sea turtles—based on the sea turtle's practice of traveling far from its place of birth but returning to that place in adulthood to give birth to a new generation. This phenomenon is beginning to stem the Chinese "brain drain." It is attributable to a number of ways in which working and living conditions in China—at least those pertaining to the educated elites—are improving. These include better housing, improved business opportunities, higher salaries, and more modern workplace equipment and management practices.[276] It will be interesting to observe whether the number of "sea turtles" grows further, or whether the disadvantages of returning to live in China (such as earnings lower than those of colleagues who work in many Western nations) prevail.

Figure 2.4 The Number of Scientists and Engineers Engaged in R&D in China, 1998–2005



Source: Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China 15-year Science and Technology Plan," Physics Today, December 2006, 39, citing National Bureau of Statistics and Ministry of Science and Technoloy, China Statistical Yearbook on Science and Technology, (China Statistics Press, Beijing), various years; national Bureau of Statistics, China Statistical Abstract 2006, (China Statistics Press, Beijing), 2006.

S&T Advancement through Espionage

In order to obtain information, knowledge, and technical data it needs for defense or commercial purposes, China goes well beyond operating formal incentive programs to entice valued scientists and engineers to return or relocate to China and conduct their work there. It also enlists them in organized efforts to obtain valuable data and information from foreign sources, particularly sources within nations in which they reside, by whatever means possible—including theft. In some cases scientists and engineers are urged to obtain proprietary intellectual property (IP) or government secrets held by their employers.

In recent years, several scientists and engineers have been convicted under the Economic Espionage Act after attempting to smuggle proprietary IP to China. In one case involving two Chinese engineers living in the United States, a Chinese company was created in Hangzhou with funding by the local and provincial governments, as well as from the 863 Program. That company was to manufacture and sell microprocessors based on American technology stolen from a U.S. firm and smuggled to China.[277] The men

were caught carrying restricted company documents at the airport just before boarding a plane bound for China.

In another case involving a former Chinese national, a software engineer was caught attempting to sell proprietary software used for U.S. military training to China's Naval Research Center.[278] Although the United States has increased its pace of prosecuting Chinese industrial espionage cases, the counterintelligence and law enforcement communities find themselves overwhelmed by the volume of these incidents.[279] (For a more detailed review of recent Chinese industrial espionage cases, see Chapter 2, Section 1, "China's Military Modernization.")

Chinese Science and Technology Advances and Applications

Optoelectronics

The field of optoelectronics encompasses all electronics technology that relies on an understanding of the physics of light, such as fiber optics, remote sensing, and solar cells. According to a 2006 study by the Bureau of Industry and Security of the U.S. Department of Commerce, commercial uses of optoelectronics, which previously had been used primarily in defense applications, have increased in the last 10 years.[280] Although U.S. firms continue to dominate in the defense sector for imaging and sensor technology, Japan, France, Korea, China, and other nations are meeting commercial demand.[281] According to the study, China achieved 159 percent growth in optoelectronics exports from 2001 to 2005, the world's second highest growth rate during that period.[282] Because U.S. export controls on many optoelectronic products preclude U.S. companies from supplying these items to end users in a number of nations, including China, and this market therefore is open to non-U.S. manufacturers, China has had an incentive to maximize the development of its optoelectronics industry. This dynamic is only one reason China is likely to retain a major presence in the optoelectronics industry over the next ten years.

While the United States currently is the leader in optoelectronics, a National Intelligence Council study estimated that a combination of China's centrally planned focus on developing night vision technology, and its ability to exploit export opportunities, will enable China to develop a significant capacity and move into second place in the world in this field by 2014, surpassing all other nations except the United States. Two nations China will surpass, France and Israel, are cooperating with China in its optoelectronics pursuits, enabling it to advance its capability more rapidly than it could if it were dependent solely on its own resources and skills.[283]

Information Technology

Chinese military planners see the integration of information technology in existing weapon platforms as key to winning wars under "informatized conditions."[284] Possessing first-rate information technology not only expands China's range of offensive and defensive capabilities, but also facilitates joint operations between PLA service branches—a necessary component of twenty-first century warfighting.[285]

Information technology is central to China's current military modernization campaign and to its overall defense industrial modernization goals.[286] For military modernization, integrating current IT systems into older military systems can act as a temporary, stopgap measure until newer systems can be fielded. Other examples of military applications for IT are conducting information operations and electronic or cyber warfare, and constructing and utilizing command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) platforms. In addition, the PLA is using IT to enhance its logistics systems and thereby improve the efficiency and reach of its forces.[287]

The Chinese defense industry also benefits from the influx of IT investment into China's commercial civilian sector. As Chinese IT companies advance technologically, many of their advances are shared with the defense sector through R&D partnerships, direct transfers, or commercial off-the-shelf products used by Chinese defense companies or the PLA directly.[288]

In addition to being useful in numerous military applications, IT advancement also contributes to research efforts pertaining to other technologies and fields. Enhanced communications, data processing, and logistics management all help to speed the advancement of other scientific fields of study such as nanoscience and robotics.[289] The use of information technology in military applications is discussed in more detail in Chapter 2, Section 1, "China's Military Modernization."

Nanotechnology

The field of nanoscience is one that is loosely defined and variously interpreted, overlapping with other fields of science and technology that deal on very small scales. Dr. Thomas P. Ehrhard of the Center for Strategic and Budgetary Assessment testified to the Commission that "the real technological wild card" appears to be nanotechnology, the manipulation of materials on the molecular scale that yields materials, devices, and systems with novel properties.[290] Examples of subfields of nanoscience include microelectronics, biotechnology, and chemistry.[291] While Chinese S&T capabilities as a whole do not yet qualify as world-class,[292] China's nanotechnology capability is an exception, particularly in nanomaterials where Chinese scientists are leaders in the field.[293]

Dr. Ehrhard told Commissioners that nanotechnology "should prove to be a critical enabler that will yield a variety of unsettling economic and security challenges, and as a result, many nations are aggressively pursuing research and development in this area. It stands to reason that the [United States] should both pursue its own nanotechnology initiatives and also closely monitor similar developments in China."[294]

This field has numerous dual-use applications.[295] Nanotechnology can be used to create new materials with properties better-suited than natural materials to a specific purpose. For example, the U.S. Air Force uses nanotechnology to develop hard, nanostructured coatings on superalloys.[296] Potential Chinese military applications of nanotechnology were noted in testimony before the Commission by Mr. Michael Vickers, then Senior Vice President for

Strategic Studies at the Center for Strategic and Budgetary Assessments:

> *Should China at some point choose to become a strategic competitor of the United States, it could also find it in its interests to engage in proxy wars to increase its global influence and weaken that of the United States. The emergence of disruptive capabilities, particularly those stemming from advances in nanotechnology, could greatly facilitate new forms of clandestine and covert strategic attack.*[297]

Nanotechnology is one of the four science "megaprojects" identified in the new S&T Fifteen-Year Plan. However, China had been making strides in nanoscience for several years preceding the initiation of that new plan. As one measure of its progress in this field, China now ranks third in the world in nanotechnology patents awarded.[298] However, China has only 21 nanotech patents on file with the U.S. Patent and Trademark Office, putting it in twelfth place worldwide by this measure.[299]

Robotics and Unmanned Vehicle Technology

When comparing the state of advancement of the robotics technology of two nations, the number and sophistication of robots used in manufacturing often is used as a measurement.[300] As foreign companies have moved manufacturing to China, they often have imported manufacturing robots to the new factories to maintain manufacturing conformity among their operations worldwide. For example, as Honda has established car manufacturing plants in China, it has brought manufacturing robots to those facilities from Japan.[301]

As more foreign companies have relocated manufacturing to China, they have begun to require local support and services for maintaining their manufacturing robots. This has resulted in Chinese engineers obtaining significant robotics assembly and maintenance expertise from foreign companies to the degree that some Chinese companies are now able to manufacture similar domestic robotic systems, based on technology obtained from foreign companies.[302] While Chinese-built manufacturing robots generally have not been of the same quality as the originals, the quality is improving and some Chinese companies are beginning to market their robots to the countries from which the original technology came.[303]

Robotics technology has military applications. Although the PLA still imports some of its most advanced unmanned aerial vehicles (UAVs), it has begun to acquire UAVs produced domestically.[304] PLA strategists envision UAVs as a powerful countermeasure to American weapon systems and warfighting tactics. Dr. Ehsan Ahrari, professor at the Asia-Pacific Center for Security Studies, noted in his testimony to the Commission:

> *The PLA is developing its capabilities in the realm of UAV warfare, drones, and related technologies. They are also diligently studying [American] tactics in the Iraqi and Afghan theaters of war, and Israel's operational and tactical measures against Hezbollah in July–August 2006. Obviously, China has extracted a number of valuable lessons.*

> *That type of knowledge contributes to China's operational and tactical strategy to use anti-ship missiles, cruise missiles, and UAVs.*[305]

Some subcomponents of robotics technology, such as sensor and imagery devices, have stand-alone reconnaissance applications as well. The imagery systems of China's advanced imagery satellites described in Chapter 2, Section 1, "China's Military Modernization," are examples of subcomponents of robotics being used in other technologies.

China has become adept at integrating commercial civilian technologies including optoelectronics, IT, nanotechnology, and robotics into military platforms. This capability has played such a significant role in China's military modernization that Defense Science Board Chairman Dr. William Schneider told the Commission that, as the United States considers ways to ensure its defense industrial base has access to the latest commercial civilian technologies, it needs to give attention to improving and speeding the same kinds of transfers:

> *The way in which the [Chinese] defense industry has been organized gradually over the past ten or so years is: the major players in the defense industry focus on systems engineering and integration and are increasingly acquiring technology from civil sector high tech companies and creating specific military applications. This process is moving along very rapidly in the information technology sector, and I think we can expect this to be replicated in nanotech and biotech and so forth. So I think there's a process in motion, but it's not fully evolved yet. One of the things that needs to be done is the defense industrial base that the United States depends on needs to be managed in a different way in order to elicit the technology that is now in the civil sector so that it will more routinely and efficiently be able to be transferred to the defense sector.*[306]

Conclusions

- China's Fifteen-Year Plan for science and technology incorporates elements of previous similar plans, but also takes into account important social factors such as needed institutional and cultural reforms. It also places new emphasis on the importance of indigenous innovation rather than reliance on imported high-tech products.
- China no longer seeks only to attain parity with Western S&T, but instead is working to surpass the technological prowess of the West.
- On the whole, Chinese S&T capabilities still are not world-class. In some key specialties such as nanotechnology, however, Chinese scientists and engineers are among the world's most advanced.
- Chinese policies promote "leapfrogging," whereby the development of Chinese technologies improves on established foreign technologies and bypasses intermediate domestic R&D steps.

This speeds product development and saves China the time and cost of accomplishing the intermediate steps. Industrial espionage contributes to this process.

- A major objective of Chinese S&T policy is to acquire technology that will strengthen the PLA while it also realizes commercial benefits.