TECHNOLOGY TRANSFER NET ASSESSMENT: WORKSHOP REPORT

LONG TERM STRATEGY GROUP

(b) (7)(C) [redacted]

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EXECUTIVE SUMMARY

As part of the ongoing work by the Long Term Strategy Group (LTSG) for OSD/Net Assessment, a meeting was convened to discuss how American technology transfer polices might be modified in order to (b) (5) [redacted]. The people attending the meeting had extensive experience in defense technology policy, export controls, and foreign technological capabilities.

The meeting began with the working assumption that American restrictions on technology transfers might need to be differently structured than they were in the Cold War. With the benefit of American technology, the resources that friendly countries closer to China devoted to their military expenditures would produce more capable forces. Those augmented forces could be expected to have a (b) (5) [redacted]. This was the initial case for exploring American technology transfers (b) (5) [redacted].

However, American technology transfers to friendly countries could have negative consequences as well. The transferred technology could be compromised and lost to China or other hostile powers, so that Chinese military power could unintentionally be increased. As a result, there appeared to be a need for a net assessment of technology transfers which weighed these costs and benefits against each other.

The discussion that followed the initial presentation of the problem fell into four categories.

Government-Industry Exchanges of Information

Unlike the Cold War, the international market today provides countries with multiple alternatives to the United States for defense related technologies. The field of advanced technology is extremely dynamic, with new dominant technologies emerging and receding quickly. Civilian applications often dominate the development of advanced technology relevant to the defense sector. The bottom line is that American firms often will have the best information about which technologies are critical, what foreign competition is like, and where technology trends are going. Developing mechanisms and personal networks that allow the government to gain information from firms that compete with each other is a critical task for improving the information that informs government technology transfer policy.

Foreign Ability to Assimilate Technology

While technology transfer policy often focuses on the transfer of hardware, the discussion emphasized the importance of human factors for successfully transferring or controlling advanced technologies. Tacit information was still a key to the successful production of advanced technology and to successful operation of advanced military systems. Paying attention to the people who are the avatars of such knowledge is important for preventing the unwanted diffusion of sensitive technologies, and for successfully transferring it to friendly recipients. The level of human capital in foreign countries was a major factor in determining how well equipment was maintained and operated, and efforts to acquire information about this would augment efforts to assess the real impact of technology transfers.

(b) (5) [redacted]

[redacted]

Aids and Obstacles to Reform

It was unanimously agreed that the current environment provided a favorable moment for reform. Reductions in American defense spending created numerous incentives for increasing foreign sales, the need to cut headquarters staff provided incentives to reduce the staff of the Defense Technology Security Agency, and the challenge of China created a compelling strategic need for a competitive strategies approach that provided technological assistance to Asian countries.

INTRODUCTION

The workshop was convened on 20 December 2011, as part of the continuing effort by the Long Term Strategy Group to develop ideas (b) (5) [redacted] by the government of the United States. In several earlier efforts, the lead that the United States enjoyed over other countries in military and other technologies had been identified as an enduring strength. That lead may be the result of factors favoring innovativeness in American business and science, the result of decades of investment in research and development that produced a cumulative advantage in technical know how, underinvestment in research and development by other states after the end of the Cold War, or cultural factors inhibiting innovative research and development in potential competitors. Whatever the reasons, (b) (5) [redacted] The question was how to (b) (5) [redacted] Given the fact that China was likely to be economically capable of spending large sums on its military, and had the advantage of operating, at least initially, in areas closer to China than they were to the United States, the United States would appear to have an interest in increasing the technological strengths of other countries closer to China, and friendly to the United States. The resources of those countries (b) (5) [redacted]. With American technology the resources those countries devoted to their military expenditures would produce more capable forces for each dollar spent than they would without American technology. Because those forces would be home based in regions near China, those augmented forces could be expected to have a significant impact on (b) (5) [redacted]. This was the initial case for exploring (b) (5) [redacted].

However, American technology transfers to friendly countries could have negative consequences as well. The transferred technology could be compromised and lost to China or other hostile powers, so that Chinese military power could unintentionally be increased. As a result, there appeared to be a need for a net assessment of technology transfers which weighed these costs and benefits against each other. The workshop was convened in order to explore how such assessments might be performed.

WHERE ARE WE TODAY?

The workshop began with a short review of where American government technology transfer policy stood. It was argued that American technology transfer policy may have been affected by the trauma of the loss of American nuclear weapons secrets to the Soviet Union in the 1943-1945 time period. This loss was dramatic, but may have been a special case. The accumulated technical expertise relevant to nuclear weapons construction in 1943-1945 was limited by the fact that the technology had only recently been invented, and incorporated a small number of technological secrets (the geometry of high explosive implosion lenses, nuclear reactor design, and neutron initiators). These technologies, if stolen, could and did greatly facilitate the work of the Soviet Union. Other defense technologies, which were based on decades of accumulated expertise, might be harder to steal and utilize. If this was the case, the early loss of nuclear weapons technology may have biased the United States toward an overly conservative set of policies for protecting defense technology.

Evidence that this was the case could be found in American technology transfer policy from the 1970s on, which was based on NSDM 119. This decision memorandum emphasized the need to protect American technology transferred abroad as well as it would be protected in the United States. It focused on the possible negative consequences of technology transfers, and paid less attention to the benefits. A participant in the workshop recalled that in the 1980s, Richard Perle set up the bureaucracy to review exports to the Soviet bloc conscious of the fact that bureaucracies by their nature tended to delay decisions and to find reasons to say no. Simply by creating an export review bureaucracy, Perle realized that he was creating a barrier to technology transfers abroad, which was his goal. Now, however, strategic circumstances that made technology transfers potentially more necessary than they were in the 1980s were blocked by that same bureaucracy.

To rectify that situation, there was perhaps a need to eliminate that bureaucracy, a move advocated by some of the participants at the workshop, but in any case to improve the analytical methodologies used to evaluate proposed transfers. What questions should that analysis try to answer in a net assessment of proposed technology transfers?

Three initial questions were initially proposed.

First, we might wish to help a country acquire more advanced technology relative to its rivals. Would the proposed transfer actually increase the technology lead the recipient country would have after it received the new technology, given the possibility that hostile countries might steal the same technology? This assessment would be affected by the speed at which the recipient country could assimilate the transfer the new technology with the assistance of the donor country, relative to the speed at which a hostile country could assimilate the stolen technology, which it would have to assimilate without active American assistance. The difference between the two rates of assimilation would appear to be affected by the relative importance of tacit knowledge that can be transferred in a cooperative relationship but which is absent in stolen hardware or documents.

Second, we might transfer technology to a recipient country in (b) (5) [redacted]. What would be the reaction of the target country to the acquisition by the recipient country of the technology in question? This is (b) (5) [redacted]. Understanding past patterns of behavior of the target country in response to foreign military developments appeared to be the key to this assessment.

Third, what would be the impact of the technology transfer on (b) (5) [redacted] was a part, given its organizational and operational practices and those of its adversaries? How would it use the new technology? What capabilities did opposing countries have to neutralize its effects, and how would they use them, given their organizations and doctrines?

DISCUSSION

Following this initial presentation, there was a vigorous and informed discussion.

GOVERNMENT-INDUSTRY EXCHANGES OF INFORMATION

The first point that was made by several participants was that in many cases, there were multiple alternative sources for many of the technologies that the United States had to offer, and so any assessment of proposed transfers had to acknowledge that if the United States declined to transfer a particular technology, others would step in to provide it. One example mentioned was that of radar test range equipment that could be used to evaluate low observable aircraft designs. This equipment was denied to the Israelis by the United States in the 1980s because it was thought to be so sensitive. Now, foreign firms lease time on their radar test ranges to anyone who can pay the necessary fee.[1] Today, if the United States withheld a technology from the foreign market, this would result in the United States simply having less revenue and less influence and control over recipient countries, by means of the supply and maintenance connections owned by the United States, than it would have had if it permitted the transfer. Other countries would displace the United States as a supplier, improving their revenue streams which they would then use to improve their technological base.

One example that was provided was in the area of image intensifying night vision equipment. In the 1980s, the United States decided night vision based on image intensifiers was a critical technology for its combat operations and so chose not to transfer it. The result was that Russian and Chinese suppliers stepped in and now controlled the international market in image intensifier night vision equipment. In addition, European suppliers provided an alternative night vision technology, thermal imaging and short wave infrared systems, which are for many purposes superior to image intensifying technologies, leaving the United States wedded to a "sunset technology" in which it does not even have a dominant position. A superior strategy for the United States would have been to sell image intensifying technologies abroad, and use the revenue to develop better thermal imaging technologies so that it could shift away from image intensifiers, leaving other countries dependent on obsolete technologies.

In response, other participants asked how we could know now which technologies would be gaining or losing importance in ways analogous to night vision relative to thermal imaging in the 1980s? It was easier to identify these trends in retrospect than it was to pick winners now. For example, today, it was noted, Russia was a powerhouse in writing computer code for military

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[1] Range instrumentation emerged in the discussion as a critical capability in military research and development in a number of cases. Russian ballistic missile development after World War II depended heavily on German range instrumentation technology, for example. Another case was the Chinese program to build an AWACs (the KJ-200), which ended in a crash of the test-bed aircraft, along with the 36 top engineers, because Chinese telemetry technology was sufficiently bad that the engineers had to be on the test airplane to monitor the prototype equipment.

purposes. How should we understand the pros and cons of restricting sales of American computer code? Focal plane arrays appear now to be critical for many military applications, another participant noted. Should their foreign sale be controlled?

From this discussion, the consensus view emerged that American firms were the best source of information about trends in technologies and international markets, particularly for dual use technologies where important civilian applications drove innovation. However, it was to be expected that firms would provide data and make arguments about American technology transfer policies that were most favorable to their commercial interests. The proper government response, therefore, was to ask firms from competing technological and commercial perspectives to make their respective cases for permitting and restricting technology transfers to the government. The government would have to assure firms that proprietary data would be protected, but if this could be done, the government would be able to get a better picture of which technologies were emerging as critical on the international market, which were waning, and what foreign competition was like. The firms, for example, had information about Chinese efforts to acquire technology from them, and this information was of value to the United States government. The success of government-industry cooperation would depend on personal relationships of trust that had to be developed over time, and that had obvious implications for conflicts of interest, and this had to be managed. Ultimately, if firms could be convinced of the national security implications of their foreign sales, they would cooperate with the American government and comply with its requests. The alternative would be to create a situation in which the most innovative American technology firms abandoned the US defense market for civilian applications. This would be more and more of a problem as American defense procurement budgets declined.

FOREIGN ABILITY TO ASSIMILATE MILITARY TECHNOLOGY

The discussion also focused on the obstacles to the effective assimilation of technology from abroad. These factors had to be understood if the actual impact of technology transfers, cooperative or hostile, were accurately to be assessed. For example, Saddam Hussein's air force acquired modern fighter aircraft, but his pilots were never trusted enough to be allowed to fly the amount of training missions that was required for pilot proficiency. The general technical "literacy" of a population was also discussed. One participant cited the testimony of a former Chinese fighter pilot now teaching at an air force academy in China that people who had not played with electronic games as children simply never became comfortable with the level of technology now embedded in modern airplane cockpit control systems. China, despite decades of effort and high levels of investment and leadership attention still cannot manufacture jet engines that last even 10 percent as long as American jet engines. Some military capabilities are based on decades of operational experience. Without that experience, the technology is less useful. When the Soviet Union first deployed aircraft carriers, Soviet test pilots went to their foreign counterparts and asked them what techniques they used to land on a carrier in a cross wind? The amazed response is that you don't – you turn the ship into the wind! This was cited as an example of the importance of tacit knowledge for translating transferred technology into real world military capabilities.

The last anecdote returned the discussion to the subject of tacit knowledge, what expert practitioners know but never write down. Participants gave examples of craftsmen fabricating forms from composite material running their hands over the fibers and saying “it does not feel right.” From this followed the importance of tracking, and where critical, controlling the movement of and access to expert practitioners. This had to be done carefully: expert practitioners can learn from contacts with foreign experts, so denying them all contact with foreigners could be counter-productive. But aggressive Chinese recruiting of retired or laid off engineers was argued to be at least as important in controlling unwanted technology transfer as were prohibitions on sales of sensitive technologies.

Finally, a senior participant argued that it was important to understand the quality of the military and industrial manpower in the countries that acquired technology. How well do they maintain their equipment? How much do they train on it to become familiar with operating it? While senior American commanders during the Cold War would, on occasion, devote significant resources to understanding these issues, it was now difficult to get good data on such human factors. This made it hard to assess how well or badly foreign countries would use foreign military technology.

COMPETITIVE STRATEGIES AND TECHNOLOGY TRANSFER

It was agreed by the group that the competitive strategies approach to evaluating technology transfers was a powerful addition to existing approaches. Executing competitive strategies analysis was therefore worth doing as well as possible. Forecasting and affecting shifts in foreign defense resource allocations required data about foreign resource allocation, a task no longer performed by the Central Intelligence Agency. The problems of estimating the costs of defense programs that foreign governments pay in their own currencies were reviewed. The standard Cold War methodology, of taking an enemy order of battle, getting an American firm to estimate what it would cost an American firm to produce the equipment in that order of battle, and then converting the dollar cost into the currency of the country in question was reviewed, along with the so-called index number problem, identifying what was the appropriate conversion factor for translating dollars into foreign currency. The problem was made more difficult by virtue of the fact that much high-tech work is labor intensive, and the real cost of the labor involved in technological innovation was hard to estimate. It is difficult, for example to get a realistic estimate of labor costs when an innovative engineer may be priceless and impossible to replace, while 100 ordinary engineers may be worthless.

The effort to get precise answers to these questions may be misguided, it was argued. Efforts to measure aggregate Soviet military power quantitatively had led to absurdities, such as evaluating the military power of a Soviet ICBM by estimating it to be the military equivalent of several million AK-47s. It was agreed that rough but adequate forecasts of anticipated foreign resource allocation shifts could be and have been made. The nature of the Soviet air defense system and its responses to American bomber programs was reviewed. A fascinating anecdote was related with regard to China. As a result of their historical experiences, senior PLA officers had an exaggerated sense of the value of massed anti-aircraft artillery in shooting down air breathing systems. As a result, the first reaction of the PLA to the American use of cruise missiles against Iraq in 1991 was to increase their purchase of anti-aircraft artillery.

AIDS AND OBSTACLES TO REFORM

The discussion turned to how the existing system of export controls might be made more responsive to American strategy. It was argued that in an era of declining American military procurement, the Navy and Air Force would be stronger advocates of foreign sales in order to reduce the unit costs of equipment they purchased, as well as to augment the capabilities of coalition partners. The Commerce Department and the Politico-Military Bureau of the State Department would be allies of reform, as would the export-promoting sub-offices of the National Economic Council.

However, the instructions issued to the Defense Technology Security Agency and the Defense Security Cooperation Agency would have to be revised. The Defense Technology Security Agency itself might be an office that could be reduced in size at a time when reductions in defense headquarter staff were being explored.

Appendix

Agenda

LTSG Technology Transfer Net Assessment Workshop

When: Tues., 20 Dec. 2011

Where: Office of Net Assessment, Pentagon

10:00-10:30	[redacted] ([redacted]
10:30-11:30	The international market in military technology [redacted]
11:30-12:00	Current issues in US policy (general discussion)
12:00-1:00	Toward a technology transfer net assessment methodology (see TOR)
1:00	Adjourn

TERMS OF REFERENCE

Technology Transfer Net Assessment

Terms of Reference

Long Term Strategy Group

What is the issue?

The use of technology transfers has been identified as one means by which the United States can use its enduring strength in technological innovation in its competition with China. However, the transfer of advanced American technology to friends and allies may increase the chance of undesirable loss of those technologies to third parties. The current system has its origins in NSDM 119 and is embodied in current Defense Technology Security Agency policy directives. It is set up to limit any possible technology losses in designated categories of technology, while allowing transfers of items in other categories. In principle, however, the correct approach is to accept the risk of technology losses when the possible negative consequences of those losses are significantly outweighed by the gains associated with the possible gains. A net assessment approach is called for, in which the net effect of discrete technology transfers is assessed.

Metrics for assessing technology transfers

The current explicit metric for tech transfers is the binary "can the proposed recipient country protect the technology as well as it is protected in the United States?" Net assessments, on the other hand, usually develop a metric by asking, "what is the balance about?" In this area, there are, initially, multiple answers to that question.

Lags and leads

Decreasing the time and cost needed to reach a given level of military capabilities in a friendly country is one obvious goal. But another goal is <u>not</u> to reduce the time and cost it takes a hostile country to reach a given level of military capabilities because it can gain access to the transferred technology. There are factors that affect the time it takes a hostile country to use clandestinely acquired military technology beyond the level of protection that is provided to the technology. The different rates at which different countries can make use of the transferred technology can be assessed, taking into account the facts that the target country and the hostile country start with different technology and capital endowments, and the fact that the target country will have the active assistance of the United States in learning about the transferred technology, while the hostile country must overcome security barriers and then assimilate the technology with less than active support from the United States. The goal is to shift the lag or lead of the friendly country over the hostile country in a favorable direction. The metric in this case would be whether the lag or lead in fielded military technologies between the target country receiving American technology and the hostile country stealing the technology goes up or down, given the differences in their ability to assimilate the new technology.

[redacted]

[redacted]. If that is the case, a separate metric may be an assessment of what the hostile country [redacted] Those costs may be high, even if the hostile country gains access to the transferred technology and can replicate it, since responses may be asymmetrical. Responding to transferred ballistic missile or submarine technologies may require missile defenses or ASW, for example. The metric in this case would be [redacted].

Tech transfer competition

Technology is often transferred in order to affect the balance between the recipient country and its local rivals and enemies. The United States is not the only country that supplies weapons to countries in regions with ongoing competitions. The goal here is to measure the impact of non-US arms transfers on a regional military balance, and to assess the effect of American technology transfers on that balance over time.

Methodologies

How would these assessments be generated? Different methods would be appropriate for different metrics.

Lags and leads

The key issue here is the ability to assimilate a transferred technology. How long does it take for an item of technology, with full American support, to be integrated into the fielded forces of a customer? How long does it take for that same technology, if clandestinely acquired, without active supplier support, to be integrated into the fielded forces of the hostile country? The existing literature approaches this question in two broadly different ways.

The first approach is executed at the national, aggregate level. At this level, the ability to assimilate technology is linked to national cultural similarities (e.g. shared norms, language, educational methods, levels of social trust). The observation is that countries that are culturally similar are both disposed to adopt foreign technology from each other and are able to replicate the organizations and technology that generate it. The level of national funding for R&D is another aggregate measure of how quickly a state can assimilate foreign technology. Using this approach, levels of cultural similarity and aggregate R&D funding would be the input into an assessment of the time required to assimilate a new technology. In those cases where there is historical information available about a country's defense R&D and acquisition cycle, this information can also be used to estimate assimilation times.

The second approach emphasizes expert information, either resident in a country or given to it. A country as a whole can be good or bad at acquiring technology but expert knowledge in a particular area, or the lack of it, can accelerate or impede technology acquisition. General Electric's long history of building high pressure compressors and turbines for electrical power generation in the United States made the assimilation of the Whipple jet engine during WW II a relatively rapid matter. The Korean experience in large volume, high quality production techniques for consumer electronics provided the basis for its rapid expansion into the production of dynamic random access memory chips in the 1990s and flat panel displays in the 2000s. The lack of advanced metallurgy and precision metal working in the Soviet Union was a roadblock to the production of the gaseous diffusion membranes necessary for Oak Ridge style uranium enrichment and for rocket motor combustion chambers larger than those used in the V-2. In both cases, work-arounds had to be devised.

In other cases, clandestinely acquired technology can provide expert information and reduce development time by identifying at the beginning of a project specific technology road blocks and technological dead-ends. The Soviet Union clandestinely acquired knowledge that commercial grade graphite would not slow down enough neutrons to sustain a chain reaction, and so were aware of the need for ultra-pure graphite. As a result, when initial Soviet tests of a reactor with commercial grade graphite failed, they did not give up, but waited for the delivery of ultra-pure graphite. Through their spies, the Soviets also knew that nuclear reactor operations would generate build-ups of xenon gas that would shut the reactions down unless ventilation channels were built into the graphite. The specific irregular and asymmetrical geometry of the high explosive lenses for the plutonium implosion bomb were also supplied to the Soviets. These are all examples of how process or design information made available from foreign sources significantly reduced the time needed to assimilate foreign technology.

This approach requires more detailed data, and would look into to the existence and behavior of firm or bureau level competence in particular areas of technology, and identify critical items of information, in order to estimate assimilation time with and without that competence or information.

(b) (5) [redacted]

The main requirement for an assessment (b) (5) [redacted].

Tech transfer competition

If foreign military technology is introduced into a regional competition, existing regional military net assessment methodologies could be used to assess the impact on the regional balance. In each case, it would be crucial to understand what the local balance was about, what were the central military concepts of operations, and trends and asymmetries in forces and concepts of operations. This data would be used to support more or less sophisticated simulations that tried to assess the impact of the foreign technology on the military balance.

Execution

The proposed net assessments would involve a lot of work. Who would do it? We can ask who has the ability and incentives to do it? Different actors may have different abilities and incentives to perform different component tasks.

The national level assessments of the ability to acquire and assimilate foreign technology might be a task taken on by OSD/Net Assessment as part of an effort to extend its assessment of the military investment balance.

The more specific, firm or bureau level assessments of technological competence and road blocks could well be taken on by the firms wishing to sell their products and services, with regard to their proposed client. The bias of the firm would be to portray their proposed client in the most favorable light. To balance this, the intelligence community could be tasked with assessing the ability of hostile countries to steal and then to assimilate specific technologies. (b) (5) [redacted]

(b) (5) [redacted].

The impact of technology transfers on regional military balances would be a logical extension of the military balance work done by OSD/Net Assessment.

(b) (7)(C) [redacted]

[redacted]