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INTRODUCTION

Some observers express concern that U.S.-Russian commercial cooperation might cost U.S. aerospace jobs, erode the country's space-technology base, and undercut competitiveness of U.S. companies by transferring sophisticated technology to a foreign competitor. In fact, the costs of cooperation will have to be balanced against the potential benefits, some of which may extend well beyond any specific project. For example, U.S. officials are deeply concerned about the proliferation of ballistic-missile technologies to developing countries. Russia is a potential source of missiles, components, and expertise, whose transfer could benefit a country trying to develop its own ballistic-missile capability.

A combination of economic incentives and economic sanctions might be effective in curtailing the sale of hardware useful in the development and deployment of ballistic missiles, and it might help to keep the rocket scientists, whose expertise is an essential part of a working ballistic-missile program, from leaving Russia to work for a developing nation that would pay well for their services. A collapsing aerospace industry, with massive layoffs, dwindling salaries, and no jobs for young scientists and engineers who are just starting out, puts great pressure on employees to seek greener pastures outside Russia. Of particular concern are those scientists who would aid states, such as Iran, that are actively hostile to the United States. Although emigration restrictions seem to have been effective in preventing some at-

tempts at expatriation by aerospace engineers,[1] one long-term solution to the "brain drain" problem is a stable, viable Russian aerospace industry.

This chapter summarizes some of the issues that come into play in a consideration of future U.S.-Russian cooperation.

DOMESTIC IMPACT

The effect on the U.S. aerospace industry of Russia's entry into the international space-launch market will depend on how the United States decides to structure commercial cooperation with the Russians and on which part of the industry attention is focused. On the one hand, access to different and up-to-date technologies, production and processing methods, and cheaper hardware could make the U.S. aerospace industry stronger in an ever more competitive world market for space-related services. On the other hand, cooperative arrangements could also lead to unwanted technology transfer, strengthening of a competitor, loss of domestic production jobs, and a weakening of U.S. capabilities because of dependence on a foreign source.

The United States is in the process of deciding how to evolve its space technology so that it can be as efficient as possible in meeting the domestic need for access to space and in competing in the international space-launch-services market.[2] Because the requirements of the Soviet/Russian space program have historically been different from those of the U.S. program, Russia has developed systems with different operational and design characteristics. Access to Russian technological innovations could offer U.S. decisionmakers a wider range of design possibilities from which to choose, some of which have already been tested and implemented by the Russians. Some elements of their aerospace industry that might enhance U.S. capabilities are automated launch capabilities, less expensive hardware, advanced materials and materials processing, computational methods, and technical expertise.[3]

U.S. Job Market and Industrial Base

The current U.S.-Russian agreement on international trade in commercial space-launch services seeks to prevent Russia from providing space-launch services at prices more than 7.5 percent below "the lowest bid or offer by a commercial space launch service provider from a market economy country."[4] It also limits the number of principal-payload[5] launches that the Russians can sell on the international market to eight[6] between now and the year 2000. Both of these quantitative limits reflect an attempt to protect domestic providers of medium- to heavy-lift launch services from encountering unfair competition from the Russian

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[1] In December 1992, more than 50 Russian rocket scientists were stopped at Moscow's Sheremetyevo Airport. They had been recruited by North Korea with the promise of salaries much higher than they could command in Russia, according to one report (U.S. Congress, Office of Technology Assessment, *Proliferation and the Former Soviet Union*, OTA-ISS-605 (Washington, DC: U.S. Government Printing Office, September 1994), pp. 32-33, 643). The report goes on to point out, "In spite of the fact that the arrest has a positive aspect, reinforcing the belief that the Russian authorities are alert to foreign efforts to recruit or corrupt their specialists, there is also a negative aspect: the event demonstrates an active, advanced effort by a state to gain technologies controlled by an international nonproliferation regime."

[2] For a discussion of the objectives and possible effects of the Clinton Administration's *Nation Space Transportation Policy*, see U.S. Congress, Office of Technology Assessment, *The National Space Transportation Policy: Issues for Congress* (Washington, DC: U.S. Government Printing Office), forthcoming, spring 1995.

[3] Chapter 5 presents a more detailed catalogue of Russian capabilities that could be useful to the U.S. aerospace industry.

[4] "Agreement Between the Government of the United States of America and the Government of the Russian Federation Regarding International Trade in Commercial Space Launch Services," 1993, p. 8.

[5] A principal payload is a telecommunications satellite or, in the absence of a telecommunications satellite, any other spacecraft or combination of spacecraft.

[6] This does not include the scheduled launch of an INMARSAT 3 satellite on a Russian Proton booster. The payloads referred to are commercial payloads; no limit is placed on the number of payloads that can be launched with either the Russian or U.S. government as the customer.

aerospace industry, which is heavily subsidized by the Russian government, from the top-level manufacturer down through all lower-tier suppliers. There is also excess capacity in the Russian aerospace industry, dormant now, that could presumably be brought into play if sufficient demand develops. The overall effect is that the Russian aerospace industry, if not constrained, might be able to meet a large demand for launch services at prices much lower than U.S. firms could offer.

The U.S. aerospace industry is made up of different segments with differing needs, which complicates the attempt to predict the effect on jobs of using Russian launch services. Removal of all quotas on the number and price of Russian launches might be burdensome competition to a U.S. launch-service provider and, at the same time, a boon to a provider of on-orbit capabilities who must pay to launch its satellites to orbit. Whether such a tradeoff would result in a net increase or decrease of jobs in the aerospace industry as a whole is not clear. Even a **net** increase in jobs might be small consolation to a launch-service provider that loses out. Some observers argue that Russian entry into the launch-vehicle market might result in an increase of business in the aerospace industry as a whole because of Russian technological capabilities that make launch services cheaper. In that case, having Russian hardware and technical expertise available to U.S. industry for marketing at home and abroad could position the U.S. aerospace industry to capture a larger share of the expanded overall market, even while it is losing market share in the launch-services component of this market.

It might also be possible for domestic firms to take advantage of Russian launch capabilities directly. As an example, the formation of Lockheed-Krunichev-Energia (LKE) International is an attempt by Lockheed to market Proton launches to geosynchronous orbit. LKE International argues that it will not be taking market share away from the U.S. Atlas or Titan, but from the French Ariane 4 and 5. Representatives of the U.S. launch industry at an Office of Technology Assessment workshop, "Lower Industrial Tiers of the Space Launch Vehicle Industry," held in March 1995 expressed another viewpoint: the domestic launch industry is struggling and does not need another competitor in the medium-to-heavy launch-service market, irrespective of any possible enhancement of U.S. capabilities through cooperation with the Russians.[7]

Apparently, the effect that any given cooperative venture with the Russians will have on jobs in the U.S. space industry will depend on how that cooperation is structured. Several possible arrangements are:

- ***Independent contribution***. Have each side design and develop its contribution separately and provide the other side with interface documents only. This type of arrangement has the advantage of making it possible to control technology transfer between the parties involved. But the components of a joint venture provided by a foreign entity are not manufactured in the United States, so there would be no contribution to U.S. manufacturing jobs. A joint arrangement with independent contributions from both parties could, however, provide a new service, or an existing service at a lower price, thereby benefiting the U.S.-based partner.
- ***Commercial buy***. In this case, a propulsion firm such as Pratt and Whitney or Aerojet might buy Russian rocket engines that could be made compatible with U.S. boosters. Although such a buy will probably lose jobs for the engine-manufacturing segment of the domestic industry, in most cases, testing and systems engineering will still be required. Also, cheaper engines might make U.S. launch services more competitive, potentially increasing business and creating jobs in that sector of the industry

[7] U.S. Congress, Office of Technology Assessment, *The National Space Transportation Policy: Issues for Congress* (Washington, DC: U.S. Government Printing Office), forthcoming, spring 1995.

and in others stimulated by low-cost launch services.

- ***Licensing technology***. A U.S. firm could buy a license for a given engine technology and set up its own production line. This licensing of technology would result in increased employment for U.S. workers if it is successful in producing a product. It could also make those parts of the industry that depend on the product of the licensed technology more competitive in the world market.
- ***Joint development***. In a joint business venture that seeks to develop a new service, the venture can benefit from the technological expertise that each side brings with it. Such ventures could bring technological advancement to both sides, which might then create new markets for the products that would result from cooperation.

The United States must also decide how much of its industrial base should be maintained to meet national security needs and to ensure access to space. Making use of existing Russian technology could reduce the amount of research and development required of U.S. firms, resulting in reduced costs, but it could also undercut the development of U.S. capabilities in certain areas. Because the space industry is considered to be indispensable to the security of the United States, many argue that the United States should develop and maintain its own capabilities in certain critical areas to prevent any weakening in its own technological base. In line with that reasoning is the National Space Transportation Policy, which states that the U.S. government will not purchase launches on vehicles not manufactured in the United States.[8] The Department of Defense (DOD) is willing to use launch systems that have foreign components and technology, but only in such a way that foreign suppliers cannot deny DOD access to space.[9] Although this might result in higher costs to the government, it ensures that the United States will be able to fulfill its space-related national security needs without depending on foreign suppliers of launch services.

Technology Transfer

Cooperative ventures entail the risk of transfer of domestic technologies that could be used to strengthen a competitor's position in the international aerospace market. Policymakers disagree over how effective specific means to prevent such transfer can really be, but present policy is clearly in the direction of loosening trade restrictions. Specifically, many items having to do with satellites and satellite technology have been moved from the U.S. Munitions List[10] onto the Commerce Control List, effectively making it easier to trade in those items.[11] There are recent reports that further loosening of restrictions is being worked out between the Department of State and the Department of Commerce.[12]

PROLIFERATION CONCERNS[13]

The principal current attempt to limit proliferation of long-range delivery systems capable of delivering weapons of mass destruction (nuclear, chemical, and biological weapons) is the Missile

[8] The White House, Office of Science and Technology Policy, *Fact Sheet: National Space Transportation Policy*, Aug. 5, 1994, section VI.

[9] *DOD Implementation Plan for National Space Transportation Policy*, PDD/NSTC-4, Nov. 4, 1994.

[10] Code of Federal Regulations 22, ch. 1, subch. M—International Traffic in Arms Regulations, Part 121—The United States Munitions List, 1994, pp. 383-402.

[11] The U.S. Munitions List regulates export of items considered to have explicit military value. Those exports are regulated by the State Department under the Arms Export Control Act (P. L. 90-629). The Commerce Control List includes dual-use items that have both civil and military application. Those items are controlled by the Commerce Department under the Export Administration Act (P. L. 96-72).

[12] Warren Ferster, "Satellite Export Controls To Ease," *Space News*, p. 1, Feb. 20-26, 1995.

[13] Most of the material in this section is taken from chapter 5 of U.S. Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, DC: U.S. Government Printing Office, December 1993).

Technology Control Regime (MTCR), created in 1987 by the United States and other Western industrialized nations. The MTCR established a presumption to deny the transfer of ballistic missiles with ranges greater than 300 kilometers and payload capacities greater than 500 kilograms to nonmember nations. These guidelines have since been extended to cover any systems "intended to deliver weapons of mass destruction." Russia has pledged to join the MTCR and has agreed to abide by its rules until it becomes a full-fledged member. Participation in the MTCR requires that Russia prohibit the transfer of complete systems, components that could be used to make complete systems, and technology involved in the production of components or of complete systems.

Missile systems and space-launch systems have much in common, and arguments arise over whether a particular technology is best suited to one type of system or the other, or could be used for both. Despite having many components and technologies in common, space-launch systems differ from vehicles designed to reenter the Earth's atmosphere and strike targets on the ground. Space-launch systems do not require the sophisticated guidance needed for long-range ballistic missiles; a 10-kilometer error is tolerable for putting a payload into orbit, but is a great tactical impediment when trying to hit a long-range target, even for weapons of mass destruction. There are many other technological barriers that separate space-launch systems from working ballistic-missile systems, including the need for sophisticated materials-processing capabilities and advanced guidance systems. Despite all the technological difficulties involved in producing a working ballistic-missile system, testing and development of weapon-delivery systems can be accomplished under the guise of developing a space-launch program. The prudent assumption is that any country that has space-launch vehicles should be considered capable of developing ballistic missiles.

Economic shortfalls in the space sector and throughout the Russian economy make the sale of expensive, high-technology missile components and systems extremely attractive. In 1992, India contracted with Russia to buy a liquid-oxygen/liquid-hydrogen engine to be used as the upper stage for its Geosynchronous Satellite Launch Vehicle (GSLV). Both India and Russia resisted attempts by the United States to declare the deal to be a violation of the MTCR, which would have triggered sanctions that U.S. law requires be applied against states engaged in such transfer. Finally, in 1993, and against the wishes of the Indian government, Russia agreed to break its contract with India and withhold the engine technology.[14]

The question remains of what the United States can do to forestall the proliferation of technology, components, and expertise from Russia to developing nations. Even if Russia is willing to abide by the MTCR, as it has pledged to do, and prohibit the export of hardware useful in ballistic missiles, it might not be able to prevent the emigration of rocket scientists seeking to escape stifling economic conditions that are aggravated by the present state of the Russian space program. Despite Russia's apparent concern over the loss of its aerospace engineers, it might not be able to prevent their departure in all cases. People with expertise can freely emigrate from Russia to neighboring countries in the Newly Independent States (NIS), and keeping track of where they go from there might not be possible.

The United States might consider it in the interest of global nonproliferation to try to ensure that the Russian space program has the greatest possible chance of remaining healthy and capable of

[14] Four of the engines were sold to India by Russia. The United States' main concern was the potential military uses of the technology that was being transferred rather than the sale of the cryogenic engines themselves. Observers differed in their opinions about the usefulness of cryogenic engines for weapons systems. Weapons systems require constant readiness, and cryogenic engines take a long time to prepare for launch. There is no question, however, that some of the technology involved in the transfer could be beneficial to the development of long-range ballistic missiles.

retaining its experts. A similar kind of decision arises in the case of the proliferation of nuclear-weapons expertise, or brain drain. Attempting to prevent the proliferation of nuclear weapons is probably more difficult because the scale of the operation required to build some kinds of nuclear weapon is small (particularly if the required nuclear material—enriched uranium or plutonium—is available on the black market), while a ballistic-missile program requires the integration of a variety of complex and sometimes large systems. Nonetheless, the U.S. government's response to the brain drain in the area of nuclear-weapons technology was to provide some direct funding to scientific researchers responsible for the development and engineering of nuclear, chemical, and biological weapons in an effort to keep them employed in areas other than the development of those weapons.[15]

Many of the scientists and engineers in the Russian civil and military space programs have expertise that could be usefully applied to space science missions. Even during Cold War periods when the political atmosphere made larger, high-profile cooperative science efforts unacceptable, small, low-profile science projects involving Russian and U.S. scientists continued. That ongoing cooperation kept the lines of communication between the two countries open and fostered commonality of interest. With the lessening of tensions following the end of the Cold War, opportunities have increased for including Russia in international science projects and for joint U.S.-Russian science missions.

[15] Since FY1992, the Nunn-Lugar amendment to Public Law 102-228 and subsequent legislation have authorized the transfer of $1.6 billion of Department of Defense funds to help accomplish the destruction and secure storage of weapons of mass destruction. Of that money, $25 million was to be the 1994 U.S. contribution to the International Science and Technology Center (ISTC), which would provide research opportunities for former Soviet Union scientists in collaborative efforts with Western scientists. See, U.S. Congress, Office of Technology Assessment, *Proliferation and the Former Soviet Union*, OTA-ISS-605 (Washington, DC: U.S. Government Printing Office, September 1994), pp. 23-28. Some U.S. private foundations have also made money available to Russian research institutions to try to curtail the proliferation of nuclear-weapons expertise.