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Center for International Security and Cooperation
Stanford University
Encina Hall
Stanford, California 94305-6165

(415) 723-9625

http://www.stanford.edu/group/CISAC/

Commercialization of Russian Technology in Cooperation with American Companies

David Bernstein

June 1999

David Bernstein, an engineering research associate at Stanford University's Center for International Security and Cooperation, participates in the Center's Project on Industrial Restructuring and the Political Economy in Russia.

The opinions expressed here are those of the author and do not represent positions of the Center, its supporters, or Stanford University.

ISBN 0-935371-53-2

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Acknowledgments

My thanks go to Carnegie Corporation of New York for its long-term support of CISAC's Project on Industrial Restructuring and the Political Economy in Russia, and to the United States Department of Commerce, Technology Administration, Office of Technology Policy, for adding its support to Carnegie's for this particular study.

Many people have contributed to this research and report in many different ways. The principal contributors were the representatives of the Russian enterprises and American companies who were willing to be interviewed for this study and to answer follow-up communications to help get the facts as correct as possible. These were all busy people who were striving to build successful ventures under difficult circumstances, and yet they gave generously of their time. Without their patient cooperation this project would have been impossible. In many cases it became clear that they did this largely because they believed in the value of sharing information that could be of benefit to all working on the economic transition in Russia.

Ksenia Gonchar and Petra Opitz conducted many of the interviews in Russia. They also shared their insight on the subject from their own research and made many valuable suggestions during the project. David Binns and Cathleen Campbell also made several helpful suggestions in reviewing the draft. Richard Brody's advice on the structure and objectives of the project was incisive.

I also wish to acknowledge the help of Elaine Wai, Sarah Lenti, and Nina Olman in gathering research materials, helping prepare the text, and coping with my disorganized habits. Finally, CISAC's editor, Megan Hendershott, brought it all together. To whatever extent the report is readable, she deserves the credit. The errors are all my own.

I. Introduction

The Soviet Union placed a high priority on science and technology and built a huge assembly of research institutes, educational programs, design bureaus, and production enterprises embodying some measure of science and/or technology. This assembly concentrated overwhelmingly on military applications. Approximately three-quarters of this complex was located in Russia, but essential elements of many programs were located in other republics. The nature, structure, size, and operation of this military-industrial complex (MIC) as well as its decline and change during the Gorbachev and post-Soviet periods of economic transition have been documented in the literature.[1]

Starting in the Gorbachev regime there was a recognition that the economy was deteriorating and that it was necessary to reduce military expenditures and increase the civilian economy. A major element of this has been the attempt to direct a much greater effort toward the development of commercial products and services based upon technologies and skills developed in the MIC. This commercialization of Soviet and Russian military technology has been attempted by the Russians both independently, through conversion programs, and in cooperation with foreign partners. The conversion programs have had very limited success. The success of attempts at cooperative commercialization by U.S. companies and Russian enterprises have also been modest, but they illustrate workable models that could be utilized by other cooperative ventures. These cooperative commercialization ventures are the primary subject of this report.[2]

[1] Julian Cooper, "Military Cuts and Conversion in the Defense Industry," *Soviet Economy* 7, no. 2 (1991): 121–142; Julian Cooper, *The Soviet Defense Industry: Conversion and Economic Reform* (New York: The Royal Institute of International Affairs and Council on Foreign Relations, 1991); Clifford Gaddy, *The Price of the Past: Russia's Struggle with the Legacy of a Militarized Economy* (Washington, DC: Brookings Institution Press, 1996); David Holloway, *The Soviet Union and the Arms Race* (New Haven: Yale University Press, 1984); Sharon Leiter, *Prospects for Russian Military R&D* (Santa Monica, CA: RAND, 1996); Kevin O'Prey, *A Farewell to Arms? Russia's Struggle with Defense Conversion* (New York: The Twentieth Century Fund Press, 1995); Glenn Schweitzer, *Experiments in Cooperation: Assessing U.S.-Russian Programs in Science and Technology* (New York: The Twentieth Century Fund Press, 1997).

[2] This research was sponsored by Carnegie Corporation of New York and the United States Department of Commerce.

Almost all technology in the Soviet Union resided in the military industrial and research enterprises, and these enterprises designed and produced almost all civilian products with a technological content such as civilian aircraft, consumer electronics, and household appliances. This was a commercialization of technology in the sense that the products came into being for commercial applications, but it was not commercialization of technology in the Western sense of attempting to use advanced technology to make products more competitive in cost or quality. In general these products were not competitive with Western ones, and the only exports of consequence were to satellite or client states. Most importantly, there was virtually no technology developed specifically and initially for civilian applications as there is in the United States, where civilian technology leads military technology in most areas both quantitatively and qualitatively. Hence there was virtually no interest in responding to a market. The advance of science and technology was not reflected in commensurate advances in civilian products.

The United States also has problems with the commercialization of some advanced technologies from the military sphere, but many of the problems are very different than in Russia. In the United States commercialization is an ongoing process in a strong market economy that is based heavily on civilian technology. Many of the fundamental scientific or technological advances are made in response to demand from the civilian economy, which is often far more active in utilizing them than is the military. In Russia technology commercialization is one element of a broad spectrum of economic reforms that are being attempted to stimulate a severely depressed economy.[3] It is often driven by state policies to enable enterprises to stay in business, although they are de facto bankrupt, rather than by market demand. This subsidized technology push often makes it difficult to assess whether a project is a success or a failure.

There can be various definitions of success in technology commercialization. One could be the establishment of a sustainable business in Russia. This is difficult to assess at this time because of the aforementioned uncertainty of the financial condition of a business, especially when it is imbedded in a larger enterprise that may be subsidized and/or de facto bankrupt. Another definition could be the acquisition of Russian technology by an American company with a resultant improvement in products or processes followed by increased exports of American products.[4] This is more straightforward to assess but of less interest from the standpoint of the rebuilding of the Russian economy. A third definition could be conversion away from military activities, especially relating to weapons of mass destruction (WMD) and the potential proliferation of such technologies and/or personnel. This is also hard to assess because of the inability to determine what would have happened in the absence of conversion.

A venture can be successful by one definition while simultaneously a failure by the others. This also complicates the task of understanding the process itself, but it is possible to study a few cases of technology commercialization in enough detail to gain some understanding of key elements of success and failure. In this study success is judged more by the first definition, the establishment of a sustainable Russian business, although with recognition that success must be considered as interim success and that a potentially successful venture can die in a failing enterprise or a declining economy. The political economy in Russia is too unsettled and the tenures of new business ventures too short to consider any business as being success-

[3] This report was written shortly after the financial and economic crisis of August 1998. The future course of economic reform is as yet unclear.

[4] In this report "products" includes both products and services.

ful in an enduring sense. Even the most successful Russian businesses in this study have marginal momentum or established markets, let alone financial reserves.

As mentioned above this research is based primarily on the study of several cases of cooperative attempts by U.S. companies and Russian enterprises to commercialize Russian technology. Additional information has been gathered through participation in workshops and conferences including sessions or presentations on technology commercialization. There is no attempt to determine the total amount of such activity, but foreign investment of all types in Russia has been very small. These cases may not be representative of what is going on at many defense enterprises, especially those that do not have foreign partners. They do, however, show models of what can be achieved, as well as some of the problems encountered in technology commercialization. While the cases illustrate many important aspects of technology commercialization, there are limitations on the data and analysis that must be borne in mind:

- The cases do not span all of the important sectors of the economy.
- Both U.S. and Russian organizations are far more willing to discuss successes than failures.
- Organizations discussed their ventures with varying degrees of openness.
- Certain data are simply not reliably available; these include quantitative financial performance, some market and sales data, relationships to government subsidies, and the role, if any, of corruption. It is because of this lack of reliable data that I have eschewed a quantitative analysis.

This study is one of a series dealing with various aspects of microeconomic reform which have been prepared by the Stanford Project on Industrial Restructuring and the Political Economy in Russia.[5] The research for this report began in early 1997. The last set of interviews were conducted in Moscow in the fall of 1998. Some enterprises reported benefits of the economic crisis in that the costs of their products were reduced compared with foreign imports; however, it is not clear how much inflation will erode those benefits. I have attempted to indicate when various data were taken. I am unable to assess the coherence of the data prior to and after the financial and economic crisis of August 1998. The effects of this crisis will not be known for some time to come. Many of the observations about factors that contribute to the success or failure of a technology commercialization project appear to remain qualitatively reasonable, assuming that the Russian government will not dramatically change the rules. However, the time to success is undoubtedly lengthened by the crisis in most cases.

Most of the Russian enterprises interviewed in the fall of 1998 did not think the crisis would have much effect on them, largely because they did not have much money in failed banks or in defaulted government securities. While their assessment of these direct effects

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[5] Two previous studies that are closely related to the current one are David Bernstein, editor, *Defense Industry Restructuring in Russia: Case Studies and Analysis* (Stanford, CA: Center for International Security and Arms Control, 1994) and David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997). These reports are available on the Internet at http://www-leland.stanford.edu/group/CISAC/test/pub/defenseindustry.pdf and http://www-leland.stanford.edu/group/CISAC/test/pub/cooperative.pdf.

may be accurate, I believe that they are all bound to suffer from the indirect effects of the myriad dislocations that will ripple through the entire economy.

Chapter II deals briefly with several aspects of the political and economic environment in which technology commercialization is being attempted. It also compares the processes of adjustment to demilitarization in the United States and Russia; this is primarily to show the difference in available strategies in market and transitional economies. Finally, it discusses some of the key factors to be considered in analyzing technology commercialization.

Chapter III contains the case studies of cooperative technology commercialization projects, usually from both American and Russian perspectives.

Chapter IV is an analysis of the case studies. I have attempted to verify the accuracy of the case studies themselves as presented in Chapter III with the interviewees; however, the analysis is my own.

Chapter V contains the conclusions and recommendations that I have drawn from this study.

II. Background

A. The Political and Economic Environment

Technology commercialization cannot be studied without reference to the political and economic conditions in the country in which it occurs. This is especially true in Russia, where there have been dramatic changes in government policy, laws, and economic conditions. There have been major changes in Russia's economy and politics since independence, most of which have been far from smooth and many of which have not been constructive from the standpoint of encouraging foreign investment or building a strong civilian market economy.

There is an important contrast between Russia and other emerging economies. The Soviet Union had reached an advanced state of industrialization and military technology before the economy collapsed. Many other emerging economies have to develop their technologies and industrial capabilities from a much lower technological level. There are advantages and disadvantages to the Russian situation. It is advantageous to have a base of technology, and, more important, trained scientists and engineers. On the other hand, the Soviet legacy of noncompetitive practices, as well as obsolete equipment and facilities, is a liability. Some of the economic reform programs have been intended to overcome these liabilities, but they have had only marginal success. Many defense enterprise managers believe their technology to be superior or equal to any in the world. As a result they assert that the best means of reviving the Russian economy is to maintain and further develop the military R&D base.[1] This belief was probably true in a few areas in the late 1980s, but it is less valid now as a result of the decline in funding for either military or civilian R&D for the past decade. A decade is a very long time in terms of modern-day technological advancement. However, the degree to which that belief is justified is not the most important issue. Whether it is true or not, the corollary assertion of the need to revive the economy through further development

[1] Alexander A. Dyukin and Natalia N. Ivanova, "The Russian Innovation System: Painful Adjustments in the Process of Economic Transformation," in "Russian Science and Industrial Economic Transformation," in *Russian Science and Industrial Policy: Moscow and the Regions, Conference Report, March 24–25, 1997,* Georgetown University, page 48.

of the military R&D base is contrary to market principles. The growth and status of all advanced technologically oriented economies is based predominantly on the advancement of their civilian R&D and industrial bases, which have outstripped their military bases.

Liberalization of prices, large decreases in military research and production, privatization of much of industry, and macroeconomic stabilization were major elements of reform in Russia. These could lead one to conclude that Russia had established the foundations and institutions of a fairly conventional market economy, even though it was not fully operational.[2] These reforms were not always constructive, however. Furthermore, while privatization was certainly needed, the actual privatization programs adopted led effectively to a gift of state assets to parties who often were not interested in building the Russian economy.[3] There is a tendency in Russia to judge privatization, capitalism, markets, etc., as conceptually wrong rather than to judge the formulation and implementation of reforms as faulty.

When Viktor Chernomyrdin succeeded Yegor Gaidar as prime minister, he declared an end to "market romanticism." Many in the West believed that Chernomyrdin's remark was for domestic consumption, but that he really intended to continue with economic reforms. In retrospect, however, it is not at all clear that he didn't mean exactly what he said, because in many ways Russia has not moved much closer to becoming a true market economy. The major reform since then has been macroeconomic stabilization, but this may have been implemented because it was important for the oligarchs, and it was not done in a manner that was sustainable as demonstrated by the economic and financial collapse in August 1998. The reforms that were needed for Russia to become a market economy—hard budget constraints, enforcement of bankruptcy, tax reform, banking reform, monetization of the economy, constructive privatization, and the payment of government obligations—are further from realization today than they were several years ago. The failure to pay government obligations has gotten far worse; it has grown from failure to pay wages, pensions, and procurement bills to the failure to service its sovereign debt. In addition to destroying the economy, as we have recently seen, these all hinder the process of technology commercialization, especially when it is attempted in cooperation with a foreign company. Ironically, profitable bilateral commercialization of Russian technology still appears to be achievable and provides some interesting investment opportunities.

The deficiencies in the economic reforms have been the stimuli for many enterprises to adopt strategies to insulate themselves from the market instead of embracing it. Rather than being motivated by the quest to operate their enterprises profitably as a means to building their own estates and careers, many, although not all, managers have sought to gain personal wealth and power through means that have weakened the financial condition of the very enterprises in which they have large ownership stakes. For them asset stripping, rent seeking, nonpayment of debts, wages, and taxes, and the payment of unwarranted dividends was the adjustment option of choice. There are, by contrast, some managers that have striven to build their enterprises and make them profitable and competitive, but these often tend to be those that are less affected by the debt and barter systems, and they have not always found the state or the economic environment conducive to their approach.

The Russians talk of the need to make dual use of technologies. The U.S. Department of Defense has also emphasized the utilization of dual-use technologies; however, the concept

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[2] Anders Åslund, *How Russia Became a Market Economy* (Washington, DC: The Brookings Institution, 1995).

[3] Michael McFaul, "State Power, Institutional Change, and the Politics of Privatization in Russia," *World Politics* 47, no. 2 (January 1995).

has very different meanings in the two countries. In the United States it primarily means to have military procurement utilize civilian technology (and components) which have been developed to a higher technical state, are being upgraded further, are less expensive, and/or are more reliable. In Russia dual use actually has two meanings. Since the technology base has come almost exclusively from the military sector, it means utilization of military technology in civilian industry, often referred to as "spinoff." This is the classic Soviet spinoff approach, except that now much more of the technology is open and available for civilian utilization. The other meaning is closer to the American concept of integrating the civilian and military technology bases (as the civilian one evolves) for the benefit of the military.[4]

The Ministry of Science has major responsibility for state support of technology commercialization in Russia. This support includes technology development, business incubators, assistance for small innovative enterprises, venture capital, support of State Research Centers, and dissemination of information on innovative technologies. These programs work through the existing research institutes and through new organizations but not through the enterprises engaged dominantly in production.

There have been other state initiatives for improvement of the infrastructure, such as programs to render the legal structure more conducive to innovation and investment. These include development of commercial law, taxation reform, standards, and laws on foreign investment; however, there is also a strong need for laws (and enforcement mechanisms) less directly related to commercialization, such as control over crime and corruption.

Privatization has often been viewed and analyzed as being an issue solely of ownership and governance of individual enterprises. For issues such as technology commercialization, national competitiveness, and general economic development, however, an equally important perspective is the relationship between the state and private sectors in economic development. Since the Soviet state had control over everything, there must clearly be a transition period in which the private sector takes an increasing role. The rate and extent of transition are significant as are the development of the interfaces between the state and the private sector.

This study is not so much concerned with whether various sectors or industries are state or privately owned as it is with how the innovation process involves both state and private actors. In the United States the entire value chain of research, development, product engineering, and production is almost always in the private sector.[5] In Russia the transitional situation leads to a tension. On the one hand, there is a need to strengthen the science and technology base, the facilities of which are still largely state-owned. On the other hand it is necessary to have better integration and coordination of R&D with production, product planning, and marketing. This is not only to facilitate transfer between the two, but to keep the R&D functions more in step with the schedule, budgetary, and performance criteria imposed by the manufacturing, marketing, and finance divisions of a company.[6] The transi-

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[4] Ksenia Gonchar, "Research and Development Conversion in Russia," Bonn International Center for Conversion, May 1997.

[5] There are programs to attempt to commercialize research performed in national laboratories through partnerships with private industry, but this is a minuscule fraction of the innovation picture in the United States.

[6] Dmitry Sergeev, "Reorganization of High-Tech Industries: Federal and Regional Aspects," in C.M. Rob Verkoeyen, Albina I. Nikkonen, and Andrei Fursenko, editors, *Management Training in High-Tech and R&D*. NATO ASI Series, 4. Science and Technology Policy, Vol. 12, 1997.

tion implies the need for an industrial policy and a strategy for utilizing the very limited state budgets for research and innovation.[7]

In summary it is apparent that a broad-base reform program is badly needed in Russia. Some individual efforts at commercialization may succeed in spite of the lack of reform, but the probability of success for any given effort, and the likelihood of U.S. company participation, would be greatly enhanced by reform. To some extent reform at a local or regional level can compensate for the lack of national reform.

B. Adjustment to Demilitarization in the United States and Russia

The conditions surrounding defense conversion and commercialization in the United States are very different from those in Russia. Nonetheless, it is worth comparing them; the American experience provides some valuable positive and negative lessons.[8]

Comparing conversion in the United States with that in the Soviet Union/Russia in the wake of the Cold War is to some extent comparing apples and oranges. The corporate, economic, and political circumstances in the two countries differed greatly in almost every respect, as did the need for conversion and the options available to companies. A more relevant comparison is that of strategies, which may include conversion, to adjust to military procurement reductions, and the results of implementing those strategies. Adjustment strategies can include downsizing by reducing employment; disposing of or deactivating assets; and corporate restructuring through mergers, acquisitions, and divestitures as well as by conversion. In this section the term “conversion” refers to the utilization of assets (human, technological, physical, or financial) previously engaged in military activities for new or expanded civilian activities. The new utilization can be the result of overt actions by companies (active conversion) or the action of others, such as employees relocating voluntarily (passive conversion). Perhaps the first comparison of interest is the general profile of the defense industry (R&D and production) in the two countries.

In the United States defense purchases of goods and services, including R&D, are concentrated in a relatively small number of prime contractors. The top ten defense contractors in 1988 won contracts worth $46.7 billion, which was 34 percent of the $137 billion worth of defense contracts that exceeded $25,000 issued that year; the top one hundred defense contractors took two-thirds of the total.[9] McDonnell Douglas, the largest defense contractor in 1988, alone received $8 billion or 5.8 percent, which accounted for 53 percent of its total revenues. In the past decade the defense procurements have been concentrated in even fewer companies as a result of defense consolidation. Even so, many nondefense firms are much larger; McDonnell Douglas ranked 35th in sales in the Fortune 500 that year.

The concentration of military contracts in a relatively small number of firms does not imply that these firms specialize in defense; quite the contrary. Among the U.S. corporations

[7] Alexander A. Dyukin and Natalia N. Ivanova, “The Russian Innovation System: Painful Adjustments in the Process of Economic Transformation,” in “Russian Science and Industrial Economic Transformation,” in *Russian Science and Industrial Policy: Moscow and the Regions, Conference Report, March 24–25, 1997*, Georgetown University.

[8] See David Bernstein, “Comparison of Conversion in Russia and the United States,” in Vladimir Genin and Arkadiy Yarovskiy, editors, *Anatomy of Russian Defense Conversion*, forthcoming 1999.

[9] John Alic, Lewis Branscomb, Harvey Brooks, Ashton Carter, and Gerald Epstein, *Beyond Spinoff: Military and Commercial Technologies in a Changing World* (Boston: Harvard Business School Press, 1992).

that are consistently among the top one hundred defense contractors, DoD prime contracts average less than one-tenth of their total business. Defense contracts made up more than 75 percent of 1988 total sales in only three of these companies, and more than 50 percent in only another six. Despite being the largest defense contractors, these firms are overwhelmingly civilian-oriented.

Defense technology commercialization often involves components, materials, and subsystems rather than major systems. In the United States this means that subcontractors may have a substantial role in technology commercialization. This may be a more significant opportunity for a subcontractor than for a large system integrator.[10] The full spectrum of such subcontractors, especially small, high-technology companies, did not exist in Russia, as the large enterprises were much more vertically integrated.

Many Russian enterprises that had been engaged in military R&D or production did attempt to convert to civilian output as their primary strategy for dealing with the sharp decline in military procurement. But in many cases this was unsuccessful. It is important to note that even if all Russian enterprises had converted successfully in the sense of producing products with advantageous features and costs, the demand in the Russian economy was far too low to absorb them; the economy had shrunk by a large factor, and it was overindustrialized to begin with.[11] The domestic market also became more competitive as trade restrictions were removed. Foreign producers had only to take their proven products to the Russian market, whereas Russian enterprises had both to convert and make the many adjustments to enter the market.[12] The enterprises that failed to make conversion profitable continued to receive state subsidies, but they also fell into debt to their suppliers, workers, and the tax collectors.

In the Soviet Union, where virtually the entire technology base was military, there were hundreds of very large enterprises. There were about one hundred enterprises with over twenty thousand industrial employees; in Russia there were about 1,700 defense manufacturing and R&D enterprises with an average of about six thousand industrial employees.[13]

In both countries the defense industries predominantly chose adjustment strategies other than conversion. In the United States there are very few cases of large-scale conversion in the defense industry, although there are isolated examples of significant conversion. Ironically, some of the best examples of this are also examples of cooperative technology commercialization ventures between U.S. and Russian defense companies in the space-launch business, and they are therefore cases of successful conversion in both countries. Norman Augustine, former chairman of Lockheed Martin, considers commercial satellite launching as the only significant case of conversion by the large American defense-system contractors.[14]

Most U.S. defense companies have not looked to conversion as the optimal means of adjustment. The strategies of U.S. companies have been dictated by market conditions and a system in which they do not get government subsidies, although in many cases they are

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[10] John Alic et al., *Beyond Spinoff,* p. 168.

[11] Quantitative estimates of this factor are highly uncertain because of the lack of market pricing, especially in the Soviet era, the emergence of an unreported (gray) economy, and the accumulation of interenterprise debt and nonpayment of state obligations.

[12] Petra Opitz and Thomas Sauer, "From Strategic Technology Alliances in Russia (STAiR): First Results," Bonn International Center for Conversion, June 1997.

[13] Clifford Gaddy, *The Price of the Past: Russia's Struggle with the Legacy of a Militarized Economy* (Washington, DC: Brookings Institution Press, 1996), Ch. 2.

[14] Norman Augustine, seminar at Stanford University, May 13, 1998.

reimbursed for certain costs associated with terminating defense contracts. The absence of subsidies requires that they make their adjustments in advance of the decline in revenues lest they face large and continuing losses from having cost reductions lag revenue reductions. As a result most companies in this situation initiated downsizing programs fairly quickly. If they chose to diversify into new products or markets, this required a capital investment, and such decisions were made company by company. Those that did choose to invest in some form of diversification had access to a fully functional system of capital markets.

Another approach dominated the adjustment strategies of U.S. defense companies. Many of the companies, especially the aerospace and electronics defense contractors, engaged in a process of industry consolidation through a series of mergers, acquisitions, and divestitures. Companies making similar military products, such as tactical missiles, that saw their markets shrinking but not disappearing bought or sold divisions so that there would ultimately be fewer competitors, and the remaining ones would have large enough production volumes to be profitable. Here again private ownership and the availability of the capital markets was key to these moves. The U.S. government was supportive of these consolidations, as long as there were still some competitors left, because they could lead to more efficient operations, which would be manifested in lower prices to the government. Through an extensive series of mergers and acquisitions between 1992 and 1996 the aerospace and defense electronics sectors consolidated into four companies—Lockheed Martin, Boeing, Northrop Grumman, and Raytheon. Lockheed Martin had negotiated to acquire Northrop Grumman, which would have reduced the number to three, but the U.S. government opposed this step, and the companies dropped plans for this acquisition. In this process several former defense contractors ceased to exist. These included IBM Federal Systems, LTV Missiles and LTV Vought Aircraft, Ford Aerospace, General Electric Aerospace, Westinghouse Defense and Electronics Systems, General Motors' Hughes Electronics, Texas Instruments Military and Electronics, Chrysler Defense Electronics, McDonnell Douglas, Rockwell Aerospace and Defense, and three divisions of General Dynamics.[15]

Following the great reduction in defense expenditures in Russia there was not a consolidation, as in the United States, but rather an across-the-board revenue shrinkage of varying degrees. To a major degree, the options of downsizing and consolidation are either not available to Russian companies or are extremely difficult to implement because of government ownership or regulations and the lack of capital markets and infrastructure. Such a capitalistic-based approach was foreign to the Russian culture, and there were no hard budget constraints or shareholders demanding profitability.

The strategy chosen by many, but not all, Russian defense enterprises was neither serious conversion nor downsizing and consolidation. In fact it was not even profit-seeking management of the enterprises. Two conditions peculiar to Russia dictated their choice of strategy. The first was the privatization process, which, even with state retention of substantial ownership, resulted in the redistribution of enormous assets and power into the hands of factory managers. The second was the weakness of the state and its failure to impose hard budget constraints, institute a social safety net, and collect taxes.[16]

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[15] Charles Bagli, "Two Giants Join in a Merger Parade in Arms Industry: Lockheed–Northrop Tie," *New York Times*, July 4, 1997, pp. A1, D2.

[16] Michael McFaul, "State Power, Institutional Change, and the Politics of Privatization in Russia."

Under these circumstances the accumulation of wealth could be realized far more easily through stripping the assets of the enterprises, nonpayment of wages, debts, and taxes, and making deals with officials rather than through converting to profit-driven production of civilian goods for a weak economy. Many enterprise managers chose this easier path; others tried conversion and then took this other path because the economy in which they had to function operated under these strange new rules of the game.

This is a logical holdover from Soviet times when industrial managers accumulated considerable power and a degree of wealth (or at least material comforts and perks). There were various means to achieve and hold on to such a station, and various criteria by which performance was evaluated by the state. These criteria did not include measures of profit, productivity, or competitive operation of an industrial enterprise. The means of accumulating wealth, which was technically not allowed, certainly did not include appreciation of the value of personally owned stock or incentive compensation based on increasing stockholders' equity. This was not even conceptually relevant. The value of an enterprise's assets, cost of inputs, and value of output were artificially determined.

The breakup of the Soviet Union led to a quasi market system in the sense that some assets were privatized and the state did not dictate quantities and types of production, the cost of inputs, or the price of outputs; however, there was not a change in the way many managers thought in terms of the ways to advance and accumulate wealth. It is therefore not too surprising that they do not see profitable business operations and the growth of equity as the best means of accumulating wealth.

One could argue that this is simply an example of responding wisely to market forces. It is similar to Willie Sutton's response when asked why he robbed banks: "That's where the money is." This is not, however, a sustainable strategy, because it contributes to the continuing decline of the economy. It remains to be seen if these managers will seek an opportunity to acquire their next increment of wealth through the operation of legitimate profit-seeking businesses, or whether the current cycle is unbreakable.

There are several defense enterprises and new companies in Russia that have sought to operate market-oriented, profit-seeking businesses. It is difficult to do this when selling to a domestic market where customers, including the state, do not always pay for what they "purchase." Some of the more successful enterprises derive most of their revenue from outside of the country, but this is often a difficult market to penetrate.

While the Russian conversion programs have not been very successful, a major transformation in the industrial profile is occurring through passive conversion. The Russian labor force is redistributing itself from the defense industry to the service sector as well as from huge state-owned enterprises to small private companies. This is occurring through market forces rather than through the overt actions of either the government or the large defense enterprises. While it can't be proved, this suggests that this reprofiling could have occurred faster and easier if the state had not initiated any conversion programs at all, but had simply created a better environment for adjustment, such as imposing hard budget constraints earlier and working to develop market institutions.

C. Technology Commercialization Issues

During the Soviet era the domestic needs for most products were met by domestic industry. One might logically assume that most of these products could be significantly improved by utilizing Russian military technology, which was far superior to civilian technology. In the best cases this could result in products that could be internationally competitive. In other cases it could at least result in products that would be domestically competitive, and supply the domestic demand, which should eventually grow to substantial levels.

If these things happened on a substantial scale, one could say that Russian military technology is being successfully commercialized—whether unilaterally or with foreign partners. Unfortunately, the situation is not so simple. There are many other factors besides the quality and price of products that determine whether the technology has been successfully commercialized, remembering that herein the criterion of success is the development of a sustainable Russian business.

Since in this study we are looking at commercialization attempts involving a U.S. company and a Russian enterprise, we assume that such a pair of organizations has identified a Russian technology that has commercial potential. Then we look at the factors that can determine whether this is likely to lead to a sustainable Russian business. The principal factors can be put in seven categories. The categories are neither unique nor orthogonal; they are technology, rights, external forces, roles of partners, structure of the Russian entity, markets, and financing.

Technology

While technology is an essential ingredient for technology commercialization, there is a tendency, especially on the part of the Russians, to overemphasize its importance in the spectrum of factors required for successful commercialization. For our purpose, technology need not be a demonstrated physical or mathematical process. It can be, and often is, skilled technical personnel. In fact that is often the easiest form of technology for an American company to commercialize.

When the technology is the result of previous research, and not simply brain power, its commercial potential hinges on whether it is fairly fundamental science or more applied technology. The former is usually further from a commercial application and requires more investment of both time and money.

It also matters whether it is very high technology or more mundane lower technology. Very high technology may have more potential to lead to a breakthrough, but many of the markets' demands, especially the Russian markets, are for more routine products.

Rights

The rights most often stressed are intellectual property rights (IPR). There is a sharp divide between rights to technology developed under the old Soviet laws and that developed since the laws were changed to be more in conformity with international standards.[17] Much of the older technology falls in the category of know-how as opposed to patents. American companies sometimes denigrate the value of unpatented know-how during negotiations even though it is precisely this know-how that has attracted them to a specific Russian organization. In negotiating rights it matters whether this know-how or background technology is weighed against the financial contribution of the U.S. partner.

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[17] Andrei Baev, "Protection of Intellectual Property Rights in Russia," in David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997), pp. 267–286, and Vladimir Meshcheryakov, "Development of Legal Regulations for Technology Commercialization in Russia," *Technology Commercialization: Russian Challenges, American Lessons* (Washington, DC: National Academy Press, 1998).

In addition to IPR many Russian groups have the rights to utilize certain physical assets, such as buildings and specialized technical facilities. Buildings, especially old ones, are generally not much of a long-term asset, but some technical equipment can be.

External Forces

There are many factors over which the partners have little or no control. The one that has grown to crisis proportions is crime. The value of the output of many technology commercialization projects is not liquid and does not attract criminals. However, the wages of the Russian participants in bilateral ventures often do get the attention of criminals. Only the Russian government can do something about this, and until it does there may not be much hope for the Russian economy. This unrecirculated "tax" will continue to render many Russian businesses noncompetitive.

Many American companies deem the legal structure pertaining to foreign investment to be prohibitive of investing for profit in Russia. It is less so when the investment is for access to technology, but this simply encourages many American partners to structure their business so as to add more value outside of Russia rather than inside. This in turn reduces the chances for the Russian partner to build a sustainable business. Another important externality is the commercial infrastructure. This had been improving in many respects until the financial and economic crisis of August 1998, when the failure of the banking system and the freezing of funds was especially destructive to the investment environment.

Reliable access to inputs at predictable prices is another external factor of importance. Various shocks such as the breakup of the Soviet Union and COMECON, interruptions of energy and transport, price liberalization, and the various economic crises have disrupted supply chains. Many sources of supply were (and some still are) monopolistic.[18] Importing inputs leads to cost increases and delays in dealing with customs regulations.

Finally, the level of state support and/or business is often unpredictable. This is exacerbated by the state's delay or outright failure in paying for products that it orders.

Roles of Participants

One of the most critical determinants of the ability of the Russian partner to build a business is the role that it can take in the cooperative commercialization venture. Many Russian enterprises are not complete business structures in that they have some poorly developed functions, such as marketing, finance, and corporate development. Some enterprises, especially research institutes, where much of the most advanced technology resides, do not produce any final product or service; they were established to do research for enterprises that designed or produced military equipment. The cooperative venture can be an opportunity to gain business experience, train personnel, and broaden the enterprise's operations. Perpetual dependence on the American partner for functions such as marketing inhibits the development of a Russian business proprietorship. If the output of the Russian partner is simply something that is embedded in the American partner's products or processes, this will also inhibit development of a sustainable business.

[18] COMECON, the Council for Mutual Economic Aid (1949–1991), was an economic union of European socialist countries.

Organization

One issue that is subject to control by the Russian partner is the restructuring of its enterprise. If it is sized to concentrate on its primary business areas, and organized and staffed to function as a market-oriented business, it will stand a far better chance of attracting partners and developing a sustainable business. Even some enterprises that are reasonably successful in conversion are becoming a centrally controlled assembly of loosely related new businesses. This often requires a decentralization or spinoff, but many Russian enterprises resist this. Commercialization projects can be planned and implemented as part of a strategic plan for the company instead of as technical projects.

Market

To have a sustainable business, the enterprise must eventually not only have products that it can produce independently but also markets that it can penetrate. These need not be the products and markets that are the immediate objectives of the commercialization venture, but the venture must be viewed as a means to reach that state.

Marketing can be in cooperation with a partner; however, the marketing role of the Russian partner should become vital, especially in the Russian market. The ability to penetrate the Russian market can provide the Russian partner with more strength in the partnership negotiations.

Financing

The American partner will frequently provide the lion's share of the initial financing for the commercialization venture. It is greatly to the benefit of the Russian partner if it can provide nonmonetary contributions of value, and this can include know-how. It can also be advantageous to provide some of the financing even against future earnings or royalties, and to attract third-party sources of financing that will take a balanced view of the contributions of the two participants.

III. Case Studies

Introduction to Case Studies

The principal sources of data in this report are the interviews conducted with U.S. and Russian companies that are engaged in cooperative technology commercialization projects. The final interviews were conducted at various dates in 1998, with the last in November. In some cases there were multiple interviews, some going back as far as 1992. Many of the most recent interviews were conducted in Moscow from September through November 1998 by Drs. Ksenia Gonchar and Petra Opitz. The enterprises/companies they interviewed were Boeing, Rocket Space Corporation Energia (RSC Energia), NPO Energomash, the State Institute of Aviation Systems (GosNIIAS), Karpov Institute of Physical Chemistry (NIFHI), Moscow Center for SPARC Technology (MCST), and the Central Aerohydrodynamic Research Institute (TsAGI).

Most of the organizations have more than one commercialization venture. The case studies may discuss the spectrum of their ventures but often go into greater depth on one or two of them. In those cases we were usually able to interview both partners in the venture; however, the chapter is organized by the organizations, not by specific ventures. Two previous reports have more extensive earlier information about some of the organizations and are referenced frequently.[1]

The ventures chosen to be studied were judged to be illustrative of some of the major factors discussed in Chapter II. It was not feasible to cover all of the interesting sectors of industry or all of the interesting cases within a sector. In this sense the data are not as complete as one might desire. I considered it more important to be able to go into some depth with a few organizations to gain an understanding of the evolution of their thinking and operation. Some of the cases are fairly long and comprehensive; others are much shorter and deal only with a small fraction of an organization's commercialization ventures. These shorter ones are included because they illustrate a key point, show a novel approach, or constitute contrast to other similar cases.

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[1]David Bernstein, editor, *Defense Industry Restructuring in Russia: Case Studies and Analysis* (Stanford, CA: Center for International Security and Arms Control, 1994) and David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997). Both of these reports are available on the Internet at http://www-leland.stanford.edu/ group/CISAC/test/pub/defenseindustry.pdf and http://www-leland.stanford.edu/ group/CISAC/test/pub/cooperative.pdf.

Air Products and Chemicals, Incorporated

Air Products and Chemicals, Inc. (APCI) is a multinational company with sales over $5 billion, 40 percent of which are abroad. It does not make end products but supplies a wide range of chemicals and processing systems for use by its industrial customers. The breadth of APCI's products and processes, as well as the high and rapidly developing technologies used to produce and develop them, requires a major R&D effort, including some fairly fundamental research that may not lead to commercial applications for some time, if ever. Since the required technologies might be invented in many different types of organizations and countries, APCI was concerned that it may not have been keeping up to date on all relevant research and have all of the required skills. In the early 1990s, the company began to look externally for some of its R&D.

This move to access externally developed technology coincided with Russia's opening of many of its research facilities to the outside world. The advanced state of physical, chemical, and metallurgical research in Russia, as well as the differential research costs between the United States and Russia, led APCI to initiate several activities there in the early 1990s. These include some contracts directly with research institutes in Russia to perform fundamental research. APCI concentrated its Russian work in Novosibirsk, which had a large concentration of Academy of Sciences institutes working in fields of interest to APCI as well as a favorable cost structure. APCI issued contracts directly to two institutes after surveying the capabilities of many. The largest project of this type is at the Institute of Thermal Physics, where there are now one hundred scientists working in several of APCI's core technologies. The technical work can be world class, and the costs are less than they would be in the United States. The Russian laboratories were well equipped in certain areas, like laser-based measurement techniques, but very poor in others, like computers. APCI invested over $700,000 on capital equipment in addition to supplying over one hundred 386/486 computers that it was replacing in its U.S. lab.

About 70 percent of APCI's work is designed to gain a better understanding of physical phenomena occurring in specific processes. The other projects are more loosely defined to look for better processes, given the understanding of the physical phenomena involved.

Milestones are established on all of the projects. The institutes report on their work quarterly and are paid quarterly also. The milestones on theoretical work have always been met. In some cases, the mathematical methods used by the Russians have enabled the solution of problems that APCI scientists thought too complex. Some of the experimental work has been delayed, but this has generally been caused by problems with logistics and infrastructure, such as delays in shipment of materials from APCI to the institutes. The work has always met or exceeded the qualitative and quantitative goals. The quarterly technical meetings are generally held at APCI because the Russian research is usually a part of an integrated project. At these meetings the Russians are given access to all relevant technical data, and there have been no problems with security of proprietary information.

APCI is flexible in terms of the contractual arrangements and distribution of rights. It has generally offered its Russian partners two options. In the first, APCI pays all of the research costs and gains full rights to all of the new developments. In this case, the Russians are utilizing their skills to solve APCI's specific problems, without previous inventions in the area. In the second, if the Russian partner has previously developed technology of interest to APCI, the Russians retain the background intellectual property rights. APCI pays for the development of applications and retains the appropriate rights to them.

In early 1998 APCI also proposed two joint projects under the Initiative for Proliferation Prevention (IPP) through the United States Industry Coalition, Inc. (USIC).[1] In this case it has multiple objectives. In addition to utilizing Russian research capabilities and technology, it also hopes to benefit from the research capabilities of some of the U.S. DOE laboratories. The costs are favorable not only because of the cost differential in Russia, but because of the DOE contribution to the project budgets.

A third approach to accessing Russian technology is through the use of a consultant who is actively looking for Russian researchers and projects that may be of interest to APCI; however, this process involves a great deal of screening to find projects that are worth pursuing and has not yet resulted in APCI starting any new projects. This consultant has personnel on the ground in Russia and could also undertake some project management responsibilities if suitable projects are found. Beyond finding possible partners and making initial contact, the use of third parties has not been productive. APCI believes that there is no substitute for having its own technical personnel go directly to the country, develop relationships, and understand how the people live and work there.

APCI has recently entered into contracts to have the Russian researchers develop software models of some of the research that they have done as well as some research done at an APCI subsidiary in Great Britain. In this case the technical communications have been conducted completely through the Internet. APCI believes that software projects could grow considerably and become a successful way of utilizing the Russians' extensive capabilities.

APCI is pleased with the results of the institutes' work. It has found that a key factor in successful cooperation is identifying a good Russian project manager who can find the right researchers and instill in them a commitment to the successful execution of the project.

[1] USIC is a coalition of member companies that is partially supported by the U.S. government. It funds technology commercialization projects that involve a Russian enterprise, a U.S. national laboratory, and often a member U.S. company.

Boeing

Both Boeing's Commercial Airplane Group (BCAG) and the Boeing Information, Space and Defense Group (BISDG) have many projects in Russia.[1] In 1993–1997 Boeing funded over $1 billion worth of contracts with the Russian aerospace industry. Though it is not easy to estimate the labor effect of these programs, there is reason to believe that it is measured in tens of thousands of jobs, not counting the multiplication effect. Many of these are well-paid jobs for technical personnel. The share of Russian programs in Boeing's outsourcing network is still relatively low, however, and does not create any dependency on either side.

Boeing's operating approach to date has been to work by contract with the Russian enterprises. In general Boeing has not taken the approach of hiring individual scientists or engineers directly and has not encouraged any of them to leave their institutes to seek employment with Boeing. Neither has Boeing encouraged any of them to start their own companies. In addition, Boeing has not hired Russian engineers to bring them to the United States. Boeing believes that its approach is the best way to help Russia maintain its core capabilities and to ensure Boeing's access to the best technology and cooperation available without contributing to the brain drain of top Russian scientists and engineers.

At every step of the way Boeing has kept the Russian government informed of its activities and plans in Russia. This, and a clear demonstration of long-term commitment, has resulted in good cooperation from the government as well as the institutes on the research projects.

Fundamental differences in the activities of BCAG and BISDG lead to very different operational practices in their respective cooperative ventures. The cooperative ventures of BCAG are primarily R&D or material-certification activities that are not initially on critical paths for the design or production of Boeing aircraft, although they may achieve that status in the future. In addition, most of these activities are relatively small and do not require complex integration of the work of the two partners. BISDG's cooperative ventures are generally large system-development projects, with critical dependence on the work of both partners. As a result, a systems-integration management approach is used. This has a profound impact on

[1] See "Russia–Boeing: Partners in Progress," a brochure published by Boeing, and David Bernstein, ed., *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

the working relationship between the partners. This situation is complicated further by the fact that some programs are commercial, and others are funded by the U.S. government and therefore have a host of different contractual requirements which Boeing (as prime contractor) must impose on its Russian partners (as subcontractors).

BCAG

Russia is a very large country, with an economy that may experience strong growth in the medium- to long-term future. It is increasingly participating in international commerce, and its civilian airliner fleet, while very large, is old, poorly maintained, and inefficient. In addition the Soviet Union had a very large aircraft industry which had previously supplied 100 percent of domestic civilian aircraft. Therefore the market for civilian aircraft in Russia should be quite large in the long run; however, it may continue to develop very slowly as a result of the weak economy. As of mid-1996, there were thirty Boeing aircraft in commercial service in the former Soviet Union and orders for about nineteen more.

These circumstances dictate that Boeing be substantively engaged with key elements of the aviation industry and R&D establishment well before the market matures. Boeing appears to have recognized that this involvement can be of mutual technological benefit in addition to any marketing benefit that might result. It has clearly recognized that for any collaboration to be successful it must be mutually beneficial, and that the preservation and further development of Russia's R&D base is in the best interest of Boeing and the United States as well as Russia. As in most large U.S. companies, there are different opinions as to how rapidly and deeply Boeing should be involved in Russia at this time. Some of its earliest contacts were with Aeroflot and the Ilyushin Design Bureau in the early 1970s; it started contacting the aircraft manufacturing plants in Voronezh and Samara in 1991.

The aviation programs therefore have both long- and intermediate-term objectives. In the long term Boeing wants to work cooperatively with the Russian aviation sector to supply the large anticipated demand for commercial jetliners in Russia. In the intermediate term it wants to utilize Russian expertise and technology to provide R&D, testing, advanced materials, tooling, and design work. In general it receives good value in these projects in spite of high transaction costs. But reducing cost was not Boeing's primary consideration. If it had been, it would probably not have been worth the effort and inconvenience of doing the work abroad. Stability and longevity of the relations are considered more important.

In addition to projects contributing technical output to the design, production, and testing of Boeing aircraft, Boeing provides a variety of other airline support services to current and potential users of Boeing planes. These include:

- Seminars on airline market concepts, including customer service, convenience, competitiveness, yield management, profitability, and financing.
- Analytical studies for Russian airlines and regulatory agencies on airline performance, market development, financial performance, and fleet development. These studies help airlines determine their aircraft needs. Boeing also provides technical and economic studies for comparisons of various airplane models.
- Operations support to the airlines that have decided to use Boeing aircraft.
- A safety program focused on safety training to all Russian airlines operating Boeing equipment. This included a joint study among Boeing, Ilyushin, and TsAGI on aging airplane

structures (1995 and 1996). In 1997, in conjunction with the Moscow Air Show, Boeing, Ilyushin, and the Russian Aviation Register organized the first Boeing-Russian conference on airplane design for safety.

• Training seminars on certification requirements of the U.S. Federal Aviation Administration, held in Moscow and Voronezh for Russian manufacturing companies. Coordination of certification methods and procedures.

• A feasibility study of new transpolar air routes between the United States and Asia across Russian territory.

BISDG

The space programs are very different in scope, objectives, and cooperative roles from the aviation projects. In aviation the cooperative work contributes in a wide variety of ways to Boeing's line of commercial aircraft and its markets. In space the cooperation consists primarily of large, long-term programs to build major systems. The two major space programs are the International Space Station (ISS) and Sea Launch. The ISS is a multinational effort, funded by governments, to place in space and operate a large manned space station.

International Space Station

Russia contributes to the ISS with the docking system (developed, manufactured, and adjusted for the Mir-Shuttle program by Energia), the functional cargo block (FCB), and the service module. The FCB was launched in November 1998 on a Proton booster (built by Khrunichev) and launched from Baikonur, Kazakhstan. This was the first of more than forty Russian rocket and U.S. space-shuttle missions that will be required to assemble the station in space.

The Service Module will provide the first living quarters and life-support systems. It is being built primarily by Energia.[2] Boeing will integrate the flight-ready hardware with all the other modules of the ISS. These projects have been plagued by a lack of the funding promised by the Russian Space Agency.

An aspect of the negotiation and contractual terms that is difficult for the Russians to understand is the different sets of terms for commercial and U.S. government-sponsored projects. Khrunichev and Energia also have a major joint venture, Lockheed-Khrunichev-Energia International (LKEI), with Lockheed (now Lockheed Martin) to provide commercial space launches marketed by LKEI, using Khrunichev's Proton boosters.[3] U.S. aerospace companies also find doing business with the U.S. government so different from doing commercial business that they generally establish totally distinct companies or divisions for the two types of business. It is therefore not surprising that the Russians find the differences puzzling.

Sea Launch

Sea Launch is the largest commercial Boeing project involving NIS partners. It is a joint venture, incorporated in the Cayman Islands, in which Boeing owns 40 percent; Kværner,

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[2] See the Energia case study.

[3] See David Bernstein, ed., *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

Europe's largest marine operator, 20 percent; NPO Yuzhnoye, the leading Ukrainian aerospace company, 15 percent; and NPO Energia, a leading Russian space company, 25 percent. The objective of the project is to provide sea-based launches of satellites for commercial customers. Sea-based launching can provide different launch locations for different satellite orbits so as to maximize payload and spacecraft life.

As the project moves from the development phase into one of serial production and launching, the partners will continue in their basic roles. In particular, Boeing will not develop the capability to manufacture components being developed and supplied by the other partners. This approach should alleviate any fears the Russians and Ukrainians might have that their role will diminish in the long run; however, the decision is also consistent with Boeing's preference that it not manufacture complex systems that it did not design. This format cements the partners into long-term interdependence; the venture literally cannot survive without its key members, and it would be difficult if not impossible for one partner to replace another. Hence the Russian (and Ukrainian) technology is being commercialized by a Western integrating contractor, but the technology is not being transferred and the NIS partners maintain their business proprietorships.

Yuzhnoye provides the Zenit rocket as the first and second stages of the Sea Launch booster, as well as operations support to Zenit in processing and launch operations. Energia supplies the third-stage Block DM-SL and is responsible for Sea Launch vehicle integration, launch operations, and range services. Boeing produces the payload fairing and interface hardware and is the overall integrator of the project. Kværner builds the 200-meter long Assembly and Command Ship, which is a floating rocket assembly plant and also serves as the mission-control facility, as well as the floating launch platform. The Home Port complex at the Port of Long Beach, California, acts as a primary site for Sea Launch operations. Boeing does not believe that recent failure of the Zenit rocket launch will have a major negative influence on the program. Sea Launch is in general a very difficult program with considerable technological challenges. There are also difficulties caused by export regulations, since technologies involved are very sensitive.[4]

Boeing Technical Research Center

Boeing has more than thirty R&D contracts with Russian aerospace research institutions and companies in Moscow, St. Petersburg, Novosibirsk, Voronezh, and Ekaterinburg, involving approximately three hundred engineers and scientists. It manages most of these contracts out of the Boeing Technical Research Center (BTRC), which was established in Moscow in 1993.[5] Some of the research is also performed at the BTRC, which is equipped with specialized computer workstations.

Several aerospace technologies are covered by R&D cooperation (including aerodynamics, fluid physics, structures, and vibroacoustics). Projects include development of computer programs for studying computational fluid dynamics; validation and expertise in wind tunnels of the new Boeing turbulence and transition models; development of wind-tunnel test devices; development of Russian-invented pressure-sensitive paints; and use of Russian friction test labs for testing all new carbon brake discs. In 1995 TsAGI and Boeing developed a

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[4] *Future Directions for Satellite Technology Export-Control Policy*. Report of a workshop held December 1, 1998, at Stanford University (Stanford, CA: Center for International Security and Cooperation, forthcoming).

[5] See David Bernstein, ed., *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

noise prediction model and database. Full-size pavement testing for six-wheel landing-gear trucks was conducted in Russia as part of certification for the 777. Manufacturing technology research programs were launched with the Institute of Aviation Manufacturing Technologies.

The following are examples of some of the projects conducted through the BTRC:

The Ilyushin Design Bureau and Boeing are working together on redesign of the center bin arches for 777 aircraft. In the early stages of the project, Boeing brought teams of Russian engineers to Seattle to acquaint them with the design problem and some of the engineering methods that would have to be used in order to assure certification. At that stage the flow of technology was mainly from Boeing to Ilyushin. After initial training with Boeing engineers in the United States, Ilyushin engineers have been redesigning the parts in Moscow at the BTRC. As the Ilyushin engineers perform the design, technology flows from Russia and is being commercialized. The technology flow to Russia includes general design methods that can be applied to a wide range of problems. Ilyushin engineers developed a simpler, lower-cost design, eventually allowing the arch beam to be created from a single piece of aluminum.

One issue that has arisen relates to the personnel involved in the work. When the Ilyushin engineers came to Seattle, Boeing ensured that they were paid on a Boeing wage scale. When the training was complete and the job was moved to Moscow, Boeing entered into a fixed-price contract with Ilyushin to perform the design work, and Ilyushin committed to use the same personnel. Boeing committed not to hire these engineers for a period of five years, and the personnel agreed to stay at Ilyushin for five years. At that point Boeing had no control over the salaries to be paid to the engineers involved.

This redesign is something that Boeing has wanted to do in order to realize cost reductions; however, it was not of high enough priority to get initiated within the heavily committed engineering resources available at Boeing. When the costs for training and equipment (at BTRC) are included, the cost of doing the project at Ilyushin may be as much as twice as expensive as doing it in-house; however, the staff was simply not available. If the same Ilyushin design team undertakes subsequent tasks for Boeing, the costs would be comparable to or less than doing the work in-house.

This particular project is, like many of Boeing's research projects in Russia, more a matter of commercializing technical skills at Ilyushin than commercializing specific technologies. The project has met all technical requirements and was conducted strictly within the budget and time schedule. Surprisingly, the project was carried out without any problems, including issues of intellectual property. The Ilyushin engineers were highly skilled with the design of large monolithic structures. In addition, all of the work was carried out at the BTRC, leading to good communication and high efficiency. The success of this project will be utilized in the next project, which was being negotiated around mid-1998.

Boeing acquired McDonnell Douglas in 1996. In 1992 McDonnell Douglas established the Joint Science Center between it and the Russian Academy of Sciences to pursue joint technology development in such areas as structures, materials, and applied sciences for space and lunar vehicles. This venture was based on an agreement to operate the Center jointly and explore twelve areas of cooperation, including:

• Advanced composites with the Moscow Aviation Technology Institute and the Central Research Institute of Machine Building. The materials resulting from this multimillion-dollar effort may be used to significantly reduce the weight of future generations of aircraft and rockets.

- Aluminum-lithium liquid oxygen tanks—a critical part of the McDonnell Douglas DC-X program—used research developed at the Joint Science Center.
- Design, development, and manufacturing of aluminum-lithium products, from the conceptual stage to proof testing of the vehicle. The Russian participants were Kamensk-Uralsky Metallurgy Company, Energia, the Institute of Lightweight Materials, the Institute of Aviation Materials, and the Russian Academy of Sciences.

Boeing has helped to certify Verkhnaya Salda Metallurgical Production Association (VSMPO) as a titanium supplier. In addition to procuring titanium from VSMPO, Boeing has introduced it to other titanium users and aerospace companies. In addition, the companies are working together to develop superior alloys. VSMPO provides about 20 percent of all titanium used in Boeing commercial products, worth up to $200 million.

The procurement of special materials for use in aircraft construction is in some ways a more complicated issue than collaborative R&D. Two of the main issues are standards and certification. The Soviet Union had excellent metallurgical capabilities, sometimes more advanced than those in Western countries; however, it had not adopted international standards. Therefore, before using any Russian materials in production, it is necessary to bring the standards in Russia into conformity with Boeing standards. Boeing's initial materials acquisition efforts were on forgings and billets. In time this may be followed by the acquisition of components fabricated from these metals, but that stage has not yet been reached. The Russian tax structure is conducive to this in that the tax rate decreases with increasing value added in Russia. Boeing and even some of its U.S. suppliers have been assisting the Russians in bringing their standards into conformity; this process can take upwards of six months, considerably longer than would be the case with a new U.S. supplier. In the case of materials acquisition, the economics must make sense in the long run, and it will be necessary for the Russian suppliers to demonstrate a record of supplying materials on time with high reliability and quality control. In the short run, there is clearly an investment involved, but here again a motivation for this effort is the building of a long-term relationship with the Russian industrial complex.

A portion of North American Rockwell, which is now Boeing North American, was contracted by the U.S. Air Force to study the Russian ejection seat system built by NPP Zvezda. Testing showed that this system outperformed comparable U.S. systems. A follow-on effort to adapt the Zvezda seat for use in U.S. aircraft has been undertaken. If selected, ejection seats will be needed for more than three thousand aircraft, putting Zvezda in the forefront of the world market for ejection seats. The project will be completed by late 1999.

As part of NASA's High-Speed aircraft research program, a Boeing-led aerospace team contracted with the Tupolev Design Bureau to conduct supersonic tests with Russia's TU-144LL and to update its flight laboratory. The project is funded by the U.S. government and Boeing and has provided data from full-scale model testing. The initial research was completed in March 1998. The project was successful and has since been continued to include eight additional flight tests. The knowledge obtained in the project may help design and produce the next generation of commercial supersonic aircraft.

Corning, Incorporated

Corning, Inc. is a $4 billion company that long has been an innovator in the development and mass production of optical products such as incandescent lamps, glass television tubes, and optical fibers for telecommunications. In 1997 Corning spent $250 million on R&D and engineering. For decades Corning has worked to fertilize its corporate research activities with international researchers in Corning's fields of interest. In a more formal approach to this initiative, it set up a corporate laboratory in France in 1975 and one in Japan in 1982. Russia was just emerging from the command economic structure in 1992 when Corning first went there to explore the possibilities of doing research, although Corning had had a commercial presence in the Soviet Union for decades. It started by negotiating research contracts with two research institutes in St. Petersburg. The first was the Institute of Silicate Chemistry, which was an institute of about five hundred people under the aegis of the Academy of Sciences. The second was the Vavilov State Optical Institute, which had more than twelve thousand employees and which later reported to the Ministry of Defense Industry. Corning's research activity in Russia grew to utilize about 125 scientists by 1994.

As with most situations of this type, the Russian institutes wanted the contracts and payment to flow through the institutes themselves, rather than to specific programs, and they sometimes attempted to utilize significant portions of the funds to alleviate the poor economic conditions of the entire institute. This became an impossible situation for Corning to manage in a way that would assure that the bulk of the funds would go toward performing the desired scientific work. As a result Corning technical leaders were not willing to place any critical-path research in these institutes. This in turn made the value of the activity in Russia questionable, particularly because it was among the objectives of this cooperative research activity to establish long-term linkages with the scientific community of the former Soviet Union.

In 1995 Corning decided that it would prefer to set up a separate company as a joint venture among Corning and the institutes. It brought the top management of the two groups to Corning's research facilities in the United States to explain how it conducted its research and to plan these joint ventures along similar lines. The Institute of Silicate Chemistry ultimately proved not to be interested in this approach and indicated that it preferred to continue to work with Corning on a contractual basis. The Vavilov Institute was more willing to enter into a joint venture; however, it had essentially nothing to bring to the venture that would, in Corning's view, entitle it to significant equity. It was finally agreed that Corning would own the new company outright, rent and renovate space in the Vavilov Institute (since Vavilov was state-owned, the property could not be transferred readily to Corning), and directly hire the scientists that would work on Corning projects. In addition to addressing the financial issues, intellectual property, and shipment of materials, this enabled Corning to exercise greater management control over the research projects and the selection of technical staff. It continued some contract work with both institutes, as well as with other institutes in Russia, but from this point on Corning focused its efforts for the long term on the new company, and therefore worked very closely with Vavilov.

Corning chose twenty-eight scientists to hire—twenty-four from Vavilov and four from the Institute of Silicate Chemistry—and proceeded to start to register the new company, the Corning Scientific Center in St. Petersburg (CSC), as a commercial company. It chose this as opposed to simply registering as a research company so that it would have the flexibility to do some manufacturing later on if it so chose. The registration was finally completed in December of 1996; there were no particular problems, but the process was very slow (by U.S. standards). The renovation was also very slow, and involved several problems of contractual differences between Corning, the renovating general contractor, and the various subcontractors. In addition to taking more time and money than anticipated, these problems tended to preoccupy the time of Corning's expatriate manager, who was hired primarily to manage the R&D. The research was at first conducted by using other space within the two institutes, and the renovation proceeded in parallel. CSC hired the researchers in mid-1997, allowing them to have joint appointments with CSC and their original institutes while the renovation of CSC's building was continuing so they would have laboratories in which to work. CSC has taken a ten-year lease on the facilities, with a commitment of both parties to renew for a second ten-year period after renegotiating the lease terms in good faith, if and as necessary.

Under the previous contracts the researchers had major input into what research they conducted. Under the new arrangement the research agenda is formulated by the normal Corning Science & Technology Group planning process, which responds to the needs of Corning's operating divisions, and includes the inputs of Corning researchers, including those in St. Petersburg. In addition to adding to the relevance of the research, this assures that there is another Corning researcher or product engineer who is personally interested in every project being performed at CSC. Corning supplies modern equipment for the CSC research, and purchases certain services which are needed infrequently from the institutes or other organizations in Russia.

Corning has also initiated or continued research at other institutes in Russia that have capabilities of specific interest to Corning. These include the General Physics Institute in Moscow and the Joint Institute for Nuclear Research in Dubna. Corning decides on a case-by-case basis how much commercialization of each successful development to do in Russia and how much to do outside of Russia.

Corning places great stock in establishing a strong and trusting relationship with its Russian partners and employees. It is careful to be sure that the objectives and constraints of both sides are clearly understood. It explains the criteria by which it will judge projects, and then tends to terminate those that do not produce useful results and to renew, and possibly expand, those that do. It has had no problem with confidentiality agreements.

Energia, Ltd.

Energia, Ltd. is a major, privatized Russian aerospace company, with a spectrum of domestic and international products. Half of its contracts are provided by the Russian government, and half are commercial, mostly international contracts. Its economic position is relatively stable; the current workforce is over fourteen thousand, and Energia is not only retaining its workers but also hiring a small number of young specialists. It had been planned that in 1998 part of the residual state stock in Energia would be sold to raise investment capital. Although several domestic and foreign institutions showed interest in this deal, it was postponed. In the meantime Energia has engaged in extensive restructuring and diversification.

The dominant share of Energia's revenue is derived from projects relating directly to its previous experience in space missions, finding new markets for its existing technology. It is also utilizing some of its technical capabilities for the design of new products for new non-space-related applications. An example is a newly designed fuel cell which is the basis of a cooperative venture with Manufacturing Technologies Corporation of the United States. This non-space-related aspect of technology commercialization is proceeding much slower and with greater commercial problems than its space activities, where Energia is well established and can participate in larger programs. It does not appear to have received the same degree of top management attention, and it is a much less familiar market than space.

The main risk factor of the enterprise is related to uncertainties of state funding of space projects. Energia will undergo a major shock if the state cancels its participation in the International Space Station (ISS) project.[1] Almost all of the delays in the ISS are linked to underfinancing. Moreover, Energia has already performed many ISS tasks which the government has not yet funded. The state debt to Energia in September 1998 was R500 million. This presents a particularly difficult problem in relations with its subcontractors, who refuse to conduct work without advance payment. If Russia cancels its participation in ISS, Energia will most probably shift to commercial contracts to supply hardware and will probably lose contracts for servicing piloted flights.

Energia's diversification strategy was selected to reduce dependence on state funding. Communication satellites became Energia's principal new field of activity in addition to piloted

[1] See the Boeing case study.

space missions and development and manufacturing of space hardware. Energia is looking for an international partner, such as a telecommunication company, that would be interested in renting the communication channels provided by the new satellites in exchange for funding the development and manufacturing of the satellites. Yamal-100 is the first project in this program; it is a satellite developed and manufactured for Gazprom. In addition, Energia was selected by the Russian government as one of two winners in a tender for development and manufacturing of communication satellites (Yamal-200 and -300) to be placed in geostationary orbits. Energia will produce four satellites for the Reshetnev plant in Krasnoyarsk, and another three for the Ministry of Communication and Russian Space Agency.

Many imported components are used in the design of Yamal satellites, and Energia has gone to a market-oriented system of deciding on the best sources for all components. Energia's U.S. office is very active in this procurement process. This approach has yet to penetrate some other parts of the company, however. Liberalizing procurement is a major step for a Russian enterprise; it not only results in more cost-effective production, but also avoids some of the problems involved with Russian suppliers who are in difficult financial condition, are unreliable, or are monopolistic.

The economic and financial crisis of mid-1998 has had a dual effect on the economic position of Energia. On the one hand, being an exporter, it benefited from the ruble devaluation and economized on payments to subcontractors, which are carried out in domestic currency. Energia did not invest in treasury bonds, did not keep money in problematic banks, and even reduced its debt of payments to workers by a factor of two. However, the long-term effects will be negative, because of the worsened prospects for state funding of ISS and other space programs. Piloted flights are threatened most of all by reduced state funding, since they are less commercialized than hardware projects and are more state dependent.

Energia provides rocket engines for Proton, Soyuz, and Progress boosters to the ISS project. It was also subcontracted by Khrunichev to jointly build the Functional Cargo Block, and is responsible for the design and manufacturing of the Service Module, which should provide the first living quarters and life-support systems. Energia subcontracts to Khrunichev for construction of the module's pressurized body. The first piloted expedition is planned for July 1999.

The Service Module project is struggling with significant financing constraints, since it must be funded by the Russian government, which has failed to fulfill its obligations. The financial and economic crisis of mid-1998 made this problem even more serious. NASA has suggested to the U.S. Congress that the United States support the Russian Space Agency with $660 million to enable it to complete the Russian part of the ISS project. In addition NASA is considering using $100 million of its funds to purchase Russian space technologies, equipment, and apparatus since it is more efficient to support the Russian Space Agency than to have Russia drop out of the project.

Americans are the main partners in international cooperation, though Energia also has contracts with many European institutions. The French space agency and other international organizations, in addition to NASA, have contracted with Energia on the program of piloted flights to Mir, and this has been a profitable business. Daimler-Benz, SPACEHAB, and Energia jointly developed a nonhermetic platform for carrying the payload to the ISS with the space shuttle. Small contracts have also been signed with German, Japanese, and French companies. This is an important source of revenue for Energia.

The androgynous peripheral docking system is an available customized product of Energia, which has been used to dock the space shuttle to Mir and will be used for the International Space Station project as well. This is a straightforward supplier contract.

Energia does not attribute success or failure of international ventures to the specific legal forms of cooperation. In 90 percent of the cases Energia works on a contract basis, and finds contracts clear, simple and manageable. In some cases an equity joint venture is more appropriate, but this form leads to other problems. Because of the financial distress in Russia, the Russian partner usually does not take the leading role in a joint venture. Thus in the Sea Launch joint venture Energia has no power to use sanctions against Boeing, which Energia believes did not fulfill some of its obligations.[2] Specifically, a team of 130 Energia engineers was sent in 1998 to California (the Home Port complex at the Port of Long Beach) to integrate and test equipment. At this point, however, the project faced problems because of delays on the Boeing side, and the team returned to Russia after three days of idleness in California. According to Energia the project's problems were caused by bureaucratic delays imposed by the U.S. State Department, and Boeing should take responsibility for these delays.

International banks are participating in facilitating large-scale international contracts. Thus on the Sea Launch project, for example, the World Bank under the guarantees of the Russian government provides guarantees to the Western commercial banks, which finance the Russian share of investment within the program.

Energia is also a major participant in the Lockheed-Khrunichev-Energia-International (LKEI) joint venture for the production and launching of rockets for commercial satellite projects.[3] Energia holds 17 percent of the equity of the joint venture and produces the rocket's fourth stage. For Energia this is purely a manufacturing business; it is not responsible for integration, marketing, or sales. The profit rate within this project is not high, but this is in general a good long-term business. Moreover, this project has substituted for radically reduced state demand for the components that Energia produced, and this has enabled it to retain staff and expertise.

Energia has also entered into some smaller ventures for the development and supply of technical products, such as fuel cells. While this is not a large program at this time, it represents a diversification that could lead to the development of a new business area. It is a good example of commercialization of Russian technology that can result in a broad range of applications and future business opportunities.

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[2] See the Boeing case study for more information on Sea Launch.

[3] See David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

NPO Energomash[1]

Energomash is a dynamic and relatively well-supported enterprise in the space business. It appears to have reasonably good prospects for growth and expansion. Nevertheless, its business is dependent on state support as well as commercial contracts. It is also dependent on a sophisticated and large network of suppliers, including those from outside the space sector. One of its primary projects is the joint venture RD/AMROSS with Pratt & Whitney. As U.S. aerospace companies sought Russian launch capabilities for the expanding space-based telecommunications market, several such U.S. companies competed for the right to work with Energomash.

The privatization process at Energomash had been initiated, but it was stopped in 1998. Given the critical economic situation in Russia, Energomash regards as questionable the advantages of being a privatized company at this time, since it feels the capital market is practically dead and is of little help in raising investment capital. Furthermore, losing the status of a state entity may create additional problems with respect to export control and government oversight.

The economic and financial crisis of mid-1998 significantly worsened conditions at Energomash. The enterprise has experienced repercussions indirectly; thousands of Russian enterprises are involved in the R&D and manufacturing supply network of Energomash at a subcontracting level, and many of these subcontractors are economically very weak and operating far below capacity. Therefore the price for some inputs is very high since the suppliers cannot achieve economies of scale.

Energomash did not invest in treasury bills and therefore did not have direct losses during the 1998 financial crisis. But the banking crisis has also increased transaction costs and complicated payments considerably. In addition Energomash has to solve many problems linked to the Russian export-control regime and customs regulations. This requires a great deal of time, and its American partner, Pratt & Whitney, is often frustrated with the amount of paperwork and red tape. The change of government in autumn 1998 also created problems, since the joint venture with Pratt & Whitney was supported by a special presidential decree

[1] See the Pratt & Whitney case study for additional information on the cooperation between Pratt & Whitney and Energomash.

and governmental decisions. Establishing links with new officials will require considerable time and effort. Nevertheless Energomash does not expect the new government to block its venture with Pratt & Whitney, even though it involves selling sensitive technologies to the United States.

Large-scale international activity is the principal source of revenue for Energomash. Domestic funding sources (Ministry of Defense and Russian Space Agency) remain "virtual," since those contracts are often not paid out. International activities enable Energomash to utilize one-third of its capacities; the rest remain practically idle. Furthermore, cooperative ventures were the decisive selection criteria for Energomash to remain in the market, while many other technically very competitive space enterprises in Russia are depressed. Consequently Energomash has made international ventures a primary strategic focus and has concentrated a large management effort on addressing the spectrum of issues related to obtaining and implementing such ventures.

International cooperation for the development of new technology and products, in contrast to the sales of existing products, allows Energomash to stay competitive in both the Russian and international markets and opens opportunities for stable and long-term business development. The strong position of Energomash in RD/AMROSS allows it to cooperatively influence its technology commercialization and negotiate deals which go beyond technology transfer into production and marketing. All rights will stay with the joint venture, and technology may be used only for the purposes described in the joint-venture agreement.

RD/AMROSS is Energomash's primary international venture.[2] Under this venture, in September 1998 the development and design stage of the RD-180 rocket engine was completed on schedule and within budget, and serial manufacturing for commercial procurements was started. The main sales will take place after 2000, with Lockheed Martin being the first major customer. The division of rights and intellectual-property protection issues are being discussed with Lockheed Martin.

The problems that emerged in the venture are technical, economic, and political. Technical problems have been solved successfully. Economic problems are caused by uncertainties of long-term economic planning in Russia, high transaction costs, and high costs of subcontractors caused by the generally weak condition of the economy. Additional problems are the result of export controls imposed by the Federal Security Agency: each hardware and software component requires separate, time-consuming paperwork. Energomash is also concerned about the recent attitude of the American government toward export control and space programs, which has become more restrictive than at the initial stage of the joint venture.[3] Nevertheless, Energomash has not as yet (September 1998) been affected by this shift. Political shifts in Russia are also problematic, since the joint venture was approved and controlled by the previous government.

Pratt & Whitney and Energomash have deep respect for each other's technical and managerial skills. Different approaches to design methodology, specifically the varying emphasis on testing versus computer modeling, enrich rather than create barriers in the partnership. Propulsion technology transfer mainly takes place from Energomash to Pratt & Whitney. However, Energomash has also learned a great deal about serial manufacturing technologies

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[2] See the Pratt & Whitney case study for the U.S. perspective on the venture.

[3] *Future Directions for Satellite Technology Export-Control Policy*. Report of a workshop held December 1, 1998, at Stanford University (Stanford, CA: Center for International Security and Cooperation, forthcoming).

from Pratt & Whitney. Quality control is applied only to the technical performance of the finished product and is not used throughout the manufacturing stage.

Energomash also has a secondary role as a supplier in the Sea Launch project. It contributes to this project with the RD-170 engine which will be joined to the Ukrainian Zenit rocket.[4] Sea Launch has been delayed for reasons external to Energomash's role. Energomash has additional foreign projects including one in Japan for the development of a rocket engine using a new fuel type.

[4] See the Boeing and Energia case studies.

FMC

FMC is one of the world's leading producers of chemicals and machinery for industry, agriculture, and the government. This Chicago-based company grossed over $5 billion in annual sales in 1996. FMC sells its products in more than one hundred countries, and sales abroad account for 48 percent of its total annual revenue. It operates more than 115 manufacturing facilities or mines in twenty-four countries, and employs roughly 22,000 people. FMC is a worldwide competitor in five broad markets: performance chemicals (for agricultural products, food ingredients, pharmaceuticals, lithium, and bioproducts), industrial chemicals (alkali chemicals, peroxygen chemicals, and phosphorus chemicals), machinery and equipment (food machinery and energy and transportation equipment), defense systems (international sales, steel products, armament systems, and ground systems), and precious metals (gold). FMC's Corporate Technology Center (CTC) provides technical support to these five market divisions. The CTC itself is broken down into four divisions—Industrial Design and Human Factors; Numerical Simulation Analysis and Design; Materials Engineering; and Electronic Engineering and Computer Science.

Within the FMC corporation, the Materials Engineering division of CTC has been heavily involved in the utilization of technology in Russia since the breakup of the Soviet Union. As of late 1997, this division had funded over forty-six projects in the NIS, the majority of which were concentrated in Russia. These projects have enabled FMC to work with seventeen different institutes and production enterprises. FMC's contractors have been both private and state-owned. In all cases FMC has chosen the people who work on its projects, even down to the technician level. It builds, and values, a good relationship with its Russian colleagues and believes that this is a vital element of its success. It frequently brings the senior people to FMC's labs in the United States to interact with their U.S. counterparts. Of the forty-six projects, only one has been unsuccessful—meaning that the Russian partner was unable to produce that which had been agreed upon. This study reviews two projects—Obukhov[1] and the Karpov Institute.

[1] For a more detailed discussion of the Obukhov case, see David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

FMC's interest in the former Soviet Union dates back to the 1930s, when the corporation first sold food-processing equipment to Russia. In the aftermath of World War II, the Soviets regarded FMC as a key player in the modernization of basic industry. Even during the Cold War years, FMC had access to markets in the Soviet Union because FMC had products that the Soviet Union needed to import, such as agricultural chemicals, food machinery, and petroleum equipment. Throughout the years, FMC has worked on a number of projects within the FSU; many of these projects are related to food production.

In 1990, FMC began cooperative work with the Obukhov enterprise in St. Petersburg. In May of 1995, a contract was signed by the two organizations for the production of semi-finished components for equipment for oil and gas operations. Obukhov's main task was to supply FMC with those unfinished steel parts which are needed for the production of oil field equipment. The contract includes provisions for the manufacturing of drilling equipment as well as for a wide range of steel products for both Russian and export markets. This contract is an attempt on FMC's behalf to modernize Obukhov's steel output so that FMC can later benefit from improved alloyed and stainless steel products. In 1994 alone, FMC bought $4 million worth of product from Obukhov; sales increased in 1995. This work is a straightforward utilization and modernization of Obukhov's production capacity and does not represent a commercialization of its technology.

By contrast, FMC's work with the Karpov Institute of Physical Chemistry (and other research institutes) involves commercialization of Russian technology. In 1993 FMC went to Russia to seek out Russian partners who might be able to help FMC with its specific needs in chemical-processing research and technology. Initially, it had no one specific institute in mind. FMC went to several with a list of problems. The Karpov Institute responded that it could work on several items on the list, and FMC picked a few of these and structured contracts. It became clear that Karpov would be best able to meet several of FMC's needs, so FMC awarded a few test contracts to the institute. In setting up the work with the Karpov Institute, FMC also developed a general contractual procedure. A project usually begins with a cooperative agreement of approximately three pages' length between the two prospective partners. In the cases that FMC chose, the work done at Karpov was usually to enhance product quality, solve a problem in production, or lower the costs for an existing FMC product. From time to time Karpov has also injected technology and ideas that were superior to what FMC was considering.

Since this first effort FMC has worked to develop an extensive knowledge of Russian technology. As a result FMC has been able to utilize various technological developments in Russia, as well as the networks that have developed with the institutes and researchers themselves. In the past, it has always been FMC which has sought out partnerships with Russian research centers for technology-related needs. As needs arise, the various product/market divisions of FMC have asked CTC to seek out Russian partnerships. With the assistance of legal counsel, CTC develops the cooperative agreement and then simplifies the document for technologists. Initial conversations regarding projects begin technologist to technologist, and basic protocols are then agreed upon. Rarely, if ever, would the CTC (or any branch of FMC) try to find an application for a technology proposed to it by a Russian organization. Some of the Russian work has consisted more of laboratory testing and analysis than research because FMC has a fair amount of this work that it is too busy to do in its own laboratories in the United States. The Russian labs are also quite cost effective compared with contractors in the United States. This coupled with their expertise and professionalism makes it very attractive for FMC to work with them.

FMC's projects with the Karpov Institute, and with other institutes, have been formed on a contractual basis. FMC holds no equity in the institutes. A project is typically carried out in stages. The process usually begins with a short report regarding the prospects and status of research for a particular field. Subsequent phases are larger and involve new R&D. Contracts for these phases are formed at the technical rather than managerial level. Typically, contracts are created between CTC and individual researchers at an institute. Thus far, FMC and Karpov have completed nine smaller-sized projects.

In general, projects usually begin one month after the onset of negotiations. Cooperative agreements typically last for five years. FMC generally pays all of the costs and retains all of the rights for twelve years. FMC does not get rights to background technology. Although FMC retains the rights to technology that it funds, it would be willing to work out licensing arrangements with the institutes if they wished to pursue commercial applications that were peripheral to FMC's interests. FMC has not sought U.S. government funding.

FMC sought out Russian technology in general and the venture with the Karpov Institute in particular in 1993 for a number of reasons:

Timing. FMC was ready to utilize Russian technical resources at a time when such resources were readily available.

Cost advantage. Using Russian technical resources was cost-effective for FMC.

Superior technology. FMC knew that Russian technology in some fields had the advantage over that in the United States due to heavily supported government labs which were working on similar technical issues.

As of June 1997, the largest contract between FMC and Karpov was for $60K. Due to the small scale of FMC's projects with Karpov, FMC often encourages the Russian researcher/technologist to form a small private company, rather than establish a contract between FMC and the Karpov Institute at large. The institute is, however, compensated for the use of facilities. Karpov has been one of the best groups to work with, and these projects have been successful. It is not just technical competence that has led to this success but also a responsiveness to FMC's specific desires, a thorough system of documenting its work, and a good job of reporting.

FMC has had some projects with other institutes that were less than completely successful. This was not because of lack of technical expertise; it was more a result of inadequate laboratory techniques and documentation and inattention to FMC's directions. The projects achieved some interesting technical results, but the documentation raised concern about the ability to reproduce and validate them. Another project was not completed because the parent institute was failing. This led to internal tensions that compromised its ability to perform well. FMC has since had success working with a key scientist from this institute as a consultant.

In the venture with the Karpov Institute, FMC's main role is to commercialize the Russian technology so that it can be used cost effectively on a large scale by FMC's product divisions. Karpov's role is to oversee and conduct research and analysis in the field of chemical processing and related technology on problems specified by FMC. Researchers at the Karpov Institute typically do not take projects to the point of commercialization; rather, commercialization is handled by either FMC or a third-party production enterprise. After commercialization, the fabrication of chemical processing technology then takes place. Fabrication usually does not take place at the Karpov Institute, but back in the United States. On the occasion that fabrication or partial fabrication takes place in Russia, which is a rarity, the cost advantage can be as much as a factor of 10–20.

In order to successfully carry out fabrication, FMC's chemical labs (several of which are located in Princeton, New Jersey) work directly with technologists in Russia via meetings, e-mail, and other forms of correspondence. Through such contact, FMC incorporates the results of Karpov's ideas and research into its technology.

Throughout the past five years, the main problems have come from customs officials and regulations, exorbitant duties, delays, red tape, and U.S. government regulations. When bringing in or taking out materials that are chemical-related, complications with custom officials are inevitable. Certain forms are required before these materials can legally be brought in or taken out of Russia. This results in lengthy holds and delays which often last for several months.

As of mid-1997 the FMC/Karpov team had completed nine projects. FMC currently uses the Net Present Value system (NPV) to assess each project and its success. Overall, according to the NPV method there have been many benefits associated with the contracts:

- Working with Russian technologists allows FMC to view technical issues through different eyes;
- FMC's projects with the Karpov Institute have served to support FMC's other commercial ventures in the FSU; and
- Working with Karpov has freed FMC's technologists and given them time to look at other issues.

FMC credits the success that it has enjoyed in working with the Karpov Institute to a good working relationship with individuals at Karpov. Management at FMC believes that the success or failure of a venture depends more on a trusting relationship than on contractual safeguards.

General Electric

General Electric (GE) has a wide scope of activities in Russia, ranging from sales of standard products to joint development and production of major equipment like aircraft engines to research and development projects. GE established an office in Moscow and its annual sales volume in Russia exceeded $500 million in 1995. These sales cover a wide range of products including a line of lighting fixtures, gas turbines for pipeline compressors, aircraft engines, medical diagnostic and therapeutic equipment, sealing compounds, and household appliances. GE also acquires raw materials and selected components in Russia.[1]

Its objectives include longer-term market penetration as well as acquisition of technology. This case study is by no means meant to describe in any depth the range of GE's Russian activities and strategies. It is included to illustrate briefly how one major diversified U.S. company approaches some of the R&D and technology commercialization opportunities in Russia. In addition GE has recognized the high level of technical skills and research accomplishments in Russia and has looked to this as a source of innovation. Most of the R&D work is routed through the Corporate Research and Development (CRD) Office. Various operating organizations within GE make their R&D requirements known to this office, which then looks for suitable technology outside of the company, including in Russia. Much of the work in Russia deals with materials, such as polymers and advanced metals.

After receiving proposals on a given subject, CRD determines which appear to be worth pursuing. It then has a representative of one of its offices in Russia visit the facility, usually a research institute, to evaluate its capabilities and the amount of investment that might be needed for things like refurbishing equipment. Often the Russian researchers will believe that their techniques and capabilities are greater than they really are relative to Western research establishments because of a lack of knowledge of the state of the art outside of Russia.

If the visit results in a positive assessment, GE will issue a contract, which may typically be for a few tens of thousands of dollars. The technical results are brought back to GE for integration into a GE project, product, or process. GE would be interested in having more of the value added in Russia, but one of the major problems is dealing with the customs authori-

[1] RUSSICA Information, Inc., RusData Dialine - Biz Econ News, September 26, 1996.

ties, who insist upon adding the full value of R&D to any exported item. The U.S. customs officials then insist on using this valuation when the item is brought into the United States.

GE is also a member of the Boeing-led team that is doing research on supersonic flight in conjunction with the Tupolev Design Bureau on the TU-144 supersonic transport. GE is researching engine inlet conditions to see if any redesign can result in weight reductions.

In addition to product sales and R&D, GE has pursued a number of major production ventures that would result in manufacturing and marketing within Russia. One of the most significant is a joint venture (Rybinsk-GE Aviation Motors) with Rybinsk Motors, a major producer of aircraft engines in Russia.[2] Both partners will provide staff and will manufacture engine parts and provide test engines. These engines will not only be used to power airplanes and helicopters, but also to drive compressors on natural gas pipelines. GE has been the leading supplier of gas turbines for this application for over twenty years, supplying almost half of those used.[3] GE has also brought Rybinsk Motors personnel to the United States for training. This combination of training, manufacturing, after-sale customer service, and marketing should give Rybinsk the opportunity to build a strong business proprietorship encompassing much of the value chain in these product lines.

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[2] *Aerospace Propulsion*, June 1996.

[3] RUSSICA Information, Inc., RusData Dialine - Biz Econ News, September 26, 1996.

The State Scientific Research Institute of Aviation Systems (GosNIIAS)

The State Scientific Research Institute of Aviation Systems (GosNIIAS) was formerly engaged in the design and integration of avionics systems for military and civilian aircraft as well as aviation-related software. It was one of the earliest enterprises to undertake commercialization of technology in cooperation with U.S. companies. In particular it worked with the Collins Commercial Avionics division of Rockwell International on the development of the avionics for the Ilyushin 96 (IL-96M/T) and the Tupolev-204 (TU-204).[1] GosNIIAS and Collins established a software laboratory at GosNIIAS to develop software for integrating Western avionics into these two new aircraft.

Rockwell, Hughes, and GosNIIAS successfully bid in 1994 for one of the Department of Defense "Fast Four" conversion projects and received a $4.1 million cost-sharing contract to develop hardware and software for an air-traffic management (ATM) system that would utilize both GPS and GLONASS data. Technology for this project came from both sides. The commercial experience was primarily from the West.

The team worked quite well together. They were the only project of the Fast Four in which the team had experience working together prior to the DoD procurement, and this proved to be a key factor in their success, which was in many respects much greater than the others.[2] The project did not, however, result in rapid commercial success. It was undertaken to prepare to bid on an ATM system for the Russian Far East, but that tender was postponed. In addition neither the IL-96 nor the TU-204 have been very successful commercial products in terms of the volume of sales.

As of November 1998, GosNIIAS viewed the projects with Rockwell as successful, but completed. One reason is that the American side was not particularly interested in the inte-

[1] See the Rockwell case study in David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

[2] See the NPO Mashinostroenia case study in this volume and also David Bernstein and Nicholas Carlson, *A Report and Analysis of the "Fast Four" Defense Conversion Projects,* U.S. Department of Defense, January 1997.

gration of GPS and GLONASS that was undertaken for the project when it was preparing for the ATM market in Russia.

The project between Rockwell and GosNIIAS included development of Russian versions of GPS, TCAS (Traffic Collision Avoidance System) components, communication management systems, an air traffic controller station, and a radar data processor. However, GosNIIAS was mostly interested in integration of GPS and GLONASS to achieve better accuracy and integrity of signals received from both satellite systems, and in principle was not interested in having only a GPS receiver. It believes that Rockwell redesigned the project and canceled its second phase for political, economic, and military reasons. This phase was in fact of most interest to GosNIIAS.

The French company Sextant Avionique became interested in the development of the integrated GPS/GLONASS receiver for aviation applications. In 1998 the French government provided a $15 million loan, guaranteed by the Russian government. In the preliminary agreement the manufacturing will be located in Russia.

GosNIIAS keeps applying to different American organizations (e.g., Orbital Sciences Corporation and FAA Technical Center) to design cooperative projects in the area of satellite navigation with the use of GPS/GLONASS. Lockheed Martin is viewed as a possible key partner, though GosNIIAS is concerned about entering into strategic relations with international companies and becoming too dependent upon them.

GosNIIAS considers its economic situation difficult but stable. Its position in the Russian market was significantly strengthened when the institute was selected by the government as a principal contractor for building the national ATM system, both the on-board avionics and the land stations. The cooperation with Rockwell helped GosNIIAS to win the leading position in the Russian ATM market, which is a new market for it since it previously specialized in avionics. In addition GosNIIAS won the government tender for development of a data transmission system that converts voice into computer information.

The main problems in late 1998 were the result of the federal budget crisis, which made the future of federal programs unclear, and the banking crisis (financial transactions became more difficult and risky). GosNIIAS did not invest in treasury bills, and financial managers of the enterprise followed the situation of the banking sector and avoided losses. Employment has stayed stable at a level of 2,500 people, compared with about 8,000 in 1992.

GosNIIAS does not expect new constraints on cooperative commercialization ventures as a result of the change in government. Export-control problems should not be too difficult, because all export contracts are facilitated by Rosvooruzheniye, the state body responsible for arms exports, and any disputes are to be resolved by this body.

As of late 1998, approximately one-third of the institute's revenue came from various international contracts. India and China are its leading contracting partners, followed by France and the United States. Another third comes from domestic contracts (the Ministry of Foreign Affairs, for international passport control; the Moscow city government, for control over sales of hard liquor and other products), and the last third are state contracts.

GosNIIAS recognized several tensions linked to cooperative ventures:

- There are difficulties coordinating the different conceptual approaches of the partners.
- The political, economic, and commercial environment in which cooperative projects operate tends to be the dominant factor at times.
- Markets relying on state budgets are poorly funded.

• Tax and duty regulations are not conducive to foreign investment.

The previous commercialization ventures, although not resulting in large revenues, provided an important stimulus for GosNIIAS to enter new markets, where it gained experience in doing business in a competitive market environment, as well as in searching for partners and funding sources. In the long run it has become clear that the indirect benefits of its business ventures, especially the introduction of GosNIIAS to the U.S. business community, facilitation of contacts, and learning how to remove barriers to international business ventures, were extremely useful in planning future activities.

GosNIIAS expects that its recently obtained role of national coordinator of the ATM system will place it in a strong position with respect to other cooperative commercialization ventures; for example, the current tender for the Moscow Center ATM system. Four companies, including Lockheed Martin, are bidding. If Lockheed Martin wins, it is highly probable that GosNIIAS will negotiate a major cooperative venture with Lockheed Martin, with GosNIIAS having the role of system integrator and local contractor. Lockheed Martin is particularly strong in the area of land-based equipment for this project.

The tender for the modernization of the ATM system in the Russian Far East was still in the process of preparation at the time of this writing (November 1998). Negotiations were being conducted between the European Bank for Reconstruction and Development and the Russian Finance Ministry, concerning a loan, to be guaranteed by the Russian government, to finance the project. The technical requirements of the system have been developed. The tender is expected to take place in early 1999. Several international companies, including Lockheed Martin and Raytheon, have expressed interest in participating.

TCAS is viewed as a very realistic project, since it is less dependent on external circumstances and governmental decisions than the ATM projects. The project qualified GosNIIAS to manufacture components of the TCAS system at its pilot production shop. Value added by GosNIIAS should account for about 10 percent.

GosNIIAS has some experience of manufacturing small volumes of electronic components, but it has never produced avionics. TCAS is principally a new product, which requires additional learning, especially in manufacturing technologies. This knowledge is viewed as the most important benefit from the cooperative project. Furthermore, consulting and a technological audit by Collins helped GosNIIAS to partially introduce the ISO 9000 quality control system (though the formal certification procedure was not carried out and not required by the American partner). This contract could be a demonstration that may be followed later by larger contracts with significant financial return. Collins transferred technical documentation in late 1997 and contracted with GosNIIAS to manufacture seventy-two samples within a year. The product was to come to Moscow 90 percent prefabricated, and GosNIIAS was to finish assembling and return the products to the United States for sale in third countries.

The main barrier to the project has been obtaining a release from customs taxes for the tooling, which has resulted in a delay. GosNIIAS finally received the license for the "manufacturing regime under customs control" from the Russian government, which means that VAT and custom duties should not be paid when the product crosses the border. GosNIIAS expects that after two weeks of training the pilot samples will be assembled, and a further six units per month will be manufactured.

Karpov Institute of Physical Chemistry

The Karpov Institute of Physical Chemistry (NIFHI) has the status of a State Research Center, granted to about sixty elite Russian institutes. In principle these centers have advantages in access to funds and government programs. In reality, however, many privileges exist on paper only and are poorly funded.

The institute's current work is more development than research. NIFHI's main facility is in Moscow, and it has a second branch in Obninsk, which was established especially for technology developments on the basis of inventions conducted at the parent institute. Currently this branch subdivision is mainly involved in manufacturing radio pharmaceuticals for treating cancer, and it manages to support the maintenance and operation of its nuclear reactor. It is not clear, however, whether the radiopharmaceutical business alone supports the reactor.

The institute has sought foreign projects as a means to augment its funding base, but foreign contracts account for only about 10 percent of the total budget, or $200,000–300,000. At the Obninsk branch they account for approximately 20 percent, if contracts with other CIS countries are included. The number and value of these contracts is increasing slightly. Some foreign companies contract directly with the individual researchers; while this decreases the role of foreign cooperation as a strategic element of an economic plan, it does provide a way to support and retain some key personnel, which at least helps reduce voluntary resignations. Particularly disturbing to the institute is the fact that neither the federal budget nor foreign contracts provide funds for maintaining the institute's scientific infrastructure and technical facilities, let alone investment in modernization. As a result, foreign cooperation does not provide significant assistance with the institute's attempts at technology commercialization or business development.

The institute has not been proactive in seeking foreign cooperation or in the training of its staff in business techniques. Instead it waits for foreigners to seek it out. Among planned cooperative projects is the development of safety systems for storing radioactive materials including plutonium from deactivated nuclear weapons. NIFHI expects to be involved in such projects together with U.S. firms. FMC was one of its first foreign partners. FMC's role is diminishing as other companies from the United States, Germany, Denmark, Japan, and China have started interacting with NIFHI. Some projects have also been obtained from the

International Science and Technology Center (ISTC), the Civilian Research and Development Foundation (CRDF), NATO, and the Soros Foundation.

In the view of NIFHI's management, the main incentive for the Western partners seems to be cost saving, whereas the main incentive of the institute is to get cash to keep the institute running, get scientific tools and chemicals needed for research, employ its core scientific personnel, and gain access to the international research community. Technology commercialization has been a goal for ten years, but it has not yet been achieved to any significant degree. Some of the institute's cooperative partners have commercialized elements of the institute's technology; however, the institute has not developed a business proprietorship out of this commercialization, participated in much of the commercialization process, or benefited beyond the funding of the research projects. Most of the existing cooperation does not provide incentives for innovation because contracts focus mainly on existing technologies. Some good results in research projects have been achieved through the sponsorship of the Soros Foundation, but commercialization of these results has not been realized.

The conditions of most contracts concerning intellectual-property protection are characterized by the institute as restrictive. The Russian partners of the contracts do not have rights to participate in commercialization of the research contracts' results. In some cases rights remain with the Russian partner for commercialization on the Russian market only. For example, one of the large contracts with FMC does not allow NIFHI to use results of R&D performed under the contract for twelve years.

Another complication is that the joint projects currently carried out by NIFHI do not take into account protection of intellectual-property rights for the basic developments conducted by the institute in previous years. Formerly awarded "author's certificates" are considered as regular publications rather than a protection instrument. In general NIFHI did not negotiate consideration for background technology know-how in its contracts with Western companies. There has been a case of joint patenting with a Canadian company of innovations resulting from a five-year project to develop new materials for electrodes working in hostile environments. But joint commercialization failed because the Canadian partner told NIFHI that the potential customer lost interest in the project. NIFHI management was skeptical but not able to verify this information. There is a lack of resources for international patenting, and although there is an agreement between Rospatent (the Russian patenting agency) and the Russian Academy of Sciences to financially support international patenting, it has not been of much help to NIFHI.

The institute has many problems in attempting technology commercialization, especially with Western partners. When Western companies make fact-finding visits, any statements of interest are often interpreted as promises, and it expects concrete results in the form of contracts, which are often not forthcoming. The contracts that are available are of very small value. As a result, there is no serious business developed on the basis of cooperation. Moreover, the institute has practically no negotiating power and is little able to influence the way cooperation is shaped and funded. Thus the main problem in cooperative ventures is NIFHI's lack of power to maximize returns and design the projects more advantageously. Being financially distressed, the institute cannot refuse the available projects, even if it considers them unfair. Moreover, other Russian academic institutes are competing with NIFHI for the same market niche and will often work for even less money.

Another problem is that NIFHI cannot afford to hire professional legal and marketing experts who could help to design better contracts and look for new large-scale projects. Lawyers and marketing experts are expensive and would not work at the level of payment

NIFHI is able to offer. It has also not made a major effort to train its personnel in market-oriented business practices. It realizes that its own efforts in fund raising and searching for profitable contracts, especially in technology commercialization, are not adequate. Thus it simply meets with people from the West who make contact with it. Furthermore, NIFHI does not publicize its services and is not well informed about available networks and methods to offer its skills on the international market, even though this need not be expensive.

NIFHI finds it equally infeasible to act on foreign advisors' evaluations of the institute's operation in commercialization activities. The first recommendation was to hire highly qualified marketing personnel for which the institute does not have the money. It has, however, had a good experience with CRDF, which worked several times as an intermediary to search for foreign partners for NIFHI for commercialization of research results.

The second recommendation was to look for stable cooperation with a Russian chemical production company in order to supplement the value chain of the institute. The director also considered this task to be unrealistic because the chemical industry is depressed and does not produce demand for innovations. Contracts from Western partners cannot compensate for low domestic demand. Organization of marketing and commercialization activities seems to be a dilemma for the institute. It has limited Internet access, and information about other marketing institutions in Russia does not exist. But at the present there is no serious effort to solve these problems.

Low pricing of contracts is another problem. Though the general economic conditions have worsened significantly and hard currency purchasing power decreased, NIFHI is not able to convince the contracting partners to increase the wages of those involved in research and other contracts.[1]

Even when it has commercial products, such as radiopharmaceuticals, the European and other Western markets are closed to products of Russian origin because of the lack of certification of these products for human treatment. NIFHI has only been able to market these products on the CIS and Chinese markets. Finally, NIFHI has difficulty dealing with the Russian customs officials, such as convincing them to distinguish between research products and manufactured ones.

There has been no serious attempt to restructure the institute to be better suited to engaging in projects with Western partners. Several startup companies have been created by the employees; these are more or less tolerated by the institute and are seen only as measures to keep people productively employed, even though the institute may get nothing from them. One such startup became totally separated from the institute and another is working in fields far from the institute's areas of activity, yet the third does help one of the institute's laboratories to survive.

It appears that the mid-1998 Russian financial crisis will affect NIFHI only through worsened government payment, which those in the Russian research community do not regard as a new event.

[1] This information came from an interview very shortly after the ruble devaluation of August 1998.

Moscow Center for SPARC Technology[1]

The Moscow Center for SPARC Technology (MCST) is a private Russian company that was formed in March 1992 by Boris Babaian, a leading figure in computer research and development in Russia. Babaian was concerned that the computer industry in Russia had been virtually destroyed by Western competition.[2] The company was founded for the purpose of entering into commercial contracts with Sun Microsystems, which has contracted with MCST for both hardware and software development work. For a few years Sun was virtually MCST's sole customer, but now it has projects with other companies in addition to those with Sun.

As of September 1998, MCST had four hundred employees, forty-five located in St. Petersburg, eighty in Novosibirsk, and the rest in Moscow. Some engineers are rotating between Moscow and the California headquarters of Sun. The company is also permanently involved in education and training of students of the Physical Technical Institute, which is a good basis for recruiting new employees.

The Institute of Precision Mechanics and Computer Engineering (IPMCE), the original parent institute of MCST, owns 36 percent of MCST, and the rest belongs to the employees. Relations with IPMCE have always been a problem for MCST. On the one hand, the director of IPMCE is rather hostile to MCST, which moved from the institute's premises to provide more open access for customers and better work conditions. On the other hand, MCST is

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[1] For the earlier history of MCST and its relationship with Sun, see David Bernstein, editor, *Defense Industry Restructuring in Russia: Case Studies and Analysis* (Stanford, CA: Center for International Security and Arms Control, 1994) and David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

[2] In 1992, Babaian attributed the technical deficiencies of the Russian computer industry to the fact that too many decisions about technology development were made at high bureaucratic levels rather than by technical experts. Computer production in Russia had virtually stopped, since Russian computers could not compete in performance, software, reliability, or price with Western computers. As a result, some of the best computer scientists were trying to find jobs elsewhere. Software development for Russian-built computers is hampered by the small installed base of Russian hardware. There is not much of a market for applications software except for Western platforms.

interested in certain advantages provided by the institute, such as a license for public contracts, advertising, image, and the availability of part-time employment of personnel permanently employed at IPMCE. Complete separation from the institute would be a problem, especially in terms of splitting the ownership rights to workstations obtained as part of contract awards.

MCST focuses its business in three basic fields: contract work for Western companies, state orders, and hardware development for a high-performance microprocessor.

Unfortunately, commercial clients in Russia have not presented significant demand for innovative software products, and the company's domestic business remains in an embryonic state. There is reason to believe that the mid-1998 financial crisis, which affected small and medium sized enterprises (SME), has created additional barriers for this market to emerge, since most potential domestic clients of MCST are SMEs. However, MCST actively searches for new market niches and clients in order to develop and diversify its business. Thus it is negotiating with banks (banking software technologies and communications), oil companies (a new generation of computer instruments to support oil exploration), and regional administrations for telecommunication projects.

MCST receives 60 percent of its revenue from Western contracts. In reality, however, this share is significantly higher, because the government orders are poorly financed and often remain on paper only. MCST is particularly upset by the need to reduce activities on the hardware project, which it estimates as the most valuable and competitive of all the company's projects.

Contract work for Western (mainly U.S.) companies is carried out in the field of software engineering of different applications, among them software engineering for telecommunication and multimedia and development of compilers and operational systems. MCST's main Western partners are Sun Microsystems, Compass (which was bought by Avant!), and Harris. In addition to developing software products for Sun, MCST helps Sun promote its products in the Russian market by introducing SPARC technology, which results in demand for Sun's workstations. There are also contracts with smaller Western firms like Transnet and Energy Line, and MCST is looking for more contract work. In earlier years MCST avoided working with any Western companies except Sun because it didn't want even a potential conflict to be perceived by Sun. It is still the conscious approach of MCST not to work with competing Western firms but to diversify into different fields of cooperation.

Cash income to finance further development of the company and extended access to Western markets is MCST's incentive to cooperate with Western partners. In addition to market access the foreign partners contribute equipment to the cooperation, mainly computers. In the case of hardware development, MCST needs a source of substantial investment capital.

MCST has concluded agreements of cooperation with all of its major partners such that every concrete project or task constitutes a separate engineering contract. Equity cross sharing (minority interests) is not attractive in general either to MCST or its Western partners. In particular, MCST does not think Sun would be interested in MCST obtaining Sun shares. MCST would not like to be acquired by a Western investor but would be interested in building up equity joint ventures. In the case of the hardware (microprocessor) project, MCST would be willing to sell control to a Western investor in order to push the project forward, since this is a capital-intensive project that requires major market familiarity and access. MCST has no knowledge or experience of applying for international research grants through organizations like the International Science and Technology Center or the Civilian Research and Development Foundation.

There are some major problems in intellectual property protection, because all property rights of the patents are with the U.S. firms that place the orders with MCST. Even though MCST is not happy with this, it does not look for other partners, such as competitors to Sun, for example, because it values the trust and reliability that has developed in that partnership. In the case of hardware development MCST bought back the patents formerly assigned to Sun and now it sells licenses to Sun. For the microprocessor development MCST holds all the patents. MCST has learned that it needs to distinguish between its intellectual property developed prior to the relationship with Sun and intellectual property that it creates under contract with Sun. The two companies have executed an amicable agreement to cover any past intellectual property about which there could be a question of ownership. Going forward, MCST will claim any prior intellectual property before it could be contaminated by a contract with Sun.

MCST believes that physical security of intellectual property at MSCT is much higher than in the United States. This is because MSCT has a very stable staff, motivated to stay with the company because of the unique opportunities to have interesting and relatively well-paid jobs. The software engineers at Avant!, for example, are much more mobile and this makes the job of keeping secrets much more difficult than at MCST.

Sun’s early software projects with MCST were low risk. This is understandable, as there was a lot for Sun to learn about doing remote software projects in Russia. With experience, confidence has been gained, but this “learning process” is repeated over and over again as each new group within Sun develops its own relationship with and level of trust in MCST. As of 1999, all of the maintenance and development for some software products is done in Russia. Examples include TeamWare, FORTRAN 77, Pascal, and Solaris I maintenance. This business is stable and provides a significant source of revenue, albeit not enough to allow MCST to support new development studies. It should also be noted that MCST is actively engaged in the development of new products, not just in the maintenance of mature products.

The relationship between Sun and MCST is structured around a contract with statements of work, deliverables, and remuneration. There is much more to the relationship than money paid for work done, however. MCST gains resources to refurbish office space, provide medical benefits, and purchase literature and equipment in addition to older equipment that Sun provides. Perhaps most significant, the MCST staff is able to become familiar with many nontechnical aspects of doing business in competitive Western markets. In return Sun gets high quality, innovative, responsibly managed work at very reasonable costs.

Understanding and appreciating all of these contributions and keeping them in perspective requires regular face-to-face contact. Normally, site visits are made to MCST on an annual basis. Because of recent cost controls imposed at Sun, the last scheduled site visit and team-building activities have not taken place. As a consequence, the relationship has been put under unusual strain. This has demonstrated the importance of activities that might be perceived to be discretionary.

Going forward, MCST will be capable of being more and more independent and self-sufficient. One way this can happen is by MCST taking over total responsibility for products that Sun no longer chooses to directly support. In the future, there is nothing to stop MCST from designing, developing, and marketing its own software products. Whether this is possible for hardware depends on two factors:

- U.S. export-control relaxation if chip fabrication is done in the United States;

• A U.S. company to provide development capital and a channel to the marketplace.

Avant! (the successor of the Compass company) is another long-term cooperative partner of MCST. Avant! increased operations with MCST, both in value and number of contracts. Moreover, Avant! has transferred a significant part of Compass's business and markets to MCST. Now MCST is fulfilling 40 percent of the engineering tasks of the former Compass company as well as all tasks related to the customer support which Compass did in the past. One of the advantages for Avant! of the cooperation with MCST is stability. For the American partner staff turnover in California was a problem. Greater reliance on MCST helped to solve this.

MCST and Harris are cooperating in three business fields: joint R&D in telecommunications, contract work, and distribution of Harris products. A tender for a project to develop a new telecommunication network, using radio relays for the Moscow region (*oblast*) is a prospect. The cooperation started recently, and no significant problems have been encountered. MCST has established a special spinoff firm, Teleintercom, to manage the telecommunication projects. Teleintercom has two other Russian participants, Demos and NII Radio (Radio Research Institute).

MCST is developing a high-capacity microprocessor on the basis of the Elbrus processor. This is a processor of a new type of architecture. One of its advantages is its compatibility with the existing processors worldwide. The cooperation that MCST needs in this field is of a different type. Here MCST already possesses a developed product and needs financing or a partner willing to jointly produce and market it. As this would mean the production of a principally new type of microprocessor, only the leading world microprocessor-developing firms would be able to carry out such a project. MCST contacted different large companies internationally, but market competition has thus far been an obstacle to such cooperation.

It is the philosophy of MCST to build up small enterprises around MCST for each field of business. This is also true for the attempts to diversify into new business fields like the development of software for banking systems, for stock exchange systems, and for the exploration of oil fields. These new small firms sometimes are founded as joint ventures with new partners in these fields in order to benefit from existing knowledge and experience. It would be advantageous to open up an office or department for project acquisition and marketing in order to extend external cooperation, but MCST does not have the financial resources to do this.

MCST has serious problems in negotiating adequate gross margins to fund R&D and growth and in finding financially viable customers in Russia. Nonetheless it has grown to four hundred employees in six years and is highly respected internationally. From its beginnings doing small contractual tasks it has been able to build a stable business. It clearly has the capability to grow much more, but its accomplishments to date are outstanding given the economic circumstances in Russia.

NPO Mashinostroenia

NPO Mashinostroenia (NPOM), a major Russian aerospace enterprise founded in 1955, is located in Reutov, a small city in the Moscow region. Prior to 1989, state-funded defense and military contracts accounted for 100 percent of the enterprise's activity. NPOM's main tasks were the research, design, production, and systems integration of space vehicles, launch systems, cruise missiles, and related equipment. NPOM no longer works solely for the state, and much of its R&D and technology commercialization is outside of the aerospace sector.

NPOM is an excellent example of an enterprise that was faced with the sudden need to diversify or convert from military design and production to civilian products. It started its diversification and conversion efforts in the early 1990s. It had several advantages over some enterprises faced with similar problems:

- The state considered it a vital resource and hence provided some support for conversion.
- As an NPO (scientific production association) it possessed both product design and manufacturing capability.
- The technology and capabilities of the space-systems sector including some of NPOM's previous work had direct civil applications.

Notwithstanding these relative advantages, the challenge of diversification was still a daunting one. In the absence of commercial experience, NPOM felt forced to develop a large number of products to see which might be marketable or might attract strategic partners or financing. Performing market analysis first would not have been of great value because the markets in Russia were not in place at that time. Products had to be brought to at least the prototype stage to attract strategic partners.

Another reason for working on several new product developments simultaneously was to try to engage a large number of technologists in this work. Some amount of state support was available for this in the early years of transition. If this were not the case, NPOM would not have had the financial ability to meet payroll and pay its bills (both of which it says that it has done since 1992).

In 1993 NPOM had a design bureau and an experimental production plant. The design bureau was divided into fifteen sections based on their special ties. There were also support divisions, including one for finance and legal affairs, a commercial marketing section, and a personnel department. Other units included a special scientific-engineering center and a center for conversion.

The enterprise had also founded about twenty joint-stock companies, referred to by management as daughter companies, in which it retained majority ownership. Still, the daughter companies were not part of the administrative system and enjoyed a certain amount of autonomy. Funds for groups no longer supported by defense contracts ("self-financing") made up about 22 percent of the enterprise's total 1993 business. These included projects supported by government credits specifically designated for conversion; these funds were officially loans, but the interest rate (13 percent in 1993) was effectively negative. Such conversion projects accounted for about 18 percent of the total 1993 budget. Finally, the enterprise allotted some of its own profits to an internal innovation fund to encourage initiative among employees. This fund comprised about 10 percent of NPOM's annual budget. In addition, NPOM received a significant amount of state subsidies. In 1993 about 15–20 percent of overall revenue was profit.[1]

The picture was slightly different as of September 1994. By then, 45 percent of revenues came from military orders, 15 percent from aerospace, 18 percent from defense conversion credits, and 22 percent from commercial civilian projects. Before reforms began, NPOM received all of its orders in the form of very large contracts from the government, through the Ministry of General Machinebuilding. In 1989–1990, it began to think about conversion. Employees were encouraged to come forward with proposals. Some of the upper managers today are people who started out at lower levels, but who proposed conversion ideas that met with some success.

Through 1989, NPOM made a very small amount of civilian products, as most of its production was in space-related technology. In the 1980s, NPOM developed new space-surveillance systems based on the Almaz satellite, which was capable of gathering radar and optical data about the earth's surface. The data from Almaz has become the source of a major commercial activity. In 1989, NPOM management got permission from the necessary military-industrial officials and the Council of Ministers for commercial distribution of data from Almaz, which was then being built. Almaz-1, the satellite that generated the enterprise's first commercial projects, was launched in March 1991, and was in orbit almost two years. The enterprise's most developed conversion activities were connected with the sale of information from the Almaz satellite. Management believed that the successful marketing of information generated by Almaz would be the bread and butter of the company's future. Data from the satellite is useful for oceanography, geology, cartography, geophysics, agriculture, forestry, and environmental management and protection. Cartography is the largest current market. This is perhaps the most straightforward form of technology commercialization, as it primarily involves the marketing of existing data; however, this type of commercialization was (and still is) not that easy for many Russian enterprises.

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[1] "Profit" in this case is not as defined in Western accounting practices. See Tatiana Krylova, "Principal Differences in Accounting Systems in Russia and the United States," in David Bernstein, editor, *Defense Industry Restructuring in Russia: Case Studies and Analysis* (Stanford, CA: Center for International Security and Arms Control, 1994).

This project had both commercial and government financing, although the enterprise started work without expecting any contribution from the government. The most lucrative contracts to distribute data from Almaz were concluded with Western customers. At first, NPOM could only make contracts with foreign businesses through the government's foreign trade agency for space deals, called GlavKosmos, which had been founded in 1985. Through GlavKosmos, the enterprise began negotiations with the Texas-based Space Commerce Corporation (SCC). By 1991, however, when NPOM was launching Almaz-1, the political and economic situation in Russia had changed dramatically. Though the Soviet government lacked a comprehensive plan for conversion, individual companies were allowed greater liberty in making decisions about production and commercialization of technologies. NPOM seized the opportunity to develop civilian, private-sector uses for Almaz-1, and signed an agreement with SCC. By the time the deal was finalized in 1991, Soviet legal requirements were relaxed, and prevailing business practices allowed enterprises to conclude contracts directly rather than through GlavKosmos.

NPOM's initial moves toward the market benefited greatly from the contact with SCC. Working on this project, managers at NPOM learned valuable lessons about the commercial business, including advertising methods, customer service, market research, and construction of the satellite itself. Management started to understand that for commercial space contracts, the whole production chain—development of equipment for the satellite, methods of collecting and processing information, techniques for exhibiting the products, etc.—must be planned according to the needs of the client. Contracts with foreign customers also required changes in satellite construction, and in the equipment used to produce and service the product. Most significantly, the size of the bulky Almaz station was scaled down to cut the cost of individual launches. Space on the satellite was also reconfigured. Originally, the designers created large spaces to accommodate military equipment. While military projects are still conducted, more space has been allocated to commercial projects.

NPOM has also developed software for analyzing satellite images in other parts of the electromagnetic spectrum, and began selling this software in 1998.

This kind of change at NPOM was not merely conversion of a production process or of the products themselves, but conversion to a new view of how to apply the space hardware produced to a new, market-directed philosophy for its development. In the past, the commercial client was a third-priority consumer, after military and science applications. Customer-oriented tasks (e.g., how to present information for the customer, how to expedite delivery, and how to add new options in supplying information) require communication throughout the value chain. These product-line changes have inevitably led to significant alterations in the structure of the enterprise and of all its units.

In 1992, after Almaz-1 fell out of orbit, NPOM negotiated another deal with the Hughes corporation to distribute Almaz information. Through Hughes, data were sold to British Petroleum and other large companies. The enterprise has also sold data to American universities and the U.S. government. Sales have not been limited to the most recent Almaz information; much of the enterprise's archival material from the past is no longer classified, and these photographs have been sold both domestically and internationally.

In early 1994, NPOM became a candidate for funds from the U.S. Department of Defense's program to assist defense diversification in the former Soviet Union. Two such funding programs were implemented. One was a project to build components for housing for military officers in Russia. Four Russian enterprises were selected to propose projects for funding under this housing program. This was in cooperation with an American company and has resulted in a modern production line for double-paned windows. The second program ("Fast Four") was for Russian conversion projects involving American partners; there were four Russian enterprises for this program also. NPOM was the only Russian firm on both lists. The housing construction program went through, but the second program, a partnership with the Double Cola Company of Chattanooga, Tennessee, to build a soft-drink bottling facility, was never consummated.

NPOM had worked with several U.S. companies on proposals for this so-called "Fast-Four" procurement.[2] Most of them were technologically oriented companies, but the Department of Defense chose the proposal from Double Cola. While this was probably the least appealing proposal from NPOM's standpoint, it gained a great deal of experience in the process. Some of the experience came from the efforts to negotiate the Double Cola venture and some came from the cooperation with other companies in the proposal phase. Some of these topics later became the subjects of technology commercialization projects, such as the railroad schedule boards discussed below.

In 1990, non-space-related production grew slightly, to around 5 percent of total production, but it was in 1991 that the ratio of civilian to defense production began a significant shift. The enterprise's space-information systems were the main focus of its attempts to find a market niche. NPOM was forced to start production of consumer products in the 1980s by order of a state directive. As long as the enterprise received sufficient funds from the state, its management was not very interested in the civilian goods, and they were distinctly second priority.

Some of the early diversification efforts were for various civilian goods, including such things as fiberglass sailboat construction, that involved markets with which NPOM was unfamiliar. Later diversification efforts were closer to familiar ground for NPOM in terms of technology, markets, or both. In several of these it relied on its strong software capabilities. A few examples in addition to the satellite data processing and marketing follow:

- The Ministry of Railroads, with EBRD funding, started to modernize some of the railway stations in Moscow. It issued a tender for metal flip-type train-schedule boards. NPOM was the only Russian company to respond, and it successfully outbid several Western European companies. These boards, and the computer interface which NPOM also produced, are an example of using enterprise technology to build a medium-tech product for which there was a sound market. This product was the outgrowth of a project that it had proposed with Hewlett-Packard in response to the DOD's Fast Four procurement. Based on the success of its first deliveries, it has received additional orders for this product line.

- OrbitSoft is a venture that was to have been established to work initially on Year 2000 software problems. The Defense Enterprise Fund (DEF) became interested in forming a joint venture between NPOM, an American software company, and the DEF.[3] Following negotiations with various potential U.S. partners, the DEF selected OrbitSoft 2000, Inc. (OS2K) in early 1996. OS2K is a U.S. company that offers software engineering services as well as project management. Part of the DEF funding was designated specifically for the enhance-

[2] David Bernstein and Nicholas Carlson, *A Report and Analysis of the "Fast Four" Defense Conversion Projects*, U.S. Department of Defense, January 1997.

[3] The Defense Enterprise Fund was established and capitalized in 1994 by the Defense Department's Cooperative Threat Reduction program to help finance ventures between U.S. companies and Russian defense enterprises.

ment of facilities, technology, and tools on site at the NPOM enterprise. For OS2K, its relationship with the DEF not only offered fiscal benefits but political benefits as well.

Through its partnership with NPOM, OrbitSoft 2000 was to be able to offer software programming services to European and American customers at costs well below those available in the United States, primarily because of the disparity in labor rates. The first activities were to be solutions to Year 2000 problems, with other software services to follow. These services were to have been offered either directly to end users or indirectly through partnering arrangements with hardware vendors or professional service companies. Such work is very skilled-labor intensive, which capitalizes on both the pay scales and the availability of skilled programmers in Russia.[4]

Initially the venture was designed to staff up to one hundred programmers. During negotiations only a few problems were encountered between OrbitSoft 2000 and NPOM in their business dealings. In the beginning projects took a little longer than originally forecasted, and this created some frustration for U.S. customers. The partners agreed that NPOM would work on a demonstration project for a client of OS2K, and that if it were successful the joint venture would be consummated and the client would issue a substantial contract for Year 2000 programming work. NPOM worked on the demonstration, and in September 1997 went to the United States to demonstrate the results.

The demonstration was fairly successful, although it required the NPOM team to stay in the United States longer than had been anticipated. The negotiations broke down, however, because the DEF was concerned about the ability of the joint venture to deal successfully with the full spectrum of issues that would be involved in the operation of the venture. This breakdown certainly does not negate the concept of an American company utilizing Russian programmers to address Y2K and other software development tasks for U.S. customers.[5] This joint venture potentially offered significant benefits to all parties. It would have been able to capitalize on the shortage of programmers in the United States as well as on the cost differential, and NPOM would have built a viable business unit capable of expanding in this and other software ventures.

NPOM views software as one of its major areas of opportunity. In late 1997 it had more than fifty people working on three projects, had set up well-equipped facilities, and had been reasonably successful in attracting foreign partners. This has also proven to be interesting employment for many of its highly skilled scientists and engineers. This software business is expanding and in 1998 it completed the first phase of a major network development for the Ministry of the Economy.

- NPOM used its photovoltaic technology from space programs to develop a system for agricultural drying, desalination, and heating water in remote locations. In the mid-1990s it began working with a U.S. company, Global Photovoltaic Specialists, with the intention of forming a joint venture. An initial market had been identified in India for drying tobacco. The U.S. Trade and Development Agency funded a study to examine the commercial feasibility of this and other applications. NPOM has also signed a contract with the major producer of solar converters in Russia.

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[4] The wage differential between the Moscow region and the West was rapidly closing until the ruble devaluation in August 1998.

[5] See the Typhoon case study.

• For many years, NPOM had been a supplier of technologies and equipment for leather treatment to factories within Russia. A partnership was concluded with the Italian firm Paletta to produce equipment for the leather industry and production began in 1992.

• Another project, sponsored by Gazprom, involves both hardware and software. It is a robot that moves inside of a gas pipeline and monitors for longitudinal cracks. It has advantages over competitive systems in its ability to move at variable speed, either forward or backward, rather than just at the speed of the gas flow. The signals are telemetered out, and software then processes the data to describe the cracks and, using the GPS data, locate them.

• NPOM has developed CAD/CAM software that is applicable to a broad class of molded plastic products. It also has the facilities for producing these parts.

• For several years NPOM has been selling small disk antennas for satellite TV reception. It is marketing these itself without a foreign partner. It has also been selling a line of fire extinguishers based on other aerospace technology.

There are other technology commercialization projects that have been pursued for a long time without success. One of these was the attempt to utilize the SS-19 ICBMs for commercial space launches. In January 1999 the Russian government approved construction of a launch facility for commercial space launches of the SS-19. NPOM is the prime contractor.[6] Another as yet unsuccessful initiative is to provide the extensive space test chambers for commercial space development projects. A third venture, also in the space field, is to market Soyuz capsules which are already built as space-rescue vehicles that would be waiting in orbit.

While recognizing the utility of non-space-related ventures, NPOM's management remains focused on preserving, maintaining, and eventually expanding high-technology products and phasing out the production of prosaic consumer goods. Though forced to pay attention to the market and to maximize profits, NPOM managers are still scientists by training. Decisions about diversification and product lines, therefore, are not made solely on rational economic calculations; science content also plays a role. The more science, the more appealing the product, even if it may mean less profit

Up through about 1994, NPOM's product selection did not reflect a high degree of sensitivity to the market. After that, however, it was engaged in several commercial products and services that were responsive to real market demand and/or that attracted foreign partners.

NPOM is still state-owned and was designated a State Science Center in 1997. Privatization had been considered in the early 1990s, but was determined not to be the best strategy, and thus NPOM chose to remain state-owned. This decision does not mean that privatization will be excluded from future consideration, however. Privatization would be considered more favorably if the decision to privatize would result in direct capital investment into the enterprise. In mid 1997, NPOM was reexamining whether to continue being state-owned or to privatize. It has already decentralized its operations in a way designed to facilitate the segregation of individual commercial activities, and has already spun off some daughter companies and allowed outside investors to acquire equity positions in them. Although state-owned, NPOM has the right to establish joint ventures and to negotiate commercial contracts. So from the standpoint of technology commercialization, the ownership of NPOM does not appear to be of great significance.

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[6] *Moscow Times*, January 20, 1999.

More recently, NPOM has not been very receptive to the idea of spinoffs. Top management appears hesitant to allow lower or mid-level managers to become independent and to keep revenues from the spinoffs. In recent years, management has only been willing to allow divisions to proceed with independent commercial projects after the immediate requirements of the enterprise had first been fulfilled. Twenty-five small private businesses (daughter companies) have developed off of the larger NPOM enterprise. In each daughter company, NPOM owns between 45 and 100 percent of the equity. In general, NPOM has expressed a preference for contract agreements over joint ventures, because contracts tend to be more direct. NPOM feels that contracts do not create the mutual dependencies that equity ventures often do.

In early 1999 NPOM reported that the ruble devaluation had actually helped it in three ways. First, contracts that had been negotiated in dollars were now more profitable since many of the inputs, including labor, were to be paid for in devalued rubles. Second, its products could be more competitive on export markets. Both of these are standard effects of devaluation. The third way is a function of the evolution to a market economy. Many goods had been imported into Russia over the past few years by traders known as shuttles. These shuttles would travel to other countries, such as China and Turkey, and buy up goods that they would then bring back and sell in Russia. These were products for which Russian-produced counterparts were not competitive. After devaluation some of the shuttles went to Russian companies, including NPOM, and contracted for them to produce these products since they knew where the demand was and the Russian products were now competitive. These shuttles act as a competitive distribution system in the absence of an organized distribution system that one would find in a true market economy.

Pratt & Whitney[1]

Rocket propulsion is a unique sector in terms of the combination of technology and the market. Russian propulsion technology, systems availability, and performance are in many important ways more advanced than that in the United States, and the market for satellite-based telecommunications has grown rapidly in the last few years. The French gained the largest portion in that market, having close to 50 percent market share in the 1980s. Therefore, when the Russian booster capabilities became commercially available, U.S. aerospace companies negotiated a variety of joint ventures to utilize them in an effort to capture more of the market. There are three such ventures that are of primary significance: Lockheed-Khrunichev-Energia-International (LKEI); Sea Launch, where Boeing is teamed with NPO Energia and with the Ukrainian enterprise Yuzhnoye; and RD/AMROSS, in which Pratt & Whitney (PW) is teamed with NPO Energomash (NPOE).[2]

The PW-Energomash venture is the newest of the three to be formalized, although the partners have been negotiating and working together since 1992. As a result of these joint ventures, the French market share is forecast to drop to about 20 percent in 2000.[3] All three also represent a substantial commercialization of Russian technology; however, from that standpoint the PW-Energomash venture has features of special interest for the purpose of this study.

In February 1997 PW established a joint venture with NPOE, a Russian state-owned enterprise that manufactures liquid-fueled booster rockets, to develop and produce the NPOE RD-180 rocket engine. The joint venture, RD/AMROSS Ltd., is based in West Palm Beach, Florida, with the technical and production work being done at NPOE's Khimky plant and PW's Florida facilities. PW is principally responsible for the management of the joint venture's

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[1] See also the case study on Energomash.

[2] The structure and history of the ventures up through 1996 are described in David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997). Also see the Energomash and Energia case studies in this section.

[3] This prediction was made by PW in early 1998, before the U.S. government raised major new concerns about the transfer of space technology.

contracts and relations with Lockheed Martin and for other marketing of the RD-180. The equity and board of directors are allocated equally between PW and NPOE. The Lockheed Martin Corporation has a nonvoting seat on the board since it will be a major customer. The joint venture itself will not do production work, but will subcontract the work to NPOE and PW. As a result, the staff of the joint venture will be relatively small, probably no more than ten people. The RD-180 is a half-thrust derivative of the 1.9-million-pound thrust RD-170 rocket engine, initially designed and manufactured by NPOE for the Soviet space program's Energia and Zenit launchers. The RD-180 will be produced for both commercial and U.S. Air Force procurements. The Atlas II-AR will be produced for the Atlas launch vehicle developed by Lockheed Martin to compete against the French Ariane and other rockets for the expanding market for commercial satellite launches. Lockheed Martin has already sold several missions for the new Atlas and is in the process of securing additional orders. The Atlas was also competing for future missions under the U.S. government's Evolved Expendable Launch Vehicle (EELV) competition, which presents another market for the RD-180. The Air Force has decided to have both competitors, Lockheed Martin and Boeing, eligible to bid on future launch procurements. This reduces the potential market for the RD-180, but it virtually assures it a substantial share of the Air Force procurements. The Air Force has stipulated that all critical components must be manufactured in the United States. Noncritical components could be produced in Russia if this is economically more efficient. Some of Energomash's production equipment is as much as thirty years old and would have to be replaced. The most efficient choice for production of some components is therefore still to be determined.

For Air Force missions, the RD-180 has its roots in initial talks between General Dynamics and NPOE for the design and construction of an RD-170 derivative for use in the Atlas commercial launch vehicle. General Dynamics subsequently sold its Space Systems Division (including the rocket-launch business) to Martin Marietta (prior to the merger of Lockheed and Martin Marietta), thereby transferring ownership of the RD-180 project rights. After initiating contact with NPOE in 1992, PW agreed to act as a "marketing and program management house" in the United States for the applications of other NPOE engines. PW eventually made a successful bid, in competition with Rocketdyne, to Lockheed Martin for the rights to the RD-180 project.

This bid process was soon followed by another competition to provide the engine for the Atlas. Lockheed Martin opted for the RD-180. PW and NPOE subsequently initiated their joint marketing and licensing agreement for liquid oxygen/kerosene engines in October 1992. To evaluate and verify performance, PW paid NPOE to test the engines, with PW oversight of the process. Once PW was satisfied that the RD-170 met all of the requirements for U.S. applications, including potential downsized utilization on the Atlas rocket, they proceeded with plans for the joint venture.

In order to facilitate the work of the joint venture, PW has sent staff to Russia to familiarize NPOE and the responsible Russian government oversight officials with the legalities of joint ventures, Western accounting standards, and general business practices in the Western market for rocket engines. Teams of legal and financial advisors have worked with NPOE officials. This has increased mutual understanding of the joint venture's contracts and operations. In addition, there are four full-time employees in the PW Moscow office who will be working exclusively on coordinating the NPOE work for the joint venture. Those individuals will remain in Russia throughout the R&D stage, as well as the possible transition stage for initiating production of the RD-180 in the United States.

Under the terms of the joint-venture agreement, NPOE will perform the design work for the RD-180, with PW oversight, and will transfer that R&D data to the joint venture. PW will use this data and establish a parallel U.S. production line. NPOE will retain responsibility for the production of all RD-180 engines being used for commercial applications. Lockheed Martin will be a major customer for both commercial and Air Force projects. Lockheed Martin, as of September 1997, stated that it planned to buy at least 101 RD-180 engines at a total cost of one billion dollars.[4]

The requirement of dual production facilities is not present in the Sea Launch or LKEI ventures and represents a significant additional aspect of technology transfer and commercialization. Transferring the manufacturing technology of such a sophisticated system entails a level of cooperation that is probably not present in a venture that is more of a supplier/purchaser nature. To facilitate the possible U.S. production of the RD-180, the U.S. government has approved a Technology Assistance Agreement (TAA) to enable PW and Lockheed Martin to provide technical requirements and specifications to NPOE.[5] The Russian government has issued the decree necessary for the licensed transfer of the required data during the R&D stage from NPOE to the joint venture, and on to PW's production facility.

The establishment of all the space-launch joint ventures has required the involvement of both the U.S. and the Russian governments, but it is probably more extensive in this case because of the dual-production aspect. The Russian government's role included substantial review and oversight, primarily by the Russian Space Agency and the Ministry of Defense, but also involving the Department of Foreign Economic Relations and the Ministry of Finance. This redundant oversight and approval process was largely a result of the fact that NPOE is still a state-owned company that produced many of the boost engines for both the Soviet space program and Soviet liquid-propelled intercontinental ballistic missiles. An example of this continuous review is the above-mentioned contract guaranteeing data transfer concurrent with the R&D stage. The time required for obtaining approval of both the joint-venture business structure and EELV compliance issues from the requisite Russian government departments was the most time-consuming part of the joint venture startup phase. The entire process took much longer than PW had anticipated. In fact, one of the biggest frustrations from PW's and Lockheed Martin's perspective has been the lengthy and convoluted Russian approval process.

PW does not think that the provenance of intellectual-property rights is a problem since such rights are all property of the state. PW has established milestones to pay NPOE for R&D data once those data have been transferred. It is expected that the transition to U.S. production will be completed by 2000, with the first finished engine deliveries scheduled in late 2000 for a first flight in 2001. A significant number of orders are expected to be for commercial customers—possibly a majority. Commercial success would increase the production in Russia.

PW is providing the financing for the joint venture, both for the R&D and for the initial production in Russia. It had invested more than $80 million as of mid-1998 and expects the final investment to approach $100 million. NPOE is paid by the joint-venture company,

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[4] Nikolai Zimin, "Energomash and Pratt & Whitney Decide to Pull Together," *Segodnya*, no. 21 (February 7, 1997), p. 6.

[5] The U.S. government policy of technology transfer related to space technology is being reviewed as of this writing (December 1998). See *Future Directions for Satellite Technology Export Control Policy*, report of a workshop held December 1, 1998, at Stanford University (Stanford, CA: Center for International Security and Cooperation, forthcoming).

under cash advances from PW, for R&D of the new RD-180 design and for production of the completed engines. The joint venture will then be paid by Lockheed Martin upon delivery of the engine. PW will recover its investment incrementally with each engine delivery.

The flow of payments within the joint venture is a reflection of its structure. Following the U.S. government's decision to maintain two EELV suppliers, the economics have changed somewhat, and RD/AMROSS and Lockheed Martin are exploring the most logical approach. Profits from the engine sales are to be divided 50/50 between PW and NPOE. In addition, NPOE will receive royalties for its initial RD-170 rocket design, which accounts for 70 percent of the design features of the RD-180. These royalties are expected to approach as much as 10 percent of the profits received by NPOE from its share of the joint venture's engine sales. The RD-170 will also be coupled to the Zenit for Boeing's Sea Launch system; however, Energia already has a large inventory of RD-170s that were transferred to it in the Soviet era. Therefore, Energomash will not benefit from this use.

The joint venture relieves the Russian government of substantial obligations for subsidizing employment at NPOE and for funding state-of-the-art space technology. In mid-1998 NPOE's Khimky production facility employed about six thousand people (down from a high of more than ten thousand). Its R&D team for the RD-180 comprises several hundred individuals and the production team for the RD-180 will eventually number more than one thousand. A smaller number of workers will be employed by PW in the U.S. EELV-dedicated manufacturing operation. This is due primarily to the fact that PW is not as vertically integrated as NPOE and will therefore subcontract out more parts of the production.

Pratt & Whitney is also working and/or negotiating with several other design bureaus and NPOs in the space-propulsion sector in Russia. Some of these involve agreements for modifications to systems licensed under the venture with Energomash. Here again the dual manufacturing agreement makes this possible since it gives PW the necessary rights as well as the ability to impose the required technical specifications for what it wants and to utilize the results.

PW is contemplating a separate, purely commercial application for the RD-120, a 180,000-pound thrust engine, also using kerosene and liquid oxygen. This project is currently in the developmental marketing stage. PW is seeking to present the joint-venture project to potential customers and is still pursuing venture capital funding. Like the commercial versions of the RD-180, the RD-120 would be manufactured exclusively in Russia.

PW also has a contract with the Chemical Automatics Design Bureau (CADB) in Voronezh to work on liquid oxygen-hydrogen rocket engines. The initial work was for CADB to perform studies for advanced upper-stage engines. PW would license another rocket motor, the RL-10, to CADB, which would make some improvements and license these back to PW. This engine would be a candidate to replace the Proton launcher's fourth stage, which is currently produced by NPO Energia but which has some problems. PW would assist CADB in setting up a production line and integrating this into the Proton fourth-stage design at Khrunichev. This could eventually lead to the formation of another joint venture.

From the standpoint of technology commercialization and technology transfer, the PW-Energomash venture is very different from LKEI and Sea Launch as a result of the dual production provision. This means that there will be a continuous and detailed exchange of engineering and production experience and data throughout the life of the venture. As a result there are likely to be many additional elements of Energomash technology for which PW may find commercial applications. The dual production agreement required by the U.S. Air Force has also forced both governments to permit a degree of exchange of technical information that may not have been permitted otherwise. This in turn can lead to a variety of cross-licensing agreements and joint development projects that could be much easier to initiate because of the extent and nature of the ongoing cooperation.

The rocket-propulsion sector in general may not be a valid model for other industries because it appears to present a unique combination of superior Russian technology and a rapidly growing market opportunity; however, the approach to cooperation in the PW-Energomash venture may be a broadly applicable model of how U.S. and Russian companies can best work together for their mutual benefit.

Central Aerohydrodynamic Research Institute (TsAGI)

The Central Aerohydrodynamic Research Institute (TsAGI) is an example of a major enterprise that has actively pursued a course of reorganization and disaggregation as an integral part of its diversification and restructuring efforts.[1] As of early 1994, TsAGI had already spun off over thirty small enterprises, with TsAGI's share of ownership ranging from 100 percent down to five percent.

TsAGI was a major research and testing institute for the aircraft and missile programs in the former Soviet Union and later in Russia. In 1994 the Russian government made TsAGI the first of many State Science Centers.[2] The state (Ministry of Science and Ministry of the Defense Industry) provided a research budget for TsAGI, but it was only about 25 percent of TsAGI's budget, much less than in Soviet days.[3] TsAGI's entire revenue in 1994 was projected at only about 20 percent of that in 1988, and much of that was from non-state sources, whereas it was predominantly state-financed in 1988. This State Science Center status also provided it with greater control over the use of its assets for commercial activities and allowed it to corporatize small spinoff firms and help finance their activities. As government support declined TsAGI faced the task of converting a portion of its facilities and activities to nonmilitary applications while maintaining its basic technology and capabilities for aerodynamic testing. This prompted a major restructuring of its ownership, governance, and organization.

TsAGI has had to balance its increasing reliance on foreign contracts with the need to maintain its ability to work for the Russian domestic market. The lack of funds for maintain-

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[1] See David Bernstein, editor, *Defense Industry Restructuring in Russia: Case Studies and Analysis* (Stanford, CA: Center for International Security and Arms Control, 1994), for a description of TsAGI's restructuring activities up to mid-1994.

[2] Russian Government Decree, "On the Realization of the Edict of the President of the Russian Federation from June 22, 1993, No. 939 'On State Science Centers of the Russian Federation,' March 29, 1994, No. 247. Russian Government Regulations, "On Conditions for the State Support for the State Science Center of the Russian Federation—TsAGI," March 29, 1994, No. 247.

[3] The Ministry of Defense Industry has since been incorporated into the Ministry of Economics.

ing its infrastructure has obliged it to turn down some orders since the deteriorating infrastructure prevents it from performing the work. In 1996 TsAGI was able to utilize only about 30 percent of its fixed assets since testing of sophisticated military aircraft (which utilizes the other fixed assets) is no longer viable.

TsAGI had a typical organizational structure in the Soviet period, comprising a single legal entity with one bank account. In 1988 its orders were all from the state, 70 percent of them for defense (which included the Soviet space program). In the early 1990s, defense orders dropped precipitously and TsAGI moved to reorganize and broaden its product and customer base. Nonstate domestic orders were important in the early years of reform, but with the general economic decline fell to 10 percent in 1993. Foreign orders grew significantly in a short time. In 1991, the first year that TsAGI was able to sign contracts abroad, these made up 10 percent of the budget, then grew to 20 percent in 1992 and 40 percent in 1993.

TsAGI established TsAGI International (TI) five years ago as a daughter company of TsAGI, registered in the United States and located in Washington, D.C. The mission of the company is to represent TsAGI's interests in the United States in view of the expansion of business with U.S. companies; to provide legal and contracting support; and in general to supervise all aspects of cooperation. All contacts with U.S. companies were facilitated via TI, and three sides (TsAGI, TI, and a U.S. partner) are usually represented in the formal contracts. Moreover, TI has been providing support in all financial transactions between partners. Recently TsAGI established a new division of foreign trade and marketing, and the former head of TI was selected to lead it. This suggests that the commercial success of TI played a role in this division's establishment.

The role of TI as an element of TsAGI's business infrastructure has significantly increased. The accumulation of experience has led to optimization of the company staff, and clearer definition and extension of its functions. The general success of TI indicated that TsAGI should develop a network of this kind of daughter firm in the markets of other large clients, especially in Germany, Great Britain, France, and China. Practical implementation of this approach, however, is limited by financial constraints.

TsAGI opted to work with its international partners primarily on a contract basis rather than establishing formal joint ventures. This strategy allows it to diversify its market niche and to work for competing clients. To expand its market presence it tries to negotiate rights for joint use of developed and manufactured equipment rather than simple cash payments for products or services. Its success in attracting prominent international clients allowed it to accept fewer but larger contracts and it believes that it is now negotiating better contracts as a result of hiring good lawyers to assist with the negotiations with Western companies. In 1996 it had about fifty major contracts with an average duration of six months. TsAGI International, which was initially intended to serve as a marketing arm, was also used heavily to facilitate legal support and contract resolution.

The primary objective of TsAGI's reorganization was to capitalize on its technological base and unique facilities by diversifying into new markets for its services and to develop new products and services based upon these core capabilities. Another important and related objective was to retain key technical personnel.

The TsAGI State Science Center (TSSC) is 100 percent state-owned, and is likely to remain so for the foreseeable future. The state has allowed TSSC broad discretion in the control of intellectual property, licensing of technology, and utilization of the income from those licenses or other forms of commercialization of its technology. To help achieve its objectives, TsAGI set up three categories of subsidiaries. Category I comprises companies that are most closely linked to the science center's core capabilities and activities. Therefore they all involve high technology, are closely related to the core business, and utilize key scientific personnel. The primary distinction between these Category I subsidiaries and the science center itself is that the former are engaged in utilization of the core capabilities for customers other than the state. These can include customers which are state- or privately owned in both Russia and abroad. Category I subsidiaries are generally close to 100 percent owned by TSSC. There may be some outside or employee ownership, but TSSC intends to maintain a controlling interest. This guarantees that the research and business interests of the science center will never be subordinated to other business pursuits of the subsidiaries. In addition to carrying out commercial businesses, these subsidiaries engage in advanced applied research that may have further commercial potential.

The second category of subsidiaries also involves substantial technology and skilled personnel from TsAGI. They differ from those in Category I in two major respects. First, they are not necessarily majority-owned by the TSSC. Equity is provided in exchange for investment capital or for employee incentives. In general the TSSC holds approximately 50 percent equity in these subsidiaries. The second difference is that TsAGI technology is utilized to develop new commercial products and services that do not involve the basic testing services of the science center as the principal element of the product or service. These ventures provide challenging opportunities for TsAGI's technical personnel, especially those who are entrepreneurially oriented.

Category III comprises subsidiaries that were established to provide employment for excess production workers, to utilize idle space and equipment, and to generate revenue without monetary investment. Some of these subsidiaries stress employment while others stress income. These are low-technology ventures.

As of September 1998, TsAGI did not think that the financial crisis and possible political problems would negatively affect its business to a great extent. This was based on the fact that TsAGI maintained a strong position in negotiations with the state; it purchased very few treasury bills which were subjected to the governmental default; and the banks where TsAGI holds its accounts remained stable. It does not expect that the new government will erect political barriers against cooperation with its Western partners.

Currently the large share of foreign contracts in the institute's portfolio (up to one-third) is explained by the low level of funding from the government and the low demand of Russian aviation companies. Nevertheless in 1998 TsAGI continued to view itself as a key aviation R&D institute, which will in the future rely more on the domestic than foreign market for aviation technologies. Management believes that it is unreasonable to expect any significant growth of foreign contracts in aviation technologies and testing since this is a shrinking market overall. Application of TsAGI's technologies and skills in markets other than aviation (e.g., automobiles, measuring equipment) may stimulate additional cooperative ventures and technology commercialization opportunities.

The company views international cooperation as the most important source of near-term revenue. It has built mutual trust with several partners and learned to overcome barriers, negotiate contracts, and identify and defend its interests. The wind-tunnel work has developed into a continuous business, but it is seriously dependent on the maintenance of TsAGI's cost advantages. The major cost advantages are in labor and vary between testing and R&D contracts. Research is more labor intensive and labor costs at TsAGI are still ten times lower than in the West, although this advantage has been decreasing in recent years. There has also been growth of material and energy expenses, and this may continue as a result of the 1998 economic crisis.

Attaining contracts for technological cooperation with foreign partners is becoming more competitive among the Russian aviation companies and R&D institutes. Russian competitors of TsAGI for R&D contracts as a rule have less technological expertise and are worse equipped technically, but they often underbid TsAGI. Domestic R&D competition is particularly significant in space research. On the other hand, given that space-related research accounts for no more than 5–7 percent of TsAGI's activities, competitive losses of contracts in this area are not too significant.

TsAGI has an advantage over domestic competitors for foreign contracts because of its early entry into the business. It has developed the trust, reputation, and image of a reliable partner, which often outweighs somewhat higher costs. In general TsAGI views its cooperation with foreign partners as successful as demonstrated by a stable level of contracts and the fact that not a single such project has been a failure.

TsAGI's foreign cooperative activities are located in the United States, Europe, and Asia in approximately equal amounts. The most important partners in Asia are China, India, and South Korea. Initial contacts have also been established with Japanese firms. However, the return from cooperation with Chinese and other Asian partners is relatively low due to the fact that these ventures have in general low to medium level of technology. Geographical expansion is possible, mainly if jointly developed products can be marketed in third countries.

The principal contributions of Western partners to joint development contracts are financial support, supply of tools and equipment, technical documentation, international market access, and training. TsAGI is particularly interested in acquiring tools and equipment for joint scientific experiments. Investment in the wind-tunnel facilities is, however, not included in the contracts. Nevertheless the availability of idle capacity (fifty-two wind tunnels) should allow TsAGI to maintain a competitive position in the testing market for a considerable time.

Contracts remain the main form of foreign cooperation because they allow TsAGI to work for competing Western firms and avoid dependence on a few. Nevertheless, the institute is currently negotiating the creation of an equity joint venture with a foreign company. The venture will be built around specific aviation equipment and will comprise several Russian companies that manufacture this kind of equipment. TsAGI expects to hold 10 percent of the venture and will contribute technology and software programs. The Russian industrial partners are motivated by import-substitution contracts and access to the third countries' markets. The foreign partner is interested in access to the Russian market and cost-competitive outsourcing. In addition to contracts, specialists at TsAGI have been awarded several international research grants from organizations, including the International Science and Technology Center (ISTC).

Protection of IPR of innovations made in Soviet times is not practical, because the so-called "author's certificates" were converted into internal Russian patents without any commercial return. However, TsAGI feels that protection of older technology is of decreasing importance. It is much more important to patent new technologies. TsAGI's strategy with respect to the intellectual property protection in joint projects and ventures is very contract-specific. Thus, joint research projects usually include agreements on joint ownership of results, whereas in development contracts the results belong as a rule to the contracting partner. This is because developments in aviation are too model-specific and are hardly applicable in competitive products. If the joint development project is aimed at commercialization in third countries' markets, however, then TsAGI is interested in the strong patent protection and shared rights. This point is usually included in the contract. In addition, the institute would also like to protect its own developments, done independently, but this is limited by financial constraints. Commercial returns from the sale of technologies in the third countries' markets are only expected after a significant time delay. In aviation the production cycle is rather long, and no less than three to five years would pass after the patent is sold before there would be a return. It is important to note that TsAGI has gradually accumulated experience in technology protection and is now much more skilled in this respect than before.

Two major problems in TsAGI's cooperative technology commercialization ventures are unfavorable work content of the projects and, in some ventures, relatively low contract prices. Currently 70 percent of such ventures are related to wind-tunnel testing and only 30 percent to R&D, but the institute would like the opposite proportion. In wind-tunnel testing the contract price is relatively low, and revenues are not sufficient for the maintenance of the wind tunnels, investment in modernization, and general support of the research and experimental base of the institute. TsAGI is working to obtain higher contract prices during negotiations. As a rule at the initial stage of negotiations the technical specialists of Western partners tend to maximize the scope of the projects, but at a later stage the scope is often reduced due to financial limits. In addition, the R&D market in aviation is shrinking globally, thus making this business more competitive and risky than before.

One of TsAGI's earliest foreign partners was the Boeing Company.[4] The average range of annual contracts with Boeing is approximately $1 million. All contracts are negotiated and concluded directly with Boeing without participation of Boeing's Technical Research Center (BTRC) in Moscow. TsAGI believes that the dynamics of cooperation with Boeing are driven by the technical targets rather than by economic or political circumstances and are more or less stable. In addition, the structure of contracts has been changing. Whereas in the past a few relatively large-scale contracts were carried out, today TsAGI is conducting many small projects, though their total value remains about the same. Cooperation with Boeing consists in general of two types of activities: wind-tunnel testing and R&D in aerodynamics. Here again approximately 70 percent of the work is testing and 30 percent is R&D. As mentioned, TsAGI is interested in increasing its share of R&D contracts, which are more labor-intensive and allow it to hold a better competitive position. Significant changes in relative prices and costs have decreased the profit from wind-tunnel testing contracts.

The issue of intellectual property protection in cooperation with Boeing has never been a subject of contention between the two. TsAGI is usually not interested in patenting the developments done for Boeing, since they are very company-specific and not suitable for commercial use in other markets. On the other hand, those Boeing contracts, which were awarded to TsAGI with the help of ISTC, are not subjected to restrictions, and the rights usually belong to both partners. Boeing could place these contracts in the United States or Europe as well as at TsAGI, but chooses TsAGI because of time savings and cost advantages. It should be noted, however, that the gap in costs for the testing business has dramatically decreased in recent years because of large increases in the cost of materials and energy in Russia. TsAGI does not expect that Boeing will increase its business at TsAGI. In fact, because of internal restructuring challenges Boeing may decrease outsourcing.

Recently a new general director was appointed with his own vision of TsAGI's future. Although he did not introduce dramatic changes in the restructuring plans, several restructuring initiatives have been launched:

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[4] See the Boeing case study.

- A new division of foreign trade and marketing was established.
- TsAGI is seeking informal association with Russian aviation companies in order to develop coordinated marketing and pricing policies. In this regard it has recently joined the European Aviation Consortium.
- TsAGI's approach to the three categories of subsidiaries remains in place, although the company has drastically decreased the number of spinoff firms through mergers of daughter companies fully controlled by the parent entity. Several divisions were also closed down. Moreover, at this time the company is pessimistic about the availability of outside investors able to commercialize technologies and facilities.

TsAGI takes different approaches to market foreign partnerships and contracts. For example, at the institute's initiative the next MAKS air show (August 1999) will be accompanied by an international conference for top managers of aviation companies, both Russian and foreign, which operate in the Russian market.

TsAGI has not been affected by the federal branch level restructuring initiatives (designed to decrease the number of prime contractor type companies), mainly because it is usually in the middle of the value chain and provides R&D and services for all competing Russian contractors. As a State Science Center, TsAGI remains a privileged key research institute, practically independent from military contracts. It views the creation of an organization capable of administrating R&D in aviation as the most effective way to support technology development and commercialization. Additional markets for TsAGI emerged because Aeroflot, Transaero, and other Russian airlines acquired or leased many foreign planes. Certification and testing of these planes for the Russian market is provided by TsAGI.

Typhoon Software and Santa Barbara Ltd.

Typhoon Software (Typhoon) is an American software company based in Santa Barbara, California, that specializes in outsourcing software development work to Russia for Western companies. Typhoon works with a Russian-American joint venture, Santa Barbara Ltd., a joint stock company located in St. Petersburg. Typhoon was formed as a startup specifically to engage in this venture. Typhoon Software owns 60 percent of Santa Barbara Ltd. The remaining 40 percent is owned by Russian investors and participants.[1]

In terms of the partnership, Typhoon contracts software development projects for Western (primarily U.S.) companies for Russian software engineers and programmers who are employed by Santa Barbara Ltd. Thus, the majority of Typhoon's work is not directed at the Russian market. Many of Typhoon's customers are large U.S. companies, roughly half of which are Fortune 500 companies, such as IBM, Honeywell, Harris, and Xerox. Typhoon only contracts work to Russian programmers and does not have a U.S.-based programming or development group.

The software development work is primarily on a fee-for-service basis in which Typhoon obtains software development and programming contracts from U.S. customers, who generally do not have offices in Russia, and contracts with Santa Barbara Ltd. (SBL) to perform the technical work. The U.S. customers generally start with small contracts and expand their size as they become satisfied with the Russians' performance. They would rather work through Typhoon than set up their own operations in Russia, which would involve a greater commitment and could be less cost effective in the long run unless they engaged in large-scale activity. Typhoon/SBL already has the necessary infrastructure and staff, and has the added flexibility of moving staff among their projects. This not only yields economies of scale, but it also provides access to a diversity of skills. In addition to reduced cost and technical innovation, some U.S. customers are attracted by the relatively low turnover of personnel compared with that in the U.S. software industry. For the most part, the revenue and profits from the

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[1] For a more detailed case study of the formation of the venture, see David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

software projects are linearly proportional to the labor expended and there is little accumulation of proprietary technology or products.

In addition to the software development and programming services, Typhoon/SBL attempts to develop hardware systems (not necessarily computer hardware) based on technologies from Russian enterprises. The hardware systems projects are based on Russian technology, and the objective of these projects is to develop proprietary products of multiple sales for applications with large markets. As of July 1997, the main projects under investigation involved cold welding for superconductivity applications, modeling of hypersonic aerodynamics, oil spill mitigation, explosive detection, and a hybrid airplane involving vertical SES takeoff and normal horizontal flight. In each of these projects the strategy is to find a strategic partner that has access to the relevant market. An interim strategy is to find sources of project financing to bring the technologies to proof of principle, prototype construction, prototype field testing, or whatever step is appropriate to enhance the probability of making a strategic alliance.

As of mid-1997, the software services activity was the only generator of revenue. The top management of Typhoon and SBL have been devoting considerable effort to promoting some of the system projects. Typhoon is reinvesting its operating profits, all of which come from the software business, along with some of its investment capital, into these larger, long-term projects. The plan is to form a separate company for each of these projects as the product development and strategic alliances warrant. The projects are primarily aimed at the commercialization of technologies which had previously been developed in Soviet/Russian defense enterprises and research institutes. Typhoon's role in these projects is essentially that of an intermediary. It seeks out support for R&D and technology commercialization in exchange for equity holdings. In these cases, the Russian participants are not the programmers of SBL. By using the cash flow generated by the software business they can generate early financing for some of the other technology commercialization projects. This can be helpful in finding partners and in securing the IPR for background technology. A potential downside to this approach is that it limits the cash and management time available to expand the software business, which has already proven to be profitable.

The technical staff of SBL, which is drawn largely from research institutes and universities in Russia, has extensive background in computer programming and engineering, mathematics, statistics, electrical engineering, and the physical sciences. Most of the senior staff members have taught computer engineering and programming. From September 1996 to June 1997, their software business doubled, employing about one hundred Russian programmers. The strongest competition is in India, where software outsourcing is already a large business sector (in 1995 India exported about $1 billion of software). Employees are still being hired and office facilities are being expanded in Russia. On the U.S. side, several employees have been added to Typhoon Software specifically for customer interaction.

A major key to success in the software business is a strong Russian manager who understands the business environment in St. Petersburg, has spent considerable time in the United States, and possesses broad technical expertise. The computer programming needs of U.S. and other Western firms have grown over the last several years, coinciding with the availability of a large number of sophisticated Russian computer programmers who lost their funding.

Western companies come to Typhoon with specific software needs. In about 85 percent of such projects, the customer provides detailed specifications for the job. In these cases, work can be done on a fixed-price basis. Even in these well-specified projects, there is frequently innovation (e.g., devising more efficient algorithms that the customer had not requested), often resulting in a dramatic difference in the performance of the resulting software.

Projects differ from customer to customer and include developmental work in communications software, LAN software, voice compression, code-level debuggers, visual simulators, screen savers, educational software, databases, and complex thermodynamic simulations. Throughout the course of each project, SBL conducts program testing on three major levels. The customer sees the program at all three levels and may also perform its own in-house testing at any level. Specific testing protocols are defined in the original project assignment.

Project management, marketing, and all customer relations are handled by Typhoon Software. For each project, a U.S. management team works to ensure that technical work is completed to specification, on time, and within budget.

In the software arena, the absence of program management capability among the Russian staff initially was the greatest problem. While the skills of the Russian programmers were high, their productivity initially was not. In order to address this problem, Typhoon decided to provide American on-site management and to provide training for Russians in project management. Productivity improved rapidly, and customers were sufficiently satisfied to contract for additional work.

The problems on the hardware system projects have been entirely different. It was possible to start the software business at a low level, with a small investment, and bootstrap the operation. In the hardware systems business this is not a practical approach, however. These projects require substantial financing and an established channel to market. Establishing the necessary contacts and promoting projects to these contacts is a major marketing effort. In many of these projects, systems are being proposed to address major problems (e.g., oil spill mitigation or luggage bomb detection) with new technologies and/or products, and it has proven difficult to find strategic partners under these circumstances.

The Typhoon/SBL joint venture has proven to be a successful venture overall despite the fact that the promotion of the system projects has been a drain on the revenues of the software business and on the time of top management. The software business alone could probably have grown faster with higher profitability were it the sole activity.

In mid-1998 there were three large software contracts pending. The first was with the government of Guam to refurbish its computer systems for handling investment, taxation, banking, etc. The second, with the Bank of America, would involve work on an encrypted global network. The third contract is a major extension of their contract with Harris and would include hardware work as well as software. Typhoon/SBL is also collaborating with IBM and Novell on speech-recognition software, which is a large potential field.

The software business at Typhoon differs from that of other U.S.-Russian cooperative ventures in that it is a startup, founded by a sole entrepreneur with no government guidance or financial assistance. The software business has been quite successful in commercializing technology in the sense of utilizing the skills of Russian programmers and software developers on a customer-by-customer basis. It has not as yet resulted in the development and marketing of proprietary software products. The commercialization of technology into hardware systems and products has also not yet been achieved.

When the financial crisis hit in August 1998, Typhoon saw it as an opportunity to capitalize on the resultant labor rate differential by hiring additional staff. Since their revenue is all dollar denominated, and they do not rely on subcontractor or supplier chains, they may actually benefit from the crisis.

IV. Analysis

In analyzing the case studies it is important to remember that the cases are limited in number and some important sectors are not included. Success in commercialization varies considerably among industrial sectors. The results depend, among other things, on the level of Russian technology compared with other countries, the integration of the industry, international market demand, geographical location, and the degree of state support during the transition.[1]

It is important to understand the differing perspectives of the Russians and Americans toward technology commercialization. The belief of the Russians in the commercial value of their technology was bolstered by the large and early U.S.-Russian ventures in the space-launch business. Many Russians believe that the ventures in this industry can serve as models for U.S.-Russian cooperative commercialization ventures throughout the defense industry. However, the political possibility of cooperation in this previously sensitive sector coincided with a rapidly growing demand for commercial space launches for which U.S. companies were not successfully competing with the French. The Russians had built complete systems, as opposed to just R&D, which offered superior technology, cost, performance records, and availability at the same time that there was rapidly growing market demand. It is unrealistic to expect that this model can be replicated across much of the industrial spectrum where this set of conditions is not present.

This can be illustrated by comparing subsectors of aerospace. Cooperative technology commercialization in aviation and space are very different. In the latter, American partners are utilizing major systems, such as Proton boosters, designed and manufactured in Russia. In aviation, there are two types of ventures. In the first, American companies (e.g., Boeing) are contracting for diverse elements of research, engineering, and testing, which they then incorporate into aircraft manufactured outside of Russia. In these cases, the technology transfer is largely, but not completely, from Russia to the United States. There are also projects, such as the IL96, in which U.S. companies (e.g., Pratt & Whitney, Collins) have entered into a joint venture for the production of Russian airliners utilizing U.S.-developed engines and avionics.

[1] Ksenia Gonchar, *Research and Development (R&D) Conversion in Russia* (Bonn International Center for Conversion, May 1997).

The ultimate plan is that many of these components will be manufactured in Russia. In this case, the main technology transfer is from the United States to Russia. The financial viability of the IL96 is not yet assured as sales have been very low. The international space ventures have been a major factor in the revitalization of the Russian space industry whereas the civil aviation industry is still in a precarious financial condition with very few sales of aircraft.

In Russia the overall process of innovation and technology commercialization involves a combination of public and private organizations and actions. The federal government is involved in sponsoring research, setting regulations for patents, standards, antitrust, etc. The private sector is generally involved in product selection, development, production, and distribution. In the Soviet Union the state had control over the entire process. It was a highly integrated system designed almost exclusively to serve the needs of the military.[2]

Industry-supported projects are more market-driven. They are generally initiated as a result of a need for technology to fulfill a commercial requirement, such as product improvement or reduction of production cost, or to solve a particular production problem. These projects usually involve only the Russian enterprise or researchers and the U.S. company. They tend to involve less research at the feasibility stage and are often more a matter of applying existing research results to a specific commercial problem. As a result their time to market is generally shorter, and the overall costs are generally less.

This can be demonstrated by comparing the U.S. and Russian approaches to the dual use of technologies. The Russian approach is application of military technology to civilian applications. The U.S. approach is primarily application of civilian technology to military applications. The latter, being market driven, has advantages of rapid development, cost reduction, competitive designs, etc. The former is slow, expensive, and monopolistic. It also suffers from some of the other problems of spinoff—e.g., the need for extensive development work to make competitive products from technologies. In the U.S. case the product development, cost-effectiveness, and manufacturing techniques have all been worked out without the burden of military procurement restrictions. If the military decides to procure components or subsystems from civil products, it is the goal of the acquisition reform program that it can buy them as is and design the military system to utilize them. This is the same way that a manufacturer of civilian products, such as electronic appliances, will design to use commercially available components. In the Russian model (military to civilian), the military products or components are rarely in a form that can be directly utilized in the civilian products. At a minimum, more cost-effective production will have to be established for the end product to be competitive.

Before looking at specific cases, it’s instructive to examine the reasons that U.S. companies do and do not invest in the commercialization of Russian technology. The primary motivations to invest are market penetration, access to technology, cost-effective R&D, access to qualified personnel, utilization of proven systems, and to further nonproliferation and demilitarization. A company may, of course, have multiple objectives.

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[2] Ksenia Gonchar, *Research and Development (R&D) Conversion in Russia.*

A. Motivations for Investment

Market penetration

Some U.S. companies are mainly interested in positioning themselves to sell their products to the Russian market when it expands. They recognize that the market for their products is currently small and developing quite slowly; however, they believe that a long-term, cooperative presence in Russia will be beneficial in their effort to capture a significant market share later. They invest in ways that will provide varying amounts of Russian content in their products and that will integrate them into the relevant sectors of the Russian economy. Their investments provide varying rates of return directly (independent of market penetration) such as by providing high quality, cost-effective R&D, but those returns alone often would not be great enough to motivate the investments. It is implicit in these cases that market penetration will involve some sort of U.S.-Russian cooperative venture with the potential for the Russian partner to develop a sustainable business.

Companies in industries with longer time horizons for product development are more suited to investment in Russia because of the long time required for technology ventures there to be functional compared with U.S. ones. In addition, investments that are made partially to penetrate the Russian market are also apt to require a long time for that market to mature. This may partially explain why companies in fields with long product cycles may be more apt to invest than companies in the computer industry, for example, where product life cycles are much shorter. A related reason is that in industries with shorter product life cycles the technology gap between the United States and Russia tends to be larger because the underfunding of R&D in these fields has led to the Russians falling a few generations behind.

Access to Technology

In selected fields where the Russians possess superior technologies or the background technology to do cutting-edge R&D, U.S. companies have sought access to this technology to improve their own products' performance and/or cost. In most of these cases the program evolves into R&D that produces still more advanced technology.

The potential for the Russian partner to form a sustainable business can range from virtually zero to quite high. A sustained research relationship and a sustainable business do not always coincide, however. The long-term business depends on both the sharing of rights in the research and the involvement of the Russian partner in aspects of commercialization beyond the research work itself.

Cost-effective R&D

This overlaps the previous category in that some key background capability is necessary to perform cost-effective R&D; however, there need not be unique or superior technology resident in the Russian organization. In addition to the wage differential, the Russian organization may have a testing facility, for example, that would be costly to replicate and/or that can be operated at significantly lower cost than existing similar facilities in other countries, including the United States. Here too the potential for the Russian partner to form a sustainable business varies widely.

Access to Qualified Personnel

This overlaps the previous two categories. There are fields in which there is a shortage of qualified personnel in the United States. The primary example in the cases studied herein is software engineers and programmers. Groups of these personnel in Russia often have skills not found in their American counterparts and/or have the advantage of having worked together in teams for several years. The potential to develop a sustainable business is again variable, but can be high if the Russian partner becomes increasingly indispensable and/or of proven value to other possible U.S. partners. The population of potential U.S. partners may be very large in this case.

Utilization of Proven Systems

There is one sector in this study, rocket propulsion, in which the Russians have highly developed and proven systems that can have a major impact on the competitiveness of U.S. space-based telecommunications systems. In this field the dollar volume of both sales and projects as well as the potential for building a sustainable business are high. In these ventures the U.S. partner sought to commercialize existing technology which was already embodied in working systems, even though it has also supported additional R&D.

Nonproliferation and Demilitarization

Private U.S. companies do not have a business motivation to inhibit proliferation and military production. The U.S. government, however, does work toward this end, and endeavors to involve private U.S. companies by providing financial and other incentives. U.S. companies interested in investing for other reasons often view U.S. government programs as a means to reduce costs and risks. Other U.S. government-sponsored programs are operated by enterprise funds and international financial institutions. The government's objective may be economic development as opposed to or in addition to nonproliferation and demilitarization, but the concept of shared cost and risk is essentially the same. This study does not deal specifically with cases of such shared risk, although some of the cases do involve such projects. The concept is extremely important, however, and whether the U.S. government should use such mechanisms to pursue its policy objectives, and, if it should, how best to make these programs effective is a subject of considerable controversy.

B. Disincentives for Investment

U.S. private investment in Russia—both equity deals and contracts—has been quite low. Therefore the disincentives must outweigh the incentives for many companies. This can affect not only the decision of whether to invest but also the size of an investment if a company does invest. It is therefore important to try to understand the disincentives.

The conventional wisdom is that U.S. companies do not invest in Russia simply because it is too risky. There is a combination of commercial risk, political risk (against which insurance can be bought), and factors like crime, corruption, inefficient bureaucracy, and poor infrastructure. U.S. companies, especially high technology companies, are quite accustomed to accepting risk in at least a fair fraction of their investments. They are familiar with the risks of competition and do not expect to win in every competitive venture they undertake. They do, however, want to understand the rules of the competition and have confidence that these rules will not be changed capriciously or ignored by the legal system. The decision is sometimes to wait or to start at a very modest level. Needless to say, U.S. companies have far more investment opportunities in the United States and globally than money to invest. When a U.S. company has an important long-term objective, it will weigh the risks and benefits and often invest in the face of considerable risk and ride out the fluctuations. There are examples of this in this study. It is necessary to compare the types of risk with which companies are familiar and are willing to accept. In the cases studied as well as in discussions with companies not investing in Russian technology commercialization, several disincentives were cited:

• Some of the technology is not as advanced as the Russians believe. Technologies may be scientifically advanced yet lack commercial potential in the evaluation of U.S. companies.

• Even though markets in Russia may eventually be quite large, they are developing much more slowly than in other countries such as China.

• There still is limited data in the West in useful forms, including financial data, about the available technology in Russia and its commercial potential. More important, there were virtually no competitive commercial high tech products developed in Russia, so the connection between technology and commercial value has not been demonstrated widely.

• Domestic funding for R&D in Russia has dropped dramatically in the last decade with the result that much of the technology and many research facilities are out of date. A decade is a very long time when product cycles in the West are often as little as one to three years.

• Very little of the technology in Russia was in the principal fields of heavy U.S. investment in technology, such as computers and information technology; software is an exception, in which there is great capability, but there was not a software industry in Russia with established software companies and products. The software was embedded in military systems and the workers were scattered about in end-user organizations.

• In the United States the easiest technology to commercialize is that which is developed in-house by commercial product companies. In Russia R&D and production were often arbitrarily separated into different enterprises.

• Much successful innovation in the United States results in incremental improvements in established products and processes. The baseline products to improve and the resultant market position do not exist in Russia.

• While U.S. companies invest extensively abroad, it is often for lower costs or market access, as opposed to investing in technology.

Many of these disincentives are less applicable to countries with less advanced technology-based economies than the United States, and in some of the enterprises studied a substantial percentage of their foreign contracts are with such countries.

C. Analysis of Cases

In this section we look at the data from the case studies, primarily by comparing different cases in terms of specific factors.

Types of Ventures

There are several types of ventures in these cases: large production joint ventures, small spinoff joint ventures, a wholly owned research laboratory, one startup equity-sharing venture, and many contracts between existing entities. The large production joint ventures are in the space-launch sector (e.g., Sea Launch and RD/AMROSS) and aviation (e.g., General Electric-Rybinsk Motors).[3] In general these joint ventures utilize both Russian and American

[3] See also the case studies of LKEI and P&W–Perm Motors in David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises* (Stanford, CA: Center for International Security and Arms Control, 1997).

technology. These are all high-investment, high-potential-reward ventures. The manufacture of the subsystems based on Russian technology is performed by the Russians with the exception of RD/AMROSS, in which manufacturing will be done by PW for any U.S. Air Force procurements in addition to Russian manufacturing for commercial customers. This dual manufacturing was initiated to satisfy an Air Force requirement, but it will be interesting to see if it leads to a closer coupling of the partners and possibly additional cross-licenses as a result of the additional technical interchange. This appears to be the case in other closely coupled ventures such as Sun-MCST, but that is a very different type of activity not involving manufacturing.

The other joint ventures have occurred when a large diversified enterprise (e.g., TsAGI, NPO Mashinostroenia) form a venture based on a small segment of their business or technology. In such ventures the Russian partner is generally loath to give up majority equity to the American company or to give full operational control to an American manager in the venture.[4] However, American companies are frequently reluctant to provide most of the financing without gaining control.

TsAGI approached the issue of technology commercialization from an organizational standpoint as well as from technical and market standpoints. Starting from the premise that TsAGI would probably remain a state-owned institute for a considerable time, it devised an organization plan that would allow it to set up subsidiaries and joint ventures, which might even be privatized, with Western partners. The split of ownership would be determined based on the degree to which a particular technology was central to the core technology and operations of TsAGI.[5]

The one case of a wholly owned research laboratory in Russia is the Corning Scientific Center in St. Petersburg. Corning's intent had been for the center to be a joint venture with two Russian institutes; however, the Russians preferred to simply obtain contracts from Corning.

The one cross-ownership venture is the relationship between Typhoon Software and Santa Barbara Ltd. It is also the one case in this study that is a bilateral entrepreneurial startup established specifically for a niche market that is dependent on marketing by the U.S. partner and technical work by the Russian partner. It is not very large, but it is important because it is successful and is a model that appears to be reproducible on a substantial scale.

The majority of ventures studied herein are contracts, although the dollar volume involved is probably smaller than in the few large space-launch joint ventures. In general both sides seem to prefer contracts. The Americans prefer contracts because it limits their exposure, and the Russians because they neither give up equity nor have to invest capital.[6] A few years ago some of the Russian enterprises in this study (e.g., NPO Mashinostroenia and TsAGI) seemed

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[4] This is often the attitude of large Russian enterprises.

[5] David Bernstein and Jeffrey Lehrer, "Restructuring of Research Institutes in Russia: The Case of the Central Aerohydrodynamic Research Institute," in *Conversion of the Defense Industry in Russia and Eastern Europe*, Proceedings of the BICC/CISAC Workshop on Conversion, 10–13 August 1994, Joseph Di Chiaro III, editor (Bonn International Center for Conversion, April 1995).

[6] There are some U.S. companies (e.g., Caterpillar and Baxter International) that have a policy of participating only in majority-owned joint ventures, and there are others (e.g., Sun Microsystems, Rockwell) that avoid joint ventures. See David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

to prefer joint ventures. In an interview in 1996 GosNIIAS was very enthusiastic about its foreign ventures, but it is now concerned about becoming too dependent on such ventures.

There is a strong tendency in Russia to look for debt as opposed to equity financing for the start of small businesses or of commercial ventures within existing enterprises. This is partly because of the lack of a venture-capital sector in Russia, but it also appears to be partly because the concept of equity financing is more foreign to people trained in the Soviet system. However, the risk-reward factors and the use of the investment in ways that imply a long time to return on investment argue for the greater use of equity financing.[7] It is not clear that this is a good long-term strategy for the Russian companies in terms of the probability of developing a sustainable business proprietorship.

The contracts category can be further subdivided based upon the requirements on behalf of American companies of the recipient of the contracts. Russian research institutes tend to insist that the contract be with the institute so they can control the allocation of contract revenues between the specific research project and the operation of the institute at large. The U.S. companies often oppose this because they want the funds to be concentrated on their research project. These Russian institutes do not have an established broadly accepted overhead rate as do contract research organizations in the United States. They often want to use indirect funds to support unemployed labor. This, and the low volume of business, makes it difficult to negotiate adequate indirect funds to maintain costly facilities.

Some companies (e.g., FMC) contract directly with the researchers whenever they can. Some institutes allow this because it is better than nothing in that it keeps key people employed. There is a problem here in that if a project is run that way and succeeds and grows, the employees are apt to start their own company.

In cases like FMC-Karpov, FMC allows payment of a certain amount of overhead to the institute. In other cases (e.g., Rockwell, Ashtech)[8] the U.S. company sometimes encourages the researchers to start their own company or tries to hire them directly. In still other cases (e.g., Air Products, Boeing CAG) the U.S. partner contracts directly with the institutes and tends to build substantial projects involving considerable facilities of the institutes, and the U.S. company will even invest in major amounts of capital equipment. These companies are often more interested in building a long-term relationship than in minimizing costs. In Boeing's case it wants to establish itself as a cooperative member of the aviation industry in Russia. In the Sun-MCST project, Sun has spent considerable money on equipment and facilities that enabled MCST to gain greater independence from its parent institute.

It appears that some of the longer-established enterprises will become major factors in the Russian economy when it strengthens. In that case they would be apt to work more with the U.S. companies that they feel have not undermined them by hiring away personnel or encouraging personnel to leave to start their own businesses.

There is a distinction between the prime contractors (e.g., Khrunichev, Energia, and Energomash) and subcontractors (e.g., TsAGI) that are also engaged in the aerospace sector. Because of its unique testing facilities TsAGI has some role in virtually every major Russian space and aviation program; however, this is usually a subordinate role as a subcontractor. In

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[7] John Barton and Simone Shaheen, "Sharing the Wealth: The Role for Venture Capitalists in Russia's Economic Development," *Law and Policy in International Business* 27, no. 1 (Fall 1995); and Franklin P. Johnson, *The Application of Venture Capital and the Entrepreneurial Revolution in Russia* (Stanford, CA: Center for International Security and Cooperation, August 1998).

[8] See David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

this position it is harder to build a coherent business in which it has control over the flow of activity.

This project did not involve interviews with enterprises that were smaller subcontractors and suppliers; however, the interviews with some of the primes (e.g., Energia, Energomash) indicated that there were serious problems in the viability of the supply chain, and that these problems were exacerbated by the financial crisis of August 1998. It is far too early to estimate the effect of these supplier problems on otherwise strong projects.

Research and Development Programs

There are several U.S. companies in this study that are heavily engaged in sponsoring R&D in Russia and gaining access to technology even though that may not be their sole motivation for working in Russia or represent their major activity there. It is interesting to compare their approaches. The companies studied herein in this category are Air Products and Chemicals (APCI), Boeing Commercial Airplane Group (BCAG), Corning, FMC, General Electric (GE), Sun Microsystems, and Typhoon Software. In a previous study other U.S. companies (e.g., Ashtech, Intel, Rockwell, and Paragraph International) were also engaged heavily in research.[9] All of the R&D ventures considered here are small to moderate in size, entailing tens or perhaps a few hundred personnel. The objectives and strategy of different U.S. companies vary widely. In some cases the primary objective is something like market penetration (e.g., BCAG, Intel) which has little direct link to R&D. Here the strategy and the evaluation of results may not be optimum if viewed solely from a technology development perspective. BCAG gets valuable results from its R&D in Russia and continues to broaden the range of projects, having recently added projects aimed at acquiring certified titanium alloys, designing tooling, and designing structural components of aircraft. It is doubtful, however, that it would have started such a major, diversified program in Russia solely for the technology.

Toward the other end of the spectrum are companies (e.g., APCI, Corning) that felt a need to be abreast of scientific and technological progress globally in certain fields. They recognized that a great deal of advanced research had been done in the large scientific infrastructure in the Soviet Union, and as this work was opened to the international community they took substantial steps to be aware of and participate in those fields. They carefully chose their principal partners and opened large (on the order of one hundred people) research operations. After these programs were established they became increasingly responsive to the product divisions and less broad-based exploratory R&D.

Sun Microsystems is such a case in the end result, but the motivations came from the initiative of Russian research personnel. In all cases except Sun the U.S. company initiated the contact and went to Russia looking for specific capabilities. In Sun's case a Russian group, which later became MCST, was actively seeking a Western partner and pursued what it perceived as the needs of various Western companies.

Other companies (e.g., Boeing, FMC, and GE) sought to satisfy various technology needs of their product divisions by finding appropriate research groups in Russia. In all three of these cases the company centralized its search for the technology through a corporate office/lab. Only in Corning's case did it establish a company laboratory in Russia, staffed with Corning personnel (who were mostly hired in Russia). This was primarily because its Russian partners were not interested in forming a joint venture. Some, such as Boeing, established a

[9] See David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

research center in Russia, but this was mainly a facility in which institutes under contract to Boeing could utilize Boeing's computer facilities.

BCAG has essentially one product line which can utilize a broad range of technologies; its long-term involvement in Russia may well involve design and/or production agreements with major enterprises, and it must position itself to move into these if and when it seems appropriate. Other companies (e.g., FMC, APCI, GE, Corning) are interested in a broad range of technologies for a broad spectrum of product lines. Each product has its own market penetration issues as well as its own technologies.

Sun's case presents an interesting contrast in that Sun works basically with only one Russian partner, MCST, which has a large number of personnel working on a few major technical problems for Sun.[10] They have been working in some of these areas (e.g. compiler development) for several years and have gradually become more central to critical-path programs within Sun. In this capacity Sun has shared an increasing amount of its proprietary information with MCST and has integrated MCST more and more into Sun programs. Sun does not have an expatriate manager in Moscow, but Sun personnel visit periodically and Sun rotates MCST technical personnel to Sun's headquarters. APCI and Corning work with a small number of Russian enterprises. FMC and GE, like Boeing, work with several partners. In at least some of its Russian projects, FMC takes a very different approach from either Boeing or Sun. It contracts for specific research tasks and then incorporates the results by itself into its products and processes. Most of the others are somewhere in between, with APCI being closer to the Sun model and GE being closer to FMC. In Boeing's case it often has the Russian contractor add considerable value in the commercialization process and will even assist the contractor with technology or in other ways to enable it to accomplish this. Boeing and Sun also learn from the different approaches that the Russian contractors take to address technical problems. This can not only lead to additional projects, but can also help the Russian partner develop a business proprietorship. Even in the many successful cooperative R&D ventures, the Russian partners believe that the Americans are forcing the price for R&D too low to enable them to maintain, let alone expand and modernize, their capabilities. This, they believe, inhibits innovation. Some American companies (e.g., Sun, Boeing, APCI, Corning) have invested heavily in equipment, particularly computer equipment, but the financial situation in all of the Russian enterprises is very tight.

The Soviet/Russian research establishment was large and supported primarily by the military. The residual Russian research establishment has shrunk, but it is still large compared with the demand (military and civil) for its services. So it is a buyer's market, and U.S. companies have been able to negotiate very favorable contracts from the standpoint of both cost and terms. As supply and demand come into better balance, the Russians become more skilled in commercial negotiations, and transaction costs and difficulties decrease, this should change.

In the United States there are many contract research companies and institutes, both for profit and not for profit, but most of them are privately owned. Their size is determined by the revenues they can generate, not by government subsidies. These markets fluctuate, but not to the extent that they have in Russia over the past decade. The infrastructures and experimental facilities of these companies are also in balance with their revenues and can be maintained within reasonably stable and competitive cost structures. This is simply not the case in Russia, and major facilities cannot be maintained following large decrements in fund-

[10] Sun has another venture with Elvis+, but it is of a very different nature; see David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises.*

ing. The fact that the state doesn't even pay for all that it orders only exacerbates the situation.

Typhoon is a special case in that it and Santa Barbara Ltd. are both startups formed expressly to work together on specific opportunities and involving some cross ownership. Therefore many of the questions that arise in a sponsor–contractor relationship are absent. Paragraph International is similar except that it is one company, and its U.S. and Russian offices are both staffed almost completely by Russians.[11]

A common characteristic of all these cases is that the lead personnel on the U.S. side stress the importance of building a relationship of mutual trust and respect. They tend not to depend on legal protection nearly as much as on the strength of the relationship. In all cases the primary points of contact are technical personnel.

Business Proprietorship

The ventures studied differ greatly in terms of the Russian partners' likelihood of building a sustainable business proprietorship. The most important factors appear to be

- the role that the Russian partner is able to take in the commercialization project, which is closely tied to the breadth of the value chain in which it participates,
- the size and duration of the cooperative venture, and
- the strategies of the two partners.

Large systems enterprises (e.g., NPO Energomash, Energia) are in much stronger bargaining positions than R&D institutes. Several U.S. aerospace companies competed for rights to Energomash's RD-180. The demand for their products often permits them to negotiate terms that enable them to participate profitably in much of the value chain. This is less so when they are engaged in projects such as ISS that are dependent on funding from the Russian Space Agency. Consequently these enterprises put a heavy emphasis on international commercial ventures.

In some cases (e.g., FMC-Karpov) the U.S. company pays to have specific narrow research projects performed. The choice of projects is based on the needs of the U.S. companies' product divisions. Following completion of the research the U.S. company integrates the results into its products or processes. If this integration is done in the United States solely by the American partner's personnel, then the Russian partner does not have an opportunity to participate in the commercialization or marketing. It may or may not have the rights to utilize the technology for its own commercial activities, but this is often less important than opportunity to increase its role in the value chain.

Cooperative commercialization ventures with Russian research institutes often involve only the performance of research. Since there is little market thinking in many of the institutes they often do not learn much about working in a market environment during these research projects. Therefore the broadening of participation in the value chain does not take place to the degree necessary to build a sustainable business. This tends to be the case when the

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[11] Paragraph International was not available for an interview for this report. For background see David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

alliance is one of technology as opposed to a market alliance.[12] These institutes often do not have a strategy that emphasizes building a sustainable commercial business.

In other cases (e.g., Sun, APCI) the U.S. company goes to great lengths to integrate the Russian partner into the larger project to which it is contributing. This involves the business aspects of the overall value chain as well as the technical ones. They periodically bring the Russian personnel to the U.S. laboratories and share proprietary data that helps the Russian partner understand the objectives and strategy of the program. This often leads to unanticipated valuable innovation by the Russian partner. The project managers at Sun, Boeing, and APCI have also helped their Russian partners get additional contracts, either with the U.S. company or with other, noncompeting companies.

The ability to expand in the value chain and develop a business proprietorship by no means depends solely on the approach of the U.S. partner. Some institutes (e.g., Karpov) do contract work for Western companies in order to survive, but they do not appear to have developed and implemented a strategy to seek this work and use it as a foundation to build a sustainable business.[13]

Other enterprises (e.g., NPO Mashinostroenia [NPOM], TsAGI, MCST) have formulated corporate strategies since the early 1990s. Implementation of these strategies has involved considerable trial and error, but they devote the necessary management resources to pushing forward strategically. NPOM and TsAGI had the advantage of becoming State Science Centers and hence receiving some amount of state support. The strategies of NPOM and TsAGI (as well as some other larger enterprises like Leninets)[14] are leading them to become diversified companies with several apparently viable business areas that have the potential not only to be sustainable but to grow substantially. Whenever they engage in a new activity they consider all aspects from the basic technology to the market considerations.

It is not clear, however, whether large companies that are collections of very different small businesses is a strong model in the long term. In the United States there was a time when conglomerates of this type were very much in vogue, but they have proven to be less significant factors over time, especially in manufacturing. Even in the U.S. model of conglomerates, the component businesses were larger, more experienced companies that had existed independently. The conglomerates were generally assembled through acquisitions of such independent businesses, whereas in the Russian case they comprise more internal startup businesses. They are more analogous to a shopping center, where diverse businesses share infrastructure, than to large Western companies. The Russian enterprises have adopted this approach as a matter of necessity since they are forced to engage in almost any business venture that can provide revenue to sustain staff and capabilities, to nurture partnerships, and to penetrate commercial markets. As capital markets mature there may be some reaggregation of these businesses, but it is hard to predict how this might evolve.

The Soviet legacy of separating research institutes from production enterprises added another burden to the institutes. They not only lacked support to carry on R&D, but they also did not have the capacity and experience in serial production. Thus their in-house capability

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[12] Petra Opitz and Thomas Sauer, "From Strategic Technology Alliances in Russia (STAiR): First Results" (Bonn International Center for Conversion, June 1997).

[13] Petra Opitz and Thomas Sauer, "From Strategic Technology Alliances in Russia (STAiR): First Results."

[14] David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

to expand their role in the value chain was limited. The production enterprises with which they had previously worked now often prefer to rely more on their own in-house R&D capability in order to keep their technical staffs employed. Even in market economies like the United States, when the economy declines companies have a tendency to do more work internally and less by subcontracting. In the long run this will lead to more rationally integrated companies. A constructive approach would be for some of the production enterprises to acquire portions of some research institutes, but this is not as prevalent an approach in Russia as it is in the United States.

In MCST's case it built a business from the ground up on the basis of the Sun contract. It was not merely good fortune that brought it this contract. MCST did a thorough job of studying the market and presenting Sun with a proposal of relevance and value. Its attitude was exactly the opposite of that of its parent institute, IPMCE, which viewed Sun simply as a source of cash.[15]

It is somewhat easier for a software company to expand in the value chain since both the end product and the R&D are of the same substance, whereas physical products resulting from laboratory R&D require different equipment and skills to produce. Some of the Russian partners, typified by MCST, have expanded in the value chain in the sense of providing essential software to their customers and have built a business proprietorship in the sense of being a contract research organization or an OEM provider of an integrated software program, but not in the sense of being a provider of much proprietary software to multiple users. Paragraph International has built a proprietorship in the latter sense. This does not detract, however, from the importance of MCST's recognition of the parameters of the opportunity it had and in developing and implementing a strategy that has led to a successful startup business.

The role of the Russian partner and the expansion in the value chain illustrates another comparative advantage of production enterprises and NPOs over research institutes. The work of the institutes is usually at the early (front) end of the value chain. (Software development can be an exception.) They are thus more removed from the final market than the other enterprises. The work of the NPOs and production enterprises has historically been directly tied to an end product or process, albeit usually military. An example at NPOM can illustrate this. For many years NPOM built and operated satellite systems to generate images of the earth from space. It was also involved in processing the data. The application of this activity to civilian needs was relatively straightforward, especially since that market was already opened and expanding, and the market was international.

By contrast, a research institute may have been doing sensor and data processing research that involved very similar physics and mathematics, but not building and operating complete systems that were deployed. Such an institute would have a much more difficult time gaining a comprehensive role in the commercialization of this technology. As important as this may be, it is not meant to detract from the fact that the management of NPOM started exploring commercial markets in the very early 1990s. They studied market-oriented business practices, trained managers, and made extensive contacts with Western companies, and then they recognized and appreciated market opportunities like this one. Many of their conversion projects were not successful, but they derived valuable experience from them and have applied this to other, more successful projects.

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[15] See David Bernstein, editor, *Cooperative Business Ventures between U.S. Companies and Russian Defense Enterprises*.

NPOM's successful marketing of the railroad schedule boards reflects that experience. It was an example of adapting the enterprise's capabilities and technology to a real market opportunity that was not in its traditional fields of business or at its traditionally high level of technology.

The size and duration of the contract is also important to the ability of the Russian partner to build from a contract to a business. Almost all contractual relationships start out small as the U.S. company tries out the process. This is not simply a test of the Russian partners' technical capability, which usually is quite credible beforehand. The issues are the ability of the partners to work together culturally as well as technically; the ability to overcome barriers of geography, language, and the complexities and defects of the Russian infrastructure; and the ability to perform research that is to specifications, on schedule, within budget, and well documented.

Recognizing this, the Russian partner should engage the Americans early on in a discussion of the longer-term potential of the relationship. This should include matters of potential size, roles, training, property rights, and business objectives. It is true that a Russian enterprise struggling to survive is not in a strong bargaining position, but a demonstration of interest in these longer-term objectives can actually increase the confidence level of the American partner.

There is another factor that limits the extent to which technical innovation can lead to broad involvement in the value chain. As pointed out above, a great deal of technology commercialization in the United States is the result of incremental improvements in products and processes. This is best suited to companies with well-established product lines and markets as well as the cash flow to allocate reasonable funds to R&D. The selection of R&D projects is made on the basis of many factors other than simply technology. Marketing, manufacturing, and finance departments have major input into the new-product development decisions, which tends to consolidate the value chain. Very few Russian companies are in such a position. In addition the traditional integration and structure of Soviet/Russian industry was not conducive to this consolidation. R&D and production were often in different enterprises; finance and distribution were handled by the state; and marketing was essentially nonexistent. Russian enterprise directors frequently talk of the need to maintain the technical chain; they talk less of the value chain as it relates to a competitive commercial product line.

V. Conclusions and Recommendations

1. U.S. companies invest in commercialization of Russian technology for diverse reasons including access to technology, reduction of R&D costs, and market penetration. The U.S. government fosters and participates in such investments in order to reduce the potential of Russian technology and personnel related to weapons of mass destruction to become a proliferation threat. Because of the different motivations of the U.S. government and U.S. companies, the two sometimes differ over policy, such as on issues like export control, or over the importance of certain types of training that deal with broader economic development as contrasted with project success. These objectives only partially overlap the Russians' objectives. As a result many cases of cooperative commercialization of Russian technology do not lead to sustainable businesses in Russia.

2. The prospects of the Russian partner developing a sustainable business depend in part on the formulation and implementation of a strategy that includes market-oriented management, staff training, marketing, and securing participation in far more of the value chain than R&D, especially in the downstream elements of the value chain. They also depend on developing a relationship that will lead to large, long-term projects with a partner that will give the Russian side an expanding role in the commercialization.

3. The federal and local Russian governments and the managers of major enterprises can assist the commercialization of technology by removing barriers and disincentives to foreign investment; building the commercial infrastructure; increasing business education; protecting intellectual property rights; imposing and adhering to hard budget constraints; promoting the development of small high-technology companies; fostering the integration of R&D with production; and cracking down on crime and corruption.

4. Russian enterprises seeking to build their businesses through bilateral technology commercialization ventures should recognize the importance of establishing separate profit centers and spinoff companies to increase the chances of partnering successfully and building well-focused, sustainable businesses.

5. Western programs could probably improve the chances of commercial success by involving both R&D and production enterprises in Russia and working to integrate subgroups of the enterprises into coherent business entities.

6. The Russian government can also stimulate technology commercialization by targeting its investment on competitively bid projects rather than organizations; by encouraging the formation of domestic and international teams to bid on projects; and by only placing orders for which it can pay promptly and reliably.

7. Western companies generally provide both capital and market access, which gives them a dominant position in cooperative commercialization ventures. Western government programs to foster economic development in Russia should balance this by taking a comprehensive approach toward the entire value chain and infrastructure, training, and local/regional economic development. The importance of local/regional commitment to conversion is one of the few elements of U.S. experience that can be utilized in Russia.

8. Long-term, expanding programs are to the advantage of both partners. This may involve greater investment by American companies than simply acquiring nuggets of technology to bring back to the United States for commercialization, but the long-term payoffs seem to justify this.

9. The level of foreign investment in technology commercialization ventures in Russia has been small, but there are a significant number of projects that have been in place for several years and are providing U.S. investors with satisfactory results. Companies wanting to invest in Russia can build on the experience of previous examples and thereby greatly increase the probability of success.

10. Success appears more easily attainable in ventures utilizing human capital (e.g., software development and R&D) as opposed to manufacturing assets, and in ventures involving complete Russian systems (e.g., rocket propulsion). Intermediate cases involving establishing new manufacturing appear more difficult, but there are successful models.

11. The financial collapse of August 1998 is having a major impact on the entire economic reform program in Russia. The form and extent of this impact on ventures involving Western partners, where finance and market access are their responsibility, are hard to predict at this time.

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