# A Strategy for NASA's Utilization of Space Assets in the Former Soviet Union

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ABSTRACT

The end of the Cold War has opened up unprecedented opportunities for the U.S. to benefit from the vast resources of the former Soviet space program. Unfortunately, due to a lack of clear and consistent policies, the U.S. space community and NASA in particular has been slow to exploit these opportunities. In this paper an improved strategy for NASA's pursuit of Russian cooperation is developed that specifies the recommended areas in which to cooperate and the suggested means for implementation. Detailed information on the capabilities and operation of former Soviet space enterprises is also presented as background. The strategy was developed using lessons learned from past and on-going joint aerospace projects with Russian as well as other international partners. Evidence to support the recommendations was gathered through dozens of interviews with space officials both in the U.S. and former Soviet Union.

The analysis identifies newly emerging objectives for international space ventures in support of foreign policy and industrial competitiveness goals. NASA's present approach to cooperating with Russia is built upon short-term government-led projects that neglect these broader objectives. Recommendations for making space policy structures at NASA and at the national level more responsive to U.S. long-term strategic interests are presented to overcome this shortcoming. To effectively meet the needs of U.S. and Russian partners alike, it is recommended that NASA make greater use of private companies with their efficient commercial practices as the interface to Russian industrial enterprises.

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# Introduction

The Soviet Union, with its enormous military strength and hostile political ideology towards Western democracies, represented the single greatest threat to U.S. national security for over thirty years. In support of its Cold War competition with the U.S., the Soviet Union created the world's largest aerospace industry to produce military hardware and technological achievements to wage its propaganda campaigns. But with the ascension of Mikail Gorbachev in 1985, a thaw in the Cold War began as a dramatic era of restructuring (perestroika) took hold of Russian society. Eventually the forces that Gorbachev put in motion went beyond his control leading ultimately to the collapse of the Soviet Union in December 1991. With the central government that created it no longer existing, the former Soviet space program was plunged into turmoil. The aerospace industry had enjoyed extensive government support throughout the Cold War years, providing it the resources to become one of the few Soviet industries with products and technologies of international caliber. Yet to the surprise and dismay of Soviet industrial leaders, their initial efforts to earn hard currency by selling space hardware and services abroad met with little success. Fear of political instabilities, effects on domestic industry, and national security concerns along with simple ignorance of what the Russians had to offer often resulted in lukewarm Western responses. This coolness toward Russian overtures has now changed led by the Europeans and their direct financial support of the Russian space program beginning in 1991. In the U.S., due mainly to foreign policy concerns that without assistance Soviet industry would be unable to transition to a market economy or control the proliferation of weapon technologies, the government has also begun to support increased space contacts with the Russians. A new agreement that substantially expands the potential areas for U.S.-Russian cooperation in space was signed by Presidents Bush and Yeltsin in June, 1992 and it has resulted in a near explosion of joint space ventures between the two former adversaries.

The new cooperative environment between the U.S. and Russia opened up many promising opportunities for American organizations to benefit from the accomplishments of the Soviet space program. The former Soviet Union has ten operational launch vehicles including the enormous Energia booster which can place more than five times as much mass into orbit as any U.S. vehicle. Even under the present chaotic conditions the Russians continue to launch over 50 flights a year, more than the rest of the world combined. Russian cosmonauts have spent over a year in space and continuously man the Mir station which has orbited the Earth since 1986, a far cry from the few weeks a year that Americans spend in space. And many Russian space technologies in such areas as materials processing, propulsion, and power systems are significantly more advanced than in the U.S.. Without a doubt, there is technically much that the Russians could offer the U.S. space program. In addition, the former Soviet Union's emphasis on mass producing simple space hardware could provide the U.S. a low cost option for meeting some of its space hardware needs.

But beyond the opportunities to enhance the U.S. space program by utilizing Russian capabilities, cooperating with the Russians also supports many foreign policy goals. The former Soviet states have undertaken an enormously difficult task in attempting to transition from an authoritarian form of government with a centrally planned economy to a democracy built upon free market capitalism. A successful completion of this transition is clearly in the best interest of the United States, so prudent policy dictates that the U.S. do whatever it can to support Russian efforts to change. Yet years of neglect and improper use have made many sectors of the Russian economy hopelessly inefficient and possibly unsalvageable. The aerospace industry is one of the few exceptions to this rule, having prospered throughout the Cold War years and developed technologies that could make it internationally competitive. International cooperation with the former Soviet space program could give the aerospace industry the opening it needs to enter the world economy and potentially lead other Russian industries out of the stagnation imposed on them by communist rule. A prosperous free market economy in Russia would provide a foundation for enhanced democracy and greater friendship with Western nations.

Without Western support, the former Soviet space industry will continue to deteriorate and its personnel will become more desperate as sources of funding disappear. Eventually individual experts or whole enterprises may be forced by economic necessity to abandon their advanced technologies or sell them to nations potentially hostile to the U.S.. The loss of technologies whose development required years of effort and the expenditure of untold resources would be a terrible waste. Likewise, proliferation of technologies with military applications from Russia to such belligerent nations as Iraq or Iran would do great damage to U.S. national security. U.S. policy must provide alternatives, besides technology abandonment or proliferation, to Russian space enterprises trying to preserve their existence. Offering the Russians a role in international cooperative space activities would provide them a viable alternative and allow for improved relations between the U.S. and former Soviet states.

The opportunities for cooperating with the Russians in space are indeed promising while the consequences of ignoring these opportunities could be disastrous. Therefore the U.S. government has begun to put great effort into enhancing space contacts with the former Soviet republics. The National Aeronautics and Space Administration (NASA) has taken the lead in utilizing Russian capabilities, although other government agencies, most notably the Department of Defense (DoD), and private corporations are also significantly involved. The U.S. State Department has taken the lead in promoting Russian cooperation and in its coordination among the various government agencies. Unfortunately, it has not been very successful in reducing interagency conflict or in developing a coherent and consistent U.S. policy on the use of former Soviet space capabilities. To date, decisions on the use of Russian space assets have been made on a case-by-case basis, sometimes representing one agency's view and sometimes representing another's. And even within agencies such as NASA, there is little unanimity on the best approach for pursuing cooperation and consequently little uniformity of policy. The result is that the U.S. government in general, and NASA in particular, has pursued inconsistent and inefficient approaches to cooperation that have limited progress and sent mixed signals to potential partners in Russia.

The analysis presented in the following chapters will address the shortcomings in NASA's approach, and the government's approach in general, for pursuing cooperation with the former Soviet space program. Although this assessment focuses on NASA's particular needs, due to the space agency's broad involvement in space activities, many of the recommendations will be widely applicable to other government agencies or to industry. The purpose of this study is to answer two main questions : 1) Under what circumstances should NASA seek cooperation with the Russians? and 2) In such cases, how should cooperation be pursued? Through answering these questions a general strategy for guiding NASA policy makers and project managers will be developed. A key consideration in deriving NASA's strategy will be its affect on other U.S. agencies and interest groups. To avoid the parochial bias that has to date plagued the debate on the use of Russian space assets, a strategic U.S.-level perspective will be maintained whenever possible. Two main sources of information will be used for determining the recommended strategies for cooperation: technical and organization knowledge of the Russian space program and evidence from past and on-going joint U.S.-Russian space projects. European experience in cooperating with the Russians as well as lessons learned from U.S. space cooperation with other nations will also be used to enlighten the recommendations. Finally, the needs and modes of operation of the U.S. space program will play a large role in determining which strategies are workable. All of this information will be integrated in an analytical framework based on the costs and benefits of international space cooperation as discussed in the next section. By weighing the benefits against the costs, appropriate areas for cooperation will be identified and through knowledge of U.S. and Russian needs and prior experience in cooperation, effective approaches for proceeding in these areas will be determined.

A major objective of this analysis is to bring together information from diverse sources to synthesize a better and more consistent strategy for cooperating in space. Too little exchange of lessons learned from different sectors of the space industry, or from related industries, has occurred resulting in many of the same mistakes being repeated. By addressing multiple sectors at once and considering the interests of more than just a single agency, this analysis will avoid the myopic outlook that is crippling present space policy toward the Russians. The entry of the Russians into the international space arena opens up many exciting opportunities for accelerating such fields as manned space exploration and the commercialization of space. By not focusing on narrow organizational interests and the risks involved, but instead creatively exploiting the unprecedented opportunities, NASA along with the rest of the U.S. space community could make use of Russian space assets to stimulate a new era of progress in the exploration and utilization of outer space.

Before proceeding on to the detailed discussions of Russian capabilities and strategies for their use, this introductory chapter provides some necessary background on the costs and benefits involved in international cooperation and the present status of joint activities with the Russians. This is followed in Chapter 2 with a thorough overview of the organization of the former Soviet space program and the space systems that support it. Significant historical information on Russian space organizations is also provided in that chapter to help create a better picture of Russian business practices and how they have developed. Chapter 3 addresses the question of in *what* areas should NASA seek U.S.-Russian cooperation in space. Chapter 4 discusses *how* cooperation should be pursued in these promising areas. The discussions in both of these chapters will draw heavily upon the cost/benefit framework presented in the next section as well as the knowledge of Russian space activities and past cooperative experiences that will be described in later chapters. Chapter 5 concludes the study with a summary of the findings from the earlier chapters and recommendations for improving NASA's approach to cooperating with the Russians. To help simplify nomenclature in the following discussion, the term "Russian" will be used loosely to mean all people of the former Soviet Union unless clear distinction between inhabitants of the different republics is required. In such cases names for individual nationalities such as Ukrainian, Azerbaijani, etc. will be used and the phrase "former Soviet" will be used when describing all residents of the former U.S.S.R..

## 1.1 Benefits and Costs of International Cooperation

The inherently supra-national nature of outer space makes it a natural place to pursue international cooperation. Although the Cold War stifled East-West space cooperation for decades, within each political bloc international joint ventures became the rule in space activities. From its earliest days of operation, the U.S. space program has solicited participation in its projects from nations all over the world. Even the dramatic competition that developed between the U.S. and U.S.S.R. in space was not necessarily inevitable. In an address at the United Nations on September 20, 1963, President John F. Kennedy said: "Why must the first flight of a man to the Moon be the subject of a competition between individual countries? Without a doubt, we need to figure out why the scientists and astronauts of our two countries -- in essence, of all mankind -- cannot consolidate their efforts in the exploration of space"[1]. Following this speak and only eleven days before he was killed, President Kennedy wrote Memorandum on Actions in National Security No. 271, only recently declassified, in which he proposed initiating space cooperation with the U.S.S.R., including the exploration of the Moon. From this newly revealed evidence it is apparent that even President Kennedy, who instigated the great race to the Moon, felt that cooperation in space was preferable to rivalry. Cooperation in space exploration and utilization enjoys much popular appeal since by international law space is considered "the province of all mankind"[2]. However, just because cooperating in space is widely appealing does not mean that the costs and risks involved in conducting multinational projects can be ignored.

Before analyzing the most promising areas for cooperation with the Russian space program and how they should be pursued, it is important to first have a clear understanding of the benefits and costs that can reasonably be expected from international cooperation. Many government agencies and private companies have jumped on the band wagon and espoused all of the wonderful things which international cooperation in space will bring without much thoughtful reflection. Such justifications for international projects as increased cultural understanding, improved friendships among nations and a greater world vision may sound great, but will multinational space projects alone really lead to a more harmonious world? It is doubtful. The added expense of internationalizing a space project must be justified by concrete benefits that result from the participation of many nations. These benefits may be political as well as technical or economic but they must be identifiable and preferably quantifiable, not some vague notion like *increased international understanding*. The following discussion begins with a general outline of the benefits and costs that can be expected from an international space project. This is followed in the next section

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1 J. Logsdon & G. Khozin, "Space Program: The Path to Space, Together or Separately? Lessons and Perspectives of the Cooperation Among the Scientists of Two Superpowers", Nezavisimaya Gazeta, August 14, 1992, p. 6.

2 "Article I", Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, United Nations Treaty, entered into force October 10, 1967.

by specific benefits and costs arising from the use of Russian space assets. The framework presented in the pages to follow will be used in later chapters to determine those areas where Russian cooperation is viable and those areas were the costs exceed the benefits and therefore cooperation should not be pursued.

### 1.1.1 General Benefits and Costs of Cooperating in Space

The three main reasons why nations pursue international cooperation in space activities are to: 1) improve the effectiveness of their space program, 2) further foreign policy objectives, and 3) support the competitiveness of their domestic industries. The most obvious benefits from cooperating in space are those garnered by a nation's space program. International cooperation usually entails cost sharing among nations which allows large space projects to be undertaken that would be too expensive for any individual nation to pursue. The trend in space activities is toward ever larger and more complex projects and consequently one would expect this motivation for international cooperation to become increasingly important. In addition to sharing costs, international cooperation allows the sharing of expertise, technology and hardware so that each nation can benefit from the strengths of its partners. In an analogous manner to a market economy, by allowing each partner to contribute to joint projects in those areas where they has a comparative advantage, the projects' net efficiency can be increased. These improved efficiencies can result in lower project costs, enhanced technical capabilities, and accelerated schedules. Through international cooperation a nation's space program can leverage on its strengths to become more effective and contribute to grand international endeavors that it could not dream of doing alone.

Yet international cooperation in space is not pursued simply for the technical and costs advantages it provides to national space programs. Political or foreign policy motivations have always played a large role in promoting international projects. Space cooperation is used to provide technical and financial support to allies and its accomplishments are used as propaganda weapons against adversaries. Few would deny that a major purpose of U.S. international space projects during the Cold War was to buttress America's position in East-West competition. The secondary effects from combining efforts in space can also be important for international relations. By working together on joint projects, the goals and perspectives of different nations are brought together providing common ground on which to build improved future relationships. And the channels of communications that are developed through joint space activities will unavoidably increase mutual knowledge and empathy among participants form different nations. Finally, through international participation a space project gains political clout which it would not otherwise have. Policy makers are much less likely to modify or cancel a project that has contributions from international partners. Therefore, international cooperation may be used as a domestic political weapon to give projects greater resiliency to the never-ending reviews from funding sources.

The ever more integrated global economy has increased recognition of the role that international cooperation and joint ventures play in improving the competitiveness of domestic industries. The space industry, like other high technology sectors, is beginning to take advantage of international opportunities to enhance domestic competitiveness. The international environment has shifted from East-West military confrontation to West-West economic competition and the goals of our international activities in space should reflect this shift[3]. In addition to pursuing international cooperation to further program effectiveness and foreign policy objectives, governments are now beginning to use joint space activities to help their domestic industries become more competitive. Through joint ventures in space, companies can learn from their foreign partners better procedures, technologies and management practices that can help to improve their overall efficiency. No nation has a monopoly on good ideas making openness to foreign practices and technologies essential to remaining competitive. International competition and cooperation are not mutually exclusive but can be used to compliment each other. Well conceived cooperative projects can improve U.S. industry's performance in areas of strategic importance to future competition. Such improved performance will provide industry the comparative advantage needed to successfully compete in the emerging global marketplace for space goods and services.

There are of course considerable costs and risks that international cooperation adds to a space project. First of all, it is simply more complicated to manage a project that has elements contributed from several different nations. There are language barriers, cultural differences, varying technical standards,

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3 K. Pedersen, "Some Thoughts on International Space Cooperation and Interests in the Post Cold War World", Space Policy, August 1992, pp. 230-232.

and diverse management and legal practices that must be overcome. Identification of interfaces specifications becomes an issue for complex international negotiations instead of being determined by the simple exchange of requirements documents. And even telephoning your partners or traveling to their facilities can add substantial expense, not to mention the costs for making foreign systems technically compatible with each other. Because of these reasons, internationalizing a space project nearly always results in increased operating costs, more convoluted management structures and slower progress.

Related to the costs for increased management complexity are the risk to program success that international cooperation brings. The U.S. has always considered leadership in space exploration an important element of its space program. In the past leadership meant out performing the Soviets and allowing U.S. allies only to contribute nonessential elements to joint space projects. However, now that competition with the Russians has waned and greater parity in space capabilities exists worldwide, the U.S. is no longer able to demand control of the critical path in all of its collaborative efforts without isolating itself. America needs to modify its definition of leadership to include leading more equal cooperative efforts that are chosen through a policy of selective interdependence[4]. Future participation in international projects will undoubtedly expose the U.S. to the prospect that its partners will not come through, possibly resulting in the project's failure. Such heightened risks are inherent in any truly cooperative activity. But by developing long-term relationships with other nations built on trust and respect, these risks can be minimized and America can remain a world leader in space. Continued U.S. leadership will also be important for justifying the space program at home now that the geopolitical imperative to compete with the Russians no longer exists.

The final costs of international space activities that should be mentioned are those related with the control of technology transfer. A major reason why nations get involved in joint space activities is because of the technological and managerial knowledge that can be gained by working with foreign enterprises. But for competitive as well as national security reasons, nations wish to control the amount of technology they transfer to a partner in a cooperative project.

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4 J. Logsdon & J. Fabian, International Cooperation in Space: New Opportunities, New Approaches, Association of Space Explorers and the Space Policy Institute, George Washington University, April 1992, p. 8.

Establishing technology safeguards can be costly and can limit interaction among participants from different nations in a joint venture. And if the safeguards fail, the costs due to reduced industrial competitiveness or compromised national security can be enormous. For these reasons, sophisticated and expensive procedures for controlling technology transfer are nearly always present in projects involving international cooperation.

### 1.1.2 Specific Reasons for Utilizing Russian Space Assets

The major benefits from utilizing Russian space capabilities fall into the same three categories as the benefits from international cooperation in general: increased space program effectiveness, support of foreign policy goals, and enhanced competitiveness of the domestic industry. Both the U.S. civil and military space programs could significantly benefit from access to the space technologies, experience, and flight systems developed as a result of the former Soviet Union's huge investment in space. These benefits could include reduced costs for development, procurement and operations, improved performance of space systems, and shorter development times. The "bargain basement" prices at which the Russians are now offering their space systems and technologies are far below what it would cost to obtain similar capabilities domestically. Additionally, there are benefits from simply coordinating the space activities of the world's two leading space powers, independent of any procurement of assets. By sharing scientific data and flight opportunities, making navigation, communications and manned systems compatible, and coordinating tracking and control operations, both the U.S. and Russian space programs could be improved even without the exchange of assets.

However, by directly utilizing Russian space assets, several important foreign policy goals could simultaneously be achieved. U.S. purchase of Russian aerospace products would provide desperately needed capital to an industry that is attempting to transition from military to commercial products and from a communist to a capitalist structure. Both of these trends are in America's best interest. Even former President Reagan, who considered the Soviet Union an "Evil Empire", has called for the U.S. to begin making large scale purchases of Russian space hardware to help "recapitalize" the economy[5]. Through joint

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5 R. Reagan, "A Good Deal: Buy Russia's Space Program", Wall Street Journal, March 25, 1992, p. 1.

business ventures with Western firms, Russian enterprises can gain not only much needed funding but also exposure to Western business practices which can teach them a great deal about how capitalism works. Supporting the aerospace industry in these difficult times, one of the few Russian industries with the potential to be internationally competitive, could allow the U.S. to create a successful model of Western-style capitalism in Russia for the rest of the economy to emulate. In addition, financial support to the aerospace enterprises would help keep their employees reasonably well paid, thus reducing the temptation to sell their services abroad and possibly proliferate weapons technologies to potential U.S. adversaries. Finally, increasing governmental and business contacts with the former Soviet Union is important for opening up channels of communications that have long been closed due to political tensions. Maintaining free and open communications will be essential if future political confrontation is to be avoided.

Allowing U.S. businesses access to Russian space assets can provide benefits by improving their competitiveness in both domestic and international markets. Through joint ventures to share technologies or cooperate in product development, production or marketing, U.S. firms can lower the costs and improve the customer appeal of their existing products. They can also gain access to completely new products or services that create heretofore unavailable business opportunities. U.S. firms can be assured that their foreign competitors are not ignoring what the Russians have to offer and that their future competitiveness may well depend on wise use of Russian capabilities. On the other hand, the most often cited reason for restricting cooperation with the Russians in space is the threat it poses to U.S. industry. Allowing low priced Russian space hardware, particularly launch vehicles, to compete in the international market could drastically reduce the market share of U.S. firms. Loss of market share would be particularly devastating in the contracting aerospace and defense industry whose companies are already experiencing mass lay-offs[6]. Although satellite manufacturers and other purchasers of launch services would benefit from access to low cost Russian boosters, the U.S. launch industry would certainly suffer, at least in the short-term.

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6 "General Dynamics Laying-Off 10-15% of Staff", Space News, September 28, 1992, p. 2. "Martin Marietta to Lay-Off 1,750 People This Year", Space News, October 5, 1992, p. 1.

Other costs or risks that accompany the use of Russian space assets are the potential for reduced national security, increased management complexity, and negative foreign policy impacts. The main national security concerns involve technology transfer, as discussed in the previous section, and support of an industry in Russia that may present a future military threat. Some in the U.S. defense establishment believe that it is unwise to aid the Russian aerospace industry because it helps Russia to sustain the ability to militarily threaten the West. The general contention that international cooperation inflates costs and risks due to increased management complexity is exacerbated in the former U.S.S.R. by their political and economic instabilities and their Byzantine management structures. By all accounts, understanding Russian business relationships is difficult and having any confidence that once you have learned them they will remain unchanged, is impossible[7]. The large initial investment required to overcome the systemic barriers between U.S. and Russian business practices is often the cause of failure for aspiring international joint ventures. Increased interaction with the Russian space program also has foreign policy costs as well as foreign policy benefits. As the U.S. pursues more joint activities with Russia, it runs the risk of neglecting its more traditional partners in the space field. There are only a limited number of space projects to go around and by improving our relationships with former Soviet states through enhanced cooperation, we may worsen our friendship with other nations by allowing their role in joint space projects to decline. And of course the most obvious cost in utilizing Russian space assets is the direct financial burden of paying for the Russian equipment. Some in U.S. industry argue that the government's priority should be to invest funds in the ailing U.S. economy where jobs need to be created, not to distribute taxpayer dollars to prop up foreign economies.

The difficulty with many of the benefits and costs discussed above is that they accrue to different organizations and interest groups throughout society and thus it is hard to balance them off against each other. The State Department may see all kinds of good foreign policy reasons to increase space cooperation with the Russians, but the domestic launch industry and its representatives in the U.S. government see only the costs that such a policy would impose on them. Similarly, some U.S. firms may be able to realize substantial benefits through

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7 E. Crawley & J. Rymarcsuk, "U.S.-Soviet Cooperation in Space: Benefits, Obstacles and Opportunities", Space Policy, February 1992, p. 36.

joint research projects with Russian enterprises but the Defense Department may object to such projects because of their potential dissemination of sensitive defense technologies. To determine the most fertile areas for pursuing joint space activities with Russia, it is important not only to weigh off the costs and benefits to one's own organization, but also to consider the affects on external organizations. Unfortunately, this approach has often not been followed leading to extensive interagency conflict in the government along with a host of industry and government disputes concerning the use of Russian space hardware.

## 1.2 Present Status of Joint Activities with Russia

The economic imperative to cut costs and become more efficient is driving many nations to investigate the use of Russian assets to improve their space programs. As cost control becomes more important, economics as well as foreign policy and scientific motives is playing a larger role in determining a nation's international space strategy. This has not always been the case. Prior to the 1970's, the U.S. and Soviet space programs eclipsed all others and openly used space as an arena for political competition in the Cold War. Other countries desiring access to space had to rely on U.S. or Russian launch capabilities to get them there. However this began to change in the 1970's as other nations, most notably the Europeans, developed their own satellites and space boosters. The 1980's saw the conversion of international space activities from a bipolar environment completely dominated by the U.S. and U.S.S.R., to one with multiple poles supported by independent launch capabilities in Europe, China, India, and Japan among others. As the number of nations utilizing space grew along with the commercial applications for space systems, economic competition became a driving force in the space industry. No longer were space activities conducted strictly for political and scientific motives as in the past, but for economic profit. Nonetheless until the 1990's, the U.S. maintained a clear superiority in space technology with its only viable competitor in terms of strength and breadth of program being the Soviet Union whose capabilities were largely inaccessible to the rest of the world. This all changed with the collapse of communism and the Soviet state, opening up the vast resources of the Russian space program for utilization by other nations. Russian space assets now represent a potential wild card that could dramatically alter the U.S.'s competitive position relative to other nations in the ever more commercial world market for space products and services[8].

Since the onset of "perestroika" the Russians have realized the importance of international space cooperation to their economy. Although scientific and political justifications for the space program still exist, the deteriorating economic conditions in the former Soviet Union have made the clear emphasis of the program economic gain. The domestic space program is promoted predominantly on its economic returns to society and international activities are widely supported because they offer opportunities for bringing hard currency into the Russian economy. The ruble's devaluation makes even minor international sales an important source of revenue for many organizations. For example, the huge Energia enterprise covers much of its operating budget on the income from a few small contracts with France, Germany and the United States[9]. Without such support Energia would be facing the loss of many of its best and brightest engineers as so many other enterprises in the former Soviet Union have experienced. The turmoil and challenges facing the Russian space program and its constituent industrial enterprises will be discussed at some length in Chapter 2, but for now suffice it to say that short-term economic survival is the industry's greatest concern. With drastic outright cuts in defense spending and effective cuts in civilian space funding caused by run away inflation, most space enterprises are in a real financial crunch. Without new sources of revenue they will not be able to pay their employees or maintain their facilities and much of the industry is in danger of simply disappearing.

To most Russians, international sales or joint ventures are seen as the natural solution to their declining domestic demand[10]. They are willing to sell their best space systems and technologies to just about any country or company who can come up with the hard currency to pay for the goods. Yet the control of potentially lucrative contacts with foreign partners remains a strong point of contention. The government formed the Russian Space Agency last year to give it control of and a cut of the profits from international space activities. But

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8 C. Covault, "International Space Programs Face Strategic Realignment", Aviation Week & Space Technology, July 27, 1992, pp. 20-21.

9 P. de Selding, "Western Contracts May Keep NPO Energia Engineers Busy", Space News, January 4-11, 1993, p. 9.

10 M. Sinelshikov, Department Chief, Russian Space Agency, interviewed in his Moscow office, October 19, 1992.

several of the larger Russian space enterprises such as NPO Energia would like to pursue Western partnerships without government interference and they continue to fight for their independence[11]. At present the management of international joint ventures in Russia remains somewhat of a hodge podge with several larger enterprises contracting directly with foreign customers with little government oversight while the government directly administers most other cooperative projects.

### 1.2.1 U.S. and Russian Space Cooperation

The U.S. and Russian space programs have a long history of limited cooperation dating back to the early 1960's. Most of these early efforts at cooperation were in strictly scientific fields such as space biology, meteorology and geodesy. The beginning of the 1970's saw some expansion of cooperative activities with the exchange of lunar soil samples and the development of compatible rendezvous and docking systems. The joint rendezvous and docking work culminated in 1975 with the joining of Apollo and Soyuz capsules in Earth orbit and the intermingling of their crews. The Apollo-Soyuz mission has been the only joint U.S.-Russian manned space project to date. The U.S. and Soviet Union's first bilateral agreement to pursue mutually beneficial cooperation in space was signed in 1972. Since then this agreement has been renewed and expanded every five years except for in 1982 when the agreement was allowed to lapse due to a downturn in East-West relations. Under the agreements, five joint working groups in the areas of space biology, solar system exploration, astronomy & astrophysics, solar-terrestrial physics and Earth sciences were established. These working groups met approximately once each year to exchange data and plan future joint activities. Until the signing of the 1992 agreement which substantially increased the areas for cooperation, only relatively small joint projects had been conducted. These projects included the flight of U.S. experiments on Soviet Bion satellites for investigating space life sciences, the flight of a Total Ozone Mapping Spectrometer (TOMS) on a Soviet Meteor-3 spacecraft, tracking of the Phobos spacecraft using the U.S. Deep Space Network and a few small commercial projects. All of these projects occurred after 1986 as cooperative activities with the Russians became more politically

11 P. de Selding, "Semenov Warns Western Groups to Bypass RSA", Space News, December 14-20, 1992, pp. 1 & 28.

acceptable. Prior to this time, bilateral relations between the U.S. and U.S.S.R. were too strained to allow any substantial cooperative ventures to proceed.

The beginning of the 1990's witnessed a near explosion of cooperative space activity between the U.S. and former Soviet Union. In June 1992 Presidents Bush and Yeltsin signed the new space agreement providing a broad framework for greatly enhanced future cooperation. Among the projects stipulated by the new agreement are joint manned activities to include the flight of a cosmonaut on the Space Shuttle in 1993, the flight of an astronaut to Mir for a three month stay in 1995 and the docking of the Shuttle to Mir in 1995. The agreement also provides for enhanced high level government contact and assistance to better coordinate the space activities of the U.S. and Russia and for increased space science and technology cooperation. In addition, the U.S. and Russian governments announced last year that NASA would award direct funding to NPO Energia to study the use of Russian hardware for U.S. missions and that a Proton launch vehicle would be allowed to launch one of the new Inmarsat-3 satellites. Both of these announcements were completely unprecedented. Never before has NASA provided direct funding to a foreign contractor, let alone a Russian contractor. Since the announcement of this award, NASA's contracts with Russian organizations have expanded and now include payments to several Academy of Science institutes, the Babakin Research Center and several other organizations. Using taxpayer dollars to fund a foreign enterprises is an entirely new approach to international cooperation for NASA. Allowing the Russians to bid on a launch for an international customer such as Inmarsat was also previously forbidden. The U.S. launch industry considers the entry of Russians launch providers into the international market a threat to their very existence and lobbied heavily against its approval[12]. Yet foreign policy concerns eventually won out and the Russians were allowed into the launch services market on a limited basis.

The DoD, or more specifically the Strategic Defense Initiative Office (SDIO), along with other government agencies have been very active in expanding Russian contacts. These organizations have emphasized acquiring advanced Russian technologies such as the space nuclear power technology contained in the Topaz-2 reactor, two of which were recently purchased by SDIO. Likewise, U.S. industry has not missed out on the emerging opportunities in Russia. Loral Space Systems has a joint venture with Fakel enterprise to produce its electric

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12 "Space Bargains From Russia", editorial in The New York Times, March 9, 1992, p. A16.

satellite thrusters in the U.S., Pratt & Whitney has an agreement to utilize NPO Energomash's liquid rocket engine technology in its U.S. engines and Lockheed and Khrunichev enterprise just announced a joint venture to market Proton boosters in the West. And it is not only the large aerospace firms that are taking advantage of the emerging opportunities in Russia. Small U.S. firms such as Payload Systems Incorporated are making use of the new openness to, among other things, fly microgravity experiments on Russian rockets. Each of these cooperative business activities will be discussed in more detail in later chapters, but for now it is enough to recognize that there are many U.S. firms actively pursuing joint ventures with Russian enterprises. On the negative side, in May 1992, the U.S. government placed sanctions on the Russian agency Glavkosmos barring it from importing to or exporting from the U.S. for two years due to its sale of propulsion hardware to India which allegedly violated missile technology non-proliferation agreements. These sanctions were intended to send a clear signal to the Russians that although the U.S. desired enhanced space cooperation, it would not tolerate defense technology proliferation to developing nations.

The speed with which Russian cooperation has taken hold of the U.S. space community has resulted in joint projects being undertaken faster than government policy makers can coordinate them. Although cooperative projects with Russian organizations tend to offer many benefits to the space user community and to help further foreign policy objectives, they often can exacerbate concerns for national security or protection of the domestic space industry. Thus NASA, the major user of space technologies in the U.S., tends to support Russian cooperation since it helps improve its programs. But NASA is also sensitive to the needs of the U.S. aerospace industry which provides most of its hardware and this somewhat tempers its enthusiasm for utilizing Russian systems. The State Department on the other hand, at least under the Bush administration, was mainly concerned with supporting Russian conversion to a market economy and therefore supported almost all U.S.-Russian joint ventures. To date, the State Department has been the greatest proponent of Russian space cooperation in the administration. The DoD wants to obtain as much advanced technology through Russian contacts as is possible but also is fearful of supporting a potential adversary by keeping its defense-related industries in tact. The Department of Transportation represents the launch industry interests and is therefore completely against allowing Russian vehicles to launch U.S. satellites. The Commerce Department represents both the launch vehicle manufacturers who want low cost Russian launchers kept out of the market and the satellite manufacturers who would like access to these lower cost vehicles. Consequently, the Commerce Department has divided loyalties but tends to be more protectionist. With all of these organizations promoting their different agendas it is not surprising that the U.S. position on cooperation with Russia has often been inconsistent. The National Space Council is supposed to coordinate government space policy, but in the past year the interagency feud has often proved too big for this organization to handle and has had to be resolved at the executive level. The State Department administers the interagency approval process for international transactions (known as the Circular 175 process) and therefore tends to have more influence than the other agencies. The State Department's influence was further enhanced by the Bush administration's emphasis on international affairs leading on occasion to nearly unilateral decisions by State in support of expanded Russian cooperation[13]. Whether the State Department will maintain such wide-ranging authority under the Clinton administration remains to be seen, but the interagency feud and the mixed signals from the U.S. government are almost certain to continue absent a major change in the policy making process.

### 1.2.2 Russian Space Cooperation with Other Nations

While U.S. space cooperation with the Russians has developed slowly and has only recently become significant, several other nations have been working with Russia for decades. Since the 1960's the French have cooperated with both the Russians and Americans in their space activities, never fully committing to either the Eastern or Western camp during the Cold War. The long Franco-Russian relationship in space has included scientific exchanges, the flight of French instruments on Russian spacecraft and, to date, three visits by French cosmonauts to Soviet space stations. Cosmonaut Jean-Loup Chretian worked on both the Salyut 7 and Mir stations and most recently in July 1992, Michel Tognini was the first Frenchman to use Mir on a commercial basis. The French paid the Russians approximately $12 million for Tognini's visit. France plans to continue sending cosmonauts to Mir every two years at a cost of $12 million per flight until at least the turn of the century, with the next flight coming in July 1993.

13 A. Lawler, "Foreign Policy Reigns in Space", Space News, January 18-25, 1993, pp. 4 & 21.

Besides the joint manned flight activities, the French are pursuing increased cooperation so that they may use Russian space assets to explore natural resources, the environment, nuclear power systems, pharmacology and improved telecommunications[14]. The last in a series of space cooperation agreements between France and Russia was signed in Paris in February 1991. This agreement was expanded by a Memorandum of Understanding in July 1992 that provided for French technical assistance and financial support for several key Russian space projects[15]. Among these projects are the Mars '94 and '96 missions that include a French-built balloon and scientific instruments. Both the French and the Germans are now providing funding directly to the Russians to keep these Mars missions on schedule.

The German government has been aggressively supporting greater use of Russian capabilities by the European Space Agency and has itself undertaken more than 50 separate space projects with Russia. Many of these projects were inherited from former East Germany, but quite a few have been recently initiated. In March 1992 a German cosmonaut spent a week on Mir for an estimated cost of $14 million, paid in cash to the Russians. Germany is also providing two cameras and twelve other instruments, along with financial support, to the Mars '94 & '96 missions. Perhaps most impressive, German companies are leading the world in private use of Russian space assets. Kayser-Threde has been flying materials processing payloads on Photon and Resurs-F spacecraft and the Mir space station since 1989[16]. It now has a joint venture with NPO Energia to sell Russian remote sensing data in the West and at the end of 1992 it bought two Tsyklon launches to place small German-built communications satellites in orbit. Deutsche Aerospace has a joint venture to build the Romantis telecommunications system to link Russia with Western Europe. Romantis will be launched by Russian boosters and the system may include some Russian satellites or component hardware. Bosch Telecom, Germany's largest telephone company, also has a joint project with NPO Energia to determine how Russian satellites could be used in its system. Other

14 I. Parker, "France and Cooperation", Space, Vol. 8, No. 5, October-November 1992, p. 16.

15 J. Lenorovitz, "French Technical Aid to Russians to Bolster Long-Term Space Plan", Aviation Week & Space Technology, August 17, 1992, p. 28.

16 "Commercial Agreement for Orbital Materials Processing Signed with German Firm", Vechernyaya Moskva, Moscow, December 29, 1987, p. 1.

Europeans besides the French and Germans are expanding space cooperation with the former Soviets. A British cosmonaut, Helen Sharman, visited Mir in early 1991 as did an Austrian cosmonaut, Clemens Lothaller, in late 1991. Both of these were paid visits to the Russian space station. An Italian company, CTI, with partial ownership by Swedish and Russian partners, is now marketing Russian space technologies in Europe for applications outside of the space industry. And the lead European propulsion company, Societe Europeenne de Propulsion (SEP) signed an agreement with NPO Energomash in December 1992 to transfer Russian advanced liquid rocket engine technology to Europe. The Europeans are clearly wasting little time in exploiting opportunities that have emerged from the opening up of the former Soviet space industry.

The European Space Agency (ESA) is responsible for continent-wide projects to utilize Russian capabilities, predominantly for reducing the costs of the European space program. Like the Americans, the Europeans were at first hesitant to use tax-payer funds to directly support the Russian space industry but they have recently overcome this inhibition. ESA now has plans to spend nearly $150 million dollars for Russian space hardware and services over the next four years. About a third of this money will be used to pay for the flight of several European cosmonauts to Mir beginning in 1994. The money will also be used to fund Russian analyzes of the European space plane design (Hermes), proposals for a joint European-Russian space station and Russian assistance with the development of advanced rocket propulsion technology. At present, ESA has over 30 contracts with Russian research institutes and industrial enterprises with a total value of around $8 million[17]. This value is expected to increase markedly over the next year. The Europeans are also investigating the possibility of developing a joint space shuttle with Russia or contributing European hardware to the Mir-2 space station. ESA signed a broad space cooperation agreement with the former U.S.S.R. in 1990 that provided the foundation for Russian cooperation and led to the development of the recent contractual relationships. Russian capabilities are more enticing to the Europeans than to the Americans since Europe trails Russia in many more areas of space technology. ESA hopes to use Russian capabilities to leap frog over many expensive technology development programs and produce its own independent manned space program at minimal

17 "Russia Gets ESA Contracts", Space Flight, June 1992, p. 182.

cost[18]. In the long-term the Russians may even join ESA and become just another member of the European space community. Although the Russians have applied for membership, it will be several years before the details of a European space merger can be worked out[19].

Europeans and Americans are not the only ones who recognize the opportunities from the internationalization of the Russian space program. For years the Indians have utilized Russian boosters to put their satellites into orbit and this relationship was recently expanded to include technology transfer projects. India's agreement to pay KB Salyut and KB Isayev some $200 million dollars for liquid Oxygen/Hydrogen rocket engine technology is well known in the West for the sanctions which it provoked from the U.S. government. Russia also has substantial cooperative space activities with other Asian nations including China and Japan. Russo-Japanese cooperation has included the paid flight of television journalist Toyohiro Akiyama to Mir in 1990 and was recently expanded by a July 1992 space agreement which allows for the launch of Japanese satellites on Russian rockets, use of Japanese electronics in Russian spacecraft and the utilization of the Mir space station by Japan. The Japanese have been criticized for their attempts to hire away "human capital" from the ailing Russian aerospace industry to improve their aspiring space program[20]. It is uncertain how successful these efforts have been, but the combination of Russian technology and Japanese business expertise undoubtedly represent a substantial threat to the market dominance of the U.S. space industry. International firms are also exploiting the opportunities to utilize Russian space assets. For example, Rimsat Limited intends to use Russian satellites to provide space-based communication services to the nations of the Pacific Rim. Russian space capabilities have attracted interest beyond the European and Asian theaters as well with negotiations underway to launch satellites for South Africa and the possibility of flying an Israeli cosmonaut to Mir next year. It is clear that joint space projects with the U.S. are only one of many opportunities available to the Russian industry for developing increased international cooperation.

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18 Y. Kovalenko, "Financial Problems Are Forcing Europe to Turn to Russia for Help in Exploring Space", Izvestiya, Morning Edition, Moscow, September 15, 1992, p. 4.

19 "European Space Agency Considers Russian Request for Membership", Satellite Week, April 13, 1992, p. 6.

20 "Headhunting in the CIS", Aviation Week & Space Technology, January 20, 1992, p. 13.

# Chapter 2

# Overview of Post-Soviet Space Activities

The Soviet Union no longer exists but it has left as a legacy to its successor states the world's largest space program. With the majority of space assets located on its soil, the Russian republic is the heir apparent for carrying on Soviet space work. Although substantial turmoil and shortages of funding now plague the former Soviet space industry, contrary to some "dooms day" reports in the West, it remains alive and functioning. Poor wages have caused significant loss of personnel in many space enterprises, but space workers have not yet completely abandoned ship. Some one thousand space-related enterprises and government facilities still employ nearly a million workers. Although launches were down from 59 to 54 between 1991 and 1992, the CIS continues to launch more space boosters than the rest of the world combined[21]. These launches each year place nearly 500 tons into orbit to maintain 30 different satellite systems consisting of 160 total spacecraft[22]. Now that we are no longer enemies with the states of the former Soviet Union, what are the opportunities for the U.S. to benefit from their vast space capabilities? And once these opportunities are identified, how can they best be pursued? To answer these difficult questions it is necessary to first take a step back and obtain an understanding of what the former Soviet space program consists of and how it has developed. To this end,

21 V. Kiernan, "Analysts: Better Russian Satellites Ease Launch Pace", Space News, January 11-17, 1993, p. 11.

22 A. Tarasov, "Club 206: Into the International Space Year on the Fragments of the Space Program", Literaturnaya Gazeta, No. 4, January 22, 1992, p. 12.

we discuss in Section 2.1 the political and administrative structures that have controlled and continue to manage the space program. This is followed in Section 2.2 by an overview of the major flight hardware that the space industry produces. Since the structure of the organizations that implement the space program in the former Soviet Union was shrouded in secrecy until very recently, Section 2.3 provides considerable new information on Russia's previously hidden space enterprises. Finally, Section 2.4 summarizes the different management practices of Russian and American space organizations and discusses what effect these may have on the potential for successful international cooperation.

## 2.1 Overall Organization

The fracturing of the Soviet Union into a loose Commonwealth of Independent States (CIS) has resulted in drastic changes in the organization of space activities in the former Soviet republics. The previous hierarchical, centrally-based control over the space program has been dispersed from the central government to the republics and from the bureaucrats to the enterprise managers. There is no longer a unified Soviet space program but a collection of space programs in eleven different republics. Of course one republic, the Russian republic, dominants all others performing more than 80% of all space projects and therefore is the true heir of the Soviet space program. However important space activities also occur in Ukraine, Kazakhstan and other republics. The following overview of the organization of post-Soviet space activities will begin with a discussion of the importance of space assets outside of the Russian republic and how they are related to the dominant Russian program. This will be followed by a synopsis of the present organization of Russian space activities and a brief history of the development of this organization. Lastly the important role played by the new Russian Space Agency within the Russian republic will be presented. The organization of space activities in the former Soviet Union continues to be in a high state of flux so that the information provided in this section provides only a snapshot as of the beginning of 1993. Without a doubt the next few years (or even months) will see many more changes which should be considered when making use of the outline in this section.

### 2.1.1 Inter-Republic Relationships

Although most space enterprises, research centers and infrastructure elements such as launch sites, control centers and training facilities are located in Russia, other republics do contain some critical elements. The two most important non-Russian republics to the space program are Ukraine and Kazakhstan. Ukraine possesses one of the three largest missile and spacecraft production centers in the former Soviet Union, Yuzhnoye Scientific and Production Association (NPO) in Dnepropetrovsk. In addition, it contains other smaller but still important space hardware manufacturing enterprises such as NPO Elektropribor in Kharkov and NPO Muson in Sevastopol. Also located in Ukraine are several major infrastructure facilities including the deep space control and tracking center in Yevpatoria on the Crimean peninsula. When taken together, these Ukrainian assets are significant enough so that their loss markedly diminishes the space capabilities of the former Soviet Union, but they are not enough to allow Ukraine to support an independent space program. Ukraine lacks any launch facilities and has only small pieces of a spacecraft control system making it necessarily dependent on others for these services[23].

The Baikonur launch facility or cosmodrome, responsible for all manned flights and capable of launching almost all former Soviet launch vehicles, is located in Kazakhstan. Containing the largest investment of any single facility dedicated to space activities in the former U.S.S.R., Baikonur is a nearly irreplaceable asset that is essential to the space program's operation. In addition to Baikonur, several important nuclear rocket research and test facilities are located in Kazakhstan around the city of Semipalatinsk. The vast open spaces of Kazakhstan make it an ideal place for testing hazardous devices but its remoteness from Moscow or other major cities makes it a poor choice for most high-technology production enterprises. Thus Kazakhstan's main contribution to the space program is in hardware testing and launch and not in the design and production areas. Other republics such as Belarus, Uzbekistan, Kirgizia, and Azerbaijan also contain some important enterprises involved with the space program that must coordinate their activities with the rest of the industry in Russia to be effective.

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23 L. Stukalina, "Timely Topic: Does a Country That Doesn't Have Enough Sugar Need Rockets?", Veherniy Kiyev, August 6, 1992, p. 2.

With the collapse of the Soviet Union during the final months of 1991, the preservation and coordination of space activities in the newly independent republics became considerably more complex. After several months of sometimes bitter negotiations, nine of the eleven former Soviet republics (excluding the three Baltic states) signed a space cooperation pact on December 30, 1991 in Minsk, Belarus. The two abstaining republics were Ukraine, which finally signed in the summer of 1992, and Moldova, which has yet to sign the agreement[24]. The Minsk agreement stipulated the creation of an ESA-like structure for coordinating space activities between independent space agencies in each of the republics. Funding for the CIS-level space activities are to be provided by each republic in proportion to their participation in the program similar to the ESA arrangement. An Interstate Space Council was formed to coordinate joint civilian space activities while all military operations remained under the control of the joint strategic forces. On March 20, 1992 the CIS republics agreed to provide funding to support common defense needs and maintain the joint strategic forces at their meeting in Tashkent, Uzbekistan. Although the Minsk agreement provided a theoretical structure for coordinating space activities in the post-Soviet states, there remained great turmoil in the space industry through much of 1992 since few republic-level space agencies existed for implementing the agreement. To help alleviate this problem, the republics began to form their own space agencies at around the time of the Minsk agreement. In September 1991 the Kazakhstan Space Research Agency was formed by decree of President Nursultan Nazarbayev. In February 1992 the Russian Space Agency (RSA) and the Azerbaijani National Space Agency[25] were formed and finally in March 1992 the National Space Agency of Ukraine was established by directive of President Leonid Kravchuk.

Once each republic had its own space agency to represent it, many difficult issues had to be addressed in dividing up the costs and benefits of the former Soviet space program. The most difficult issue continues to be who will pay for on-going space activities. The intent of the Minsk agreement is that each republic should pay according to its use of space systems, but determining level of use

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24 M. Smith, Russia/US Space Interaction: A Trip Report With Observations and Options, Congressional Research Service Report Number 92-774, October 27, 1992, p. 2.

25 S. Sememova, "Azerbaijan has its Own Space Program", Rossiyskaya Gazeta, Moscow, September 16, 1992, p. 6.

and allocating costs for development of future capabilities is very difficult in the chaotic political and economic environment in the former U.S.S.R.. To date the financing of most activities has fallen to the Russian republic leaving many space enterprises in the smaller republics who do not receive Russian funding in particularly desperate straits. For example, although Ukraine has over 50,000 people involved in its space industry, the Ukrainian government refused until recently to provide any state funding to these enterprises resulting in their substantial decay. Due to the unacceptable levels of unemployment caused by this policy, the Ukrainian government recently reversed itself and began to help fund space production enterprises within its borders[26]. Besides the financial difficulties in managing a multinational space program, many issues of sovereignty and local control have been raised by the partition of the former Soviet space program. The most striking of these was the battle between Russia and Kazakhstan for control of the Baikonur cosmodrome. After months of debate which included riots at Baikonur and delays of some launches, the Russian and Kazakhstan governments finally signed an agreement on May 25, 1992 for the cosmodrome's joint use The agreement assigned ownership of the cosmodrome to Kazakhstan but gave rights of use to Russia and the CIS strategic forces under certain stipulations of cost and profit sharing[27]. Kazakhstan was also given approval authority over environmental protection measures and selection of staff at the cosmodrome, both long-time issues of contention with the local government.

### 2.1.2 Organization of Space Activities in the Russian Republic

The bulk of former Soviet space activities (around 85%) are now administered by the Russian republic. It is the only former Soviet republic with a sufficient breadth of assets to be able to conduct independent space operations. The present organization of space activities in Russia will be presented in this section with the following section containing a history of how this organizational structure developed. To many acquainted with the Soviet space program of only a year or two ago the present structure will appear wholly unfamiliar and the

26 L. Dayen, "Sensations Without Secrets: Ukraine is a Space Power", Demokratychna Ukrayina, April 11, 1991, pp. 1-2.

27 "Agreement Between the Republic of Kazakhstan and the Russian Federation on Procedure for Use of the Baikonur Cosmodrome", Kazakhstanskaya Pravda, May 29, 1992, pp. 1-3.

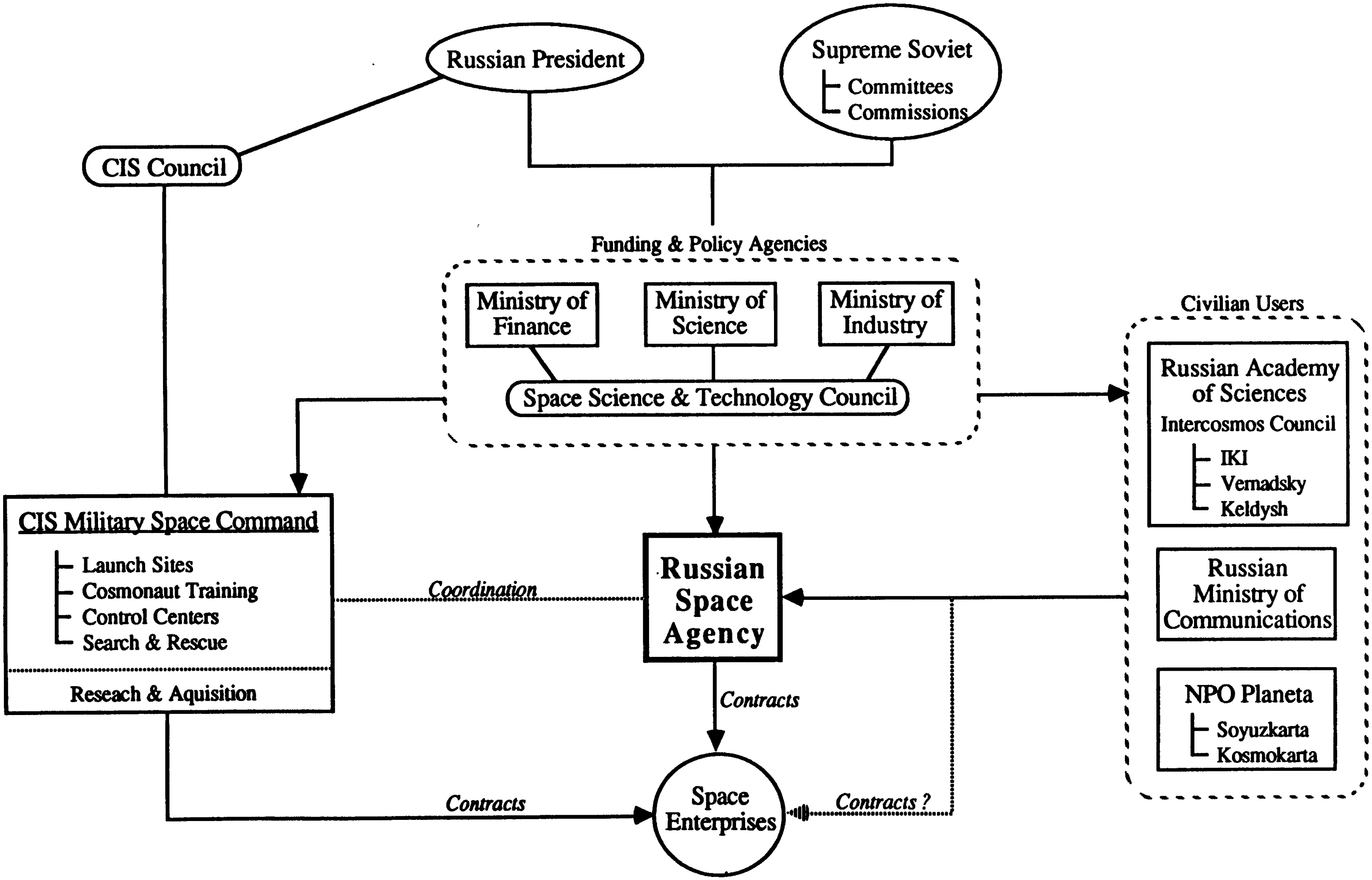
changes drastic. In fact, although substantial cosmetic changes have occurred to administrative structures in the former U.S.S.R., many of the same people and modes of operation remain basically the same as they were in the Soviet era, particularly at the lower organizational levels.

Starting from the very top of the policy making structure, gone are the old organizations which formed the core of the Soviet system, the Politburo, Central Committee of the Communist Party, Council of Ministers and their implementing arms the Military-Industrial Commission (VPK) and the State Planning Committee (Gosplan). In their place a powerful elected President in each republic has emerged (Boris Yeltsin in Russia) and a legislature consisting of a directly elected Congress of Peoples Deputies (over a thousand members in Russia) and their pared down operating wing the Supreme Soviet or Parliament (around 400 members). A Council of Heads of Government unites all the republics into a loose confederation know as the Commonwealth of Independent States (CIS). The old Ministry of General Machine Building (MOM), which contained all space production enterprises, was dissolved following the August 1991 coup attempt that was supported by its lead minister, Oleg Shiskin. Russian space enterprises are now part of the Department of Cosmonautics within the Ministry of Industry of the Russian Federation, however their connection with the ministry is much looser than it was under the Soviet system. Enterprises are free to develop new products and customers and to pursue foreign contacts without specific ministry approval, none the less, they remain government owned institutions although they will be privatized in the future.

An overview of the organizational relationships within the Russian space program is presented in Figure 2.1. As previously mentioned the Russian President and legislature make the highest level policy decisions for space as they do for all branches of the government. Several committees and commissions in the Supreme Soviet deal directly with space policy issues, the most important of these is the Commission on Transport, Communications, Informatics and Space chaired by Deputy Alexei Adrov. On Deputy Androv's urging, for the first time in 1993 civilian space expenditures will be a line item in the state budget requiring specific legislative approval. In the future, oversight of space expenditures by the Supreme Soviet is expected to increase as the Russian Deputies become more adept at wielding legislative power. Presidential and legislative direction guides the government's ministry structure in allocating

Figure 2.1

# Organization of the Russian Space Program



funds for space. The main ministries involved in the space program are the Ministry of Economy and Finance which processes budget requests, the Ministry of Science, Higher Education and Technology Policy which reviews all budget requests dealing with science and technology, and the Ministry of Industry which oversees the industrial enterprises. Space activities represent only a small fraction of the responsibilities of each of these ministries. To better coordinate space activities among the vast government ministry structure, an interagency Space Science and Technology Council under the Chairmanship of Yuri Osipov (President of the Russian Academy of Sciences) was recently created. This council, which is administered by the Ministry of Science, is responsible for coordinating all civilian space activities within the Russian republic. It will review funding proposals from the Russian Space Agency (RSA) and from other government agencies to assure that their budgets and plans are compatible with high level policy directives. There is some talk particularly in the RSA that a Space Council directly under the president, similar to the one that used to exist in the U.S., will soon be formed[28]. However, when and if space policy will be elevated to such a level remains uncertain at present.

Three main types of organizations are funded by the ministerial financial and policy agencies: military users, civilian users and the RSA. All military space operations are administered at the CIS-level and approved by the CIS's Council of Heads of Government. The military Space Command is under the direction of Colonel General Vladimir Ivanov and its structure has changed little from the Soviet era. The military still controls most space infrastructure operating all launch sites as well as most control and tracking centers and conducts the training of cosmonauts and their recovery upon landing. The RSA coordinates its operations with the military so that it is able to use its immense space infrastructure. The CIS Space Command has an R&D and acquisition system independent of the RSA and it contracts directly with space enterprises to obtain space hardware. All other users are supposed to rely on the expertise of the RSA and obtain space services through this agency. However, since the RSA is a relatively new organization that has yet to solidify its power, some civilian users continue to bypass the RSA and contract directly with industrial enterprises (shown as dotted line in Figure 2.1). The major civilian users are the

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28 M. Smith, Russia/US Space Interaction: A Trip Report With Observations and Options, Congressional Research Service Report Number 92-774, October 27, 1992, pp. 3-4.

Russian Academy of Sciences which is responsible for all space science missions, the Russian Ministry of Communications, Information and Space which maintains the civilian satellite telecommunications system and NPO Planeta which manages the Earth observation and resources program. In addition to these, there are dozens of other government agencies which use space assets to a lesser extent. All of these civilian users receive funding from the state budget which they either use internally or provide to industry through the RSA to meet their program objectives. Intersputnik, the Soviet equivalent to Intelsat, is another important user of Russian space assets that provides international telecommunication services. Unlike the agencies previously mentioned, Intersputnik receives much of its funding from non-governmental sources[29]. Most civilian users have little internal space expertise and simply funnel their resources allocated for space to the RSA. The Academy of Science is the major exception to this rule. Several institutes within the academy system employ thousands of people who are exclusively dedicated to space research. Within these institutes, substantial research and instrument fabrication for space missions is performed separate from the space industry.

The new focal point for civilian space activities is the Russian Space Agency (RSA). Ironically, although Soviet ideology supported the central planning of nearly all aspects of society, for over thirty years the Soviet space program operated without the benefit of a central space agency. Modeled on NASA in the United States, the RSA was established in February 1992 to overcome this shortcoming and to provide central coordination of all civilian space activities. It receives funding directly from the state budget to develop advanced space systems and technologies and then channels these funds to industrial enterprises who perform most of the work. It also receives funding from other government agencies who would like to utilize space systems and acts as their contracting agency with the industrial enterprises. The operation of the RSA and its major programs will be discussed in more detail in Section 2.1.4. The final element of the Russian space program is the space industry or industrial enterprises themselves. The majority of the people involved in the space program are employed by the industrial enterprises. The industry possesses most of the know-how and assets and it is the place where most value-added operations

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29 R. Riccitiello, "Intersputnik Links East to West", Space News, October 5-11, 1991, pp. 1& 21.

occur. The principal enterprises within the space industry of the former Soviet Union are discussed at length in Section 2.3.

### 2.1.3 Historical Development of the Space Program Structure

The system for administering the Soviet space program was set up in the late 1940's as a copy of the political establishment that then ruled the country. It was a rigidly authoritarian pyramid with the Politburo and Communist Party Central Committee at the top and the design bureaus and factories at the bottom simply performing the tasks assigned to them. The communist party chieftains, and Khrushchev in particular, saw excellence in space exploration as an important means of proving the effectiveness of communism. From his position as General Secretary of the Communist party in the late 1950's and early 1960's, Khrushchev demanded ever more impressive space "breakthroughs" with which to impress the world and the design bureaus of Korolov, Yangel and Chelomei struggled to keep the space spectaculars coming[30]. Khrushchev, with little formal education and simple peasant ways had a poor understanding of space technology but this did not stop him from directly managing its development. To him space exploration was no more than a Cold War propaganda weapon to be wielded against the Americans. To assure firm control of this weapon, nearly all decisions of any consequence involving the space program bypassed the government's Council of Ministers and were acted upon directly by the Communist Party Central Committee. Several powerful commissions and committees, such as the Military and Industrial Commission (VPK), were charged with assuring that the dictates of the Central Committee were carried out[31]. The role of the design bureaus was to inform the top political leadership of the technical possibilities and then to unquestioningly carry out their orders.

As time passed and the bureaucracies which implemented the space program grew, they began to assert their authority. After the departure of Khrushchev, the top Soviet leadership was less enthusiastic about space. The ministries and large design bureaus were given more freedom and they used this freedom to substitute their departmental interests for state interests in the space

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30 W. McDougall, The Heavens and the Earth: A Political History of the Space Age, Basic Books, New York, 1985, p. 249.

31 A. Dupas, "The Political Organization of the Soviet Space Economy", The Cambridge Encyclopedia of Space, Cambridge, England, 1990, p. 331.

program. The unwieldy network of commissions that had developed over the years and the weak central government structure that had been chronically circumvented by the Central Committee, were incapable of resisting the special interests once the top leadership ceased to directly manage space activities. The powerful Ministry of General Machine Building (MOM) became the major customer as well as the sole producer of space hardware[32]. Power to approve projects was transferred from the center to the bureaucracy since the MOM possessed all the technical expertise and external evaluations of its projects were next to impossible. The major way of justifying a new program under the MOM management system was whether the United States had a similar program, not whether it contributed to any long-term objective[33]. This approach led to the development of such systems as the Buran space shuttle to match American capabilities even though the Russian space program had no identified need for a spaceplane. Bureaucratic politics took over as the MOM gained in influence and many technical and managerial approaches, although obsolete, continued to be used. With the erosion of the pyramid of control, the Central Committee and VPK roles degenerated to "rubber stamping" proposed projects which the MOM had already decided it would pursue. The political leadership maintained ideological control but ceded all programmatic control to the bureaucracy which in the absence of independent reviews or public scrutiny, often relied on personal preferences and other extraneous criteria in making its decisions. Which Chief Designers supported a particular project was very important in determining the project's future. The MOM and its affiliated design bureaus became completely self-contained acting as the program planner, inspector, client and vendor all at the same time. This situation led to a heavy reliance on large resource-intensive projects which mainly benefited the huge design bureaus that led them and little consideration of the needs of other potential space service users outside of the MOM sphere of influence. In particular, commercial applications of space systems were almost completely neglected.

In the 1970's and 1980's the declining efficiency of the space industry led to the amalgamation of research institutes, design bureaus and factories together

32 T. Cremins & E. Newton, "Changing Structure of the Soviet Space Program", Space Policy, May 1991, pp. 135-136.

33 "The Scientific-Technical Revolution and the Economy: Russia and Space", Russian Council of Ministers Space Program Working Group, Pravitelstvennyy Vestik, Number 7, February 1992, p. 5.

into what were called Scientific-Production Associations (NPOs). The idea was that by combining research and design organizations with manufacturing plants, the ensuing synergy would increase the transfer of technology into final products and consequently improve industry effectiveness. The result was even more concentration of power in the hands of the space hardware producers with little diminishment of their tendency to use old reliable technologies. The NPOs continued to grow in power throughout the 1980's further eroding the original pyramid of control so that when the Soviet system finally collapsed in 1991, these enterprises were well poised to assert their independence.

By the beginning of the 1990's the Communist Party had formally relinquished its monopoly power over society and an elected President and parliament were beginning to establish control. The MOM had created within itself a branch, Glavkosmos, to market Soviet space wares abroad in an attempt to shore-up the industry's weakening position and make space operations more profitable. But this was not to be as Glavkosmos was largely unsuccessful in making foreign sales and political upheavals were soon to intercede. Following the August 1991 coup attempt, the MOM along with many other ministries were disbanded and the Russian space industry was thrown into turmoil. Most of the industry quickly rallied around the Minster of General Machine Building, Oleg Shiskin, by joining the Russian General Machine Building Company (Rosobshchemash) which he led[34]. Rosobshchemash was also known by other names including NPO Cosmos and Korat until its final designation was decided upon[35]. However the largest space enterprise, NPO Energia, led by Yuri Semenov saw the turmoil as a perfect opportunity to assert complete enterprise independence and refused to join Rosobshchemash. Semenov's action was the natural progression of a process which has been building in the Soviet Union for over thirty years whereby control of the space program was dispersed to increasingly lower levels. Semenov saw the Rosobshchemash organization as just the MOM under a different name and he felt that NPO Energia had the clout to obtain international and domestic funding without higher level interference. To some extent he was proven right as NPO Energia wrested complete control of

34 E. Crawley, "Trip Report on the Current Status of the Soviet Space Organization", MIT internal memorandum, November 25, 1991.

35 V. Khrustov, "Ministry of General Machine Building to Undergo Radical Transformation", Tass television news program, Moscow, 0956 GMT, September 20, 1991.

the Mir space station away from the central government and earned considerable hard currency by selling flights to the station to foreign cosmonauts.

The creation of the Russian Space Agency in February 1992 basically brought an end to the need for Rosobshchemash and presented a new challenge to NPO Energiya's independent authority. Yuri Koptev, the First Deputy of both the MOM and the Rosobshchemash organizations was appointed director of the RSA. He quickly seized control of most international dealings from Glavkosmos and began to consolidate his power base in the old MOM building in central Moscow. However, although there are some apparent similarities between the former MOM and the RSA organizations, there are some important differences. The RSA is intended to truly consolidate the management of all civilian space activities, something which the MOM with all its affiliated commissions and ministries was never able to do. But more importantly, the RSA will be only a client of space projects distinct from the enterprises which actually produce the hardware. This arrangement is fundamentally different from the ministry structure where the central authority continuously interfered and micro managed the production enterprises. Even with the RSA's charter to not interfere in enterprise operations, Yuri Semenov and other large NPO managers still fear the centralizing power of the RSA. Since its founding, a battle has raged between the two personalities of Koptev and Semenov, advocating centralization and dispersion respectively, for control of the Russian space program[36]. Semenov has historical trends and some early victories to bolster his independence movement, while Koptev has the success of centralized space agencies in almost all other developed countries to support his approach. Whether the RSA will ever fully consolidate its authority and become the "Russian NASA" still remains to be seen.

### 2.1.4 Role of the Russian Space Agency

The Russian Space Agency was established to address several widely recognized shortcomings in the Russian space program. The most important of these was the lack of a central authority to coordinate space activities and the need to make greater use of market incentives to improve program efficiencies. With the decline of military and space funding, these shortcomings were

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36 L. David, "Russian Space Program Caught in Power Struggle", Space News, October 12-18, 1992, p. 25.

exacerbated leading to widespread *conversion* of space production assets to consumer products manufacturing. Significant amounts of Russian space manufacturing capability has and continues to disappear and is being replaced by facilities to make products ranging from refrigerators to children's toys[37]. A major objective of the RSA is to assure that *conversion* efforts proceed in a logical manner so that irreplaceable space capabilities are not lost. Another oft-sited shortfall of the Russian space industry is its slowness to insert new technology into its operating systems. This slowness has led to Russian satellites that are much heavier and short-lived than their foreign counterparts and to many basic space system designs that have not changed in almost 30 years[38]. Making Russian engineering design more progressive and responsive to customer needs is another major objective of the RSA. To meet these objectives, the RSA intends to radically reorganize the space industry using the "principles of rationalism, democratization, and commercialization"[39]. It will be responsible for creating a national long-term space development plan with specific projects to be implemented along the way. The agency will write specifications for each of these projects and conduct open competitions between independent design bureaus to determine the best approach for proceeding. According to the RSA, the design bureaus are strictly subordinate to the government customer although the agency does not intend to interfere with how the enterprises manage their internal matters[40]. The RSA consists of only a small staff (approximately 200 people) and does not have the manpower to micro manage as the MOM did. The relationship between the RSA and the production enterprises will be for the most part that of a customer to a seller with all the attendant market benefits which this type of relationship brings. However, the RSA does have some coordination and approval roles, especially in dealing with foreign nations, which make it more than simply a purchasing agent for space products.

The program of the Russian Space Agency is broken into six categories: scientific missions, manned flight, Earth observation, communications &

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37 V. Litovkin, "How to Earn Money for Conversion", Izvestiya, July 9, 1991, p. 2.

38 V. Postyshev, "Space: TheMoving Ground is Moving Out From Under Us, But We Still Won't Forget About the Stars", Rossiyskaya Gazeta, June 23, 1992, p. 4.

39 B. Konovalov, "Russian Space Agency Set Up", Izvestiya, February 28, 1992, p. 5.

40 B. Ostroumov, Deputy General Director of the Russian Space Agency, interviewed in his Moscow office, October 18, 1992.

navigation, microgravity use, and advanced technology development. The RSA is the central coordinating and contracting organization in the Russian government for all of these diverse space activities. Unlike in the United States, great emphasis is put on economic returns when justifying new space projects in the former Soviet Union. An entire research institute under the RSA, the Economics & Production Planning Institute (AGAT), employs over a thousand people in calculating the expected benefits from space activities. These calculations are often highly involved and the results somewhat dubious. Table 2.1 shows some published results from AGAT on the savings that several major categories of space systems are supposed to provide to the Russian economy. A simplified version of a typical calculation to determine these numbers might go as follows. Space systems are used to forecast 100 tornadoes so that countermeasures can be taken. Without this forewarning, each tornado would have caused approximately one million rubles of damage. Thus, the presence of the satellites returns R100 million to the Russian economy[41]. Although these type of arguments may be somewhat suitable for meteorological and communication satellites which have direct economic applications, the Russians don't stop there and even attempt to use such calculations to justify their manned flight and scientific programs. This over-reliance on economic measures is a indicator of the poor understanding of economic and strategic business issues that continue to plague decision making within the Russian space program.

Table 2.1 - Estimated Economic Return from Russian Space Applications[42]
(Billions of Rubles During Each 5-Year Plan Period)

| Application Program | 1986-90 | 1991-95 | 1996-2000 |
|---|---|---|---|
| Meteorology | 3.9 | 5.8 | 9.6 |
| Earth Resources | 2.2 | 4.8 | 5.8 |
| Communications | 2.6 | 4.1 | 5.6 |
| Navigation | .2 | .8 | 3.8 |

To implement its program the RSA gets about 40% of the space budget with the rest going to the military. In 1989 the total budget for space activities in the

41 V. Avduyevsky & G. Uspensky, "Systems Designing of Economy-Oriented Space Complexes", Scientific and Economy-Oriented Space Systems, Mir Publishers, Moscow, 1988, pp. 75-77.

42 "CIS/USSR Space Program", Interavia Space Directory 1992-93, Jane's Information Group, 1992, p. 12.

former Soviet Union was R6.9 billion (or 1.5% of the state total) of which about R3 billion went to civilian projects. The development programs for the Energia booster and Buran space shuttle consumed nearly half of the civilian space funds with a remarkably small amount (only R220 million) allocated to on-going manned activities. In comparison, the Academy of Science space institutes received about R300 million for their activities in 1989. In 1990 and 1991 the total space budget shrank to R6.3 billion and R5.8 billion respectively and although the budget for civilian programs alone was R8.7 billion in 1992, it effectively shrank to even a greater extent than in the past due to run-away inflation[43]. In comparable prices, the military space budget for 1992 was cut in half while the civilian budget was reduced by 25%. To offset declining funding, around $30 million was earned from flying foreign cosmonauts and equipment in space. Using a conservative exchange rate of R200 to the dollar, this means R6 billion, or almost one half of all civilian space dollars in 1992 came from foreign sources. From this simple calculation it is clear why the RSA is so interested in expanding its international affiliations and earning hard currency from abroad.

## 2.2 Existing Space Systems

The purpose of this section is to summarize the existing space systems of the former Soviet Union and to discuss the benefits that each of these systems could offer a U.S. partner. In examining the space capabilities of the CIS, emphasis will be placed on non-military systems since they are the ones most likely to be involved in any cooperative venture. But to completely neglect military space capabilities would require ignoring over half of Russia's space activities giving an unrealistic picture of the true breadth of their program. Almost all non-scientific space assets are "dual-use" in that they can be equally well used for both military and civilian applications. However, there are some strictly military space systems in the former Soviet Union, most of which have designations in the Cosmos series, that have no civilian application. Before proceeding onto the core discussion of "dual-use" and civilian space systems, a brief overview of the major military systems will be given.

43 V. Golovachev, "What's the Purpose of the Shuttle Going Up to Mir?", Trud, Moscow, September 15, 1992, p. 2.

The former Soviet Union maintains an active reconnaissance (spy) satellite network for observing militarily important developments worldwide. Short duration photographic reconnaissance satellites make up the core of the Russian system, providing rapid response high resolution imagery but requiring literally dozens of launches each year. Unlike Western spy satellites, the Russians use photographic film to obtain images which must be recovered and developed before it is useful. This approach demands short missions so that military planners do not have to wait too long for information. Russian photographic reconnaissance satellites are derived from the same design as the manned Vostok capsule and the civilian use Resurs-F Earth resources satellites[44]. Recent upgrades to the technology provide for multiple re-entry pods to return a satellite's film in several installments allowing longer life missions and consequently fewer launches. The Russians also possess a particularly well developed ocean surveillance capability. The main spacecraft supporting this system are the nuclear-powered Rorsat radar satellites and the Eorsat electronic intelligence satellites (Elints). Working together these two systems provide a complete picture of the activities of Western fleets at sea under all weather conditions. Several Eorsats are launched each year to maintain the full operational constellation of six satellites to monitor electronic transmissions from foreign navies. Besides the Eorsats, the CIS also maintains a substantial terrestrial Elint capability. The Rorsat program has been declining in recent years, following the 1978 dumping of radioactive debris from a Rorsat nuclear core on Canada. This event and other near accidents with nuclear systems have increased international criticism of the program and resulted in no Rorsat launches since 1988.

In addition to its reconnaissance systems, the former Soviet Union also possesses an operational Anti-Satellite (ASAT) capability along with several other military satellite systems. Its ASAT system consists of co-orbital conventional warheads launched by SL-11 boosters as well as ground based laser and microwave beam weapons to destroy an enemy's critical communications and surveillance capabilities during wartime. The U.S. Defense Department estimates that Russian ASATs provides a 70-75% kill probability for satellites orbiting within their 5,000 kilometer range[45]. The former U.S.S.R. has tested its

44 N. L. Johnson, The Soviet Year In Space 1989, Teledyne Brown Engineering, 1990, p. 37.

45 G. Piotrowski, Soviet Military Power 1985, US Government Printing Office, 1986.

ASAT interceptors over a dozen times since development began in the late 1960's using Cosmos satellites as the target. For military communication needs, the Russians rely on "dual-use" systems in geosynchronous and high inclination (Molniya) orbits as well as several dedicated low altitude systems. The low altitude military communication systems provide direct links for tactical operations and a store and dump capability for long-range communications. Approximately five launches of SL-8 boosters from Plesetsk each year are used to maintain the low altitude communication capabilities. Lastly, the former Soviet military maintains several other miscellaneous satellite systems for defense purposes including the "dual-use" GLONASS navigational system and a nine satellite constellation to provide early warning of ballistic missile launches. This long list of threatening capabilities make Russian space activities a major concern to the Western defense community.

### 2.2.1 Launch Systems

The former Soviet space program utilizes 10 different launch vehicles from a half dozen classes to boost its payloads into space. They range in lift capability from one to one hundred metric tons to Low Earth Orbit (LEO) and all rely exclusively on liquid propulsion systems. Soviet launch vehicles are designated in three different ways, by their: (1) Russian name, (2) DoD designation and (3) Sheldon class and number. The ten operational vehicles along with some performance characteristics are shown in Table 2.2.

The A-class boosters are the oldest yet still the most actively used launch vehicles in the Russian inventory. Over half of all launches in 1991 were by A-class vehicles which have accumulated almost 1,400 successful flights. Of the seven variants of the family that have been developed over the last 35 years, only three are presently produced. The A-3 Vostok is a two and a half stage launch vehicle used to put sun-synchronous remote sensing satellites into orbit. Its payload capability for such missions is just under two metric tons. Only one A-3 flew in 1991 since the newer and more capable Zenit vehicle has now replaced it for many sun-synchronous missions. The A-4 Soyuz (also two and a half stages) is the most frequently used launch vehicle in the world and has been responsible for launching all Russian manned missions since 1964. It is best known for boosting manned Soyuz-TM and unmanned Progress-M capsules to the Mir space station for resupply. However the majority of its 24 missions in 1991 were to launch military photo reconnaissance satellites and some civilian Resurs, Photon and Cosmos scientific spacecraft. All man-related launches are from Baikonur while either major cosmodrome can support reconnaissance missions. Flights of both A-3 and A-4 boosters from Plesetsk none the less, are very rare.

Table 2.2 - Launch Vehicles of the Former Soviet Union[46]

| Russian Name | DoD Number | Sheldon Number | Year of Debut | Launch Sites | Orbital Missions as of 1991 | Payload to LEO (tons) |
|---|---|---|---|---|---|---|
| Vostok | SL-3 | A-3 | 1959 | BA & PL | 149 | 4.7 |
| Soyuz | SL-4 | A-4 | 1963 | BA & PL | 967 | 7.2 |
| Molniya | SL-6 | A-6 | 1961 | BA & PL | 264 | 1.8 (SEO) |
| Cosmos | SL-8 | C-1 | 1964 | PL & KY | 371 | 1.5 |
| | SL-11 | F-1 | 1966 | BA | 115 | 3.0 |
| Tsyklon | SL-14 | F-2 | 1977 | PL | 94 | 4.0 |
| Proton | SL-12 | D-1e | 1967 | BA | 154 | 2.5 (GSO) |
| Proton | SL-13 | D-1 | 1968 | BA | 22 | 20.6 |
| Zenit | SL-16 | J-1 | 1985 | BA | 12 | 13.7 |
| Energia | SL-17 | K-1 | 1987 | BA | 1 | 105.0 |

The A-6 Molniya (a three and a half stage vehicle) is the final operational variant now used for high altitude semi-synchronous missions such as Molniya communication, Prognoz and early warning satellites. In the 1960's, the A-6 was used to launch planetary spacecraft and lunar probes until it was replaced in these missions by the more powerful Proton launcher. The A-6 is formed by placing a third core stage on top of the A-4 booster which allows the vehicle to perform higher energy missions. The vehicle was flown 8 times in 1991 and its projected replacement by a new three stage Zenit vehicle is unlikely to occur for at least several more years. A-class boosters were derived from the SS-6 Sapwood Intercontinental Ballistic Missile (ICBM)[47] and therefore have many

46 Launch site abbreviations are BA for Baikonur, PL for Plesetsk and KY for Kapustin Yar and orbit abbreviations are SEO for Semi-Synchronous Elliptic Orbit and GSO for Geo-Stationary Orbit.

47 M. Stoiko, Soviet Rocketry: Past, Present, and Future, Holt, Rinehart, Winston, 1970, p. 94.

impressive operational characteristics such as the ability to launch within 48 hours of reaching the pad even under very severe weather conditions[48].

The only remaining C-class booster is the C-1 Cosmos, the former U.S.S.R.'s smallest launch vehicle. Derived from the SS-5 Skean Intermediate Range Ballistic Missile (IRBM), the two stage C-1 vehicle launches many types of small communication, navigation and experimental satellites mostly for the military. Historically, it also played a strong role in orbiting scientific payloads for the Intercosmos and Cosmos programs. It is the only launch vehicle flown out of Kapustin Yar and is also the only vehicle not flown from Baikonur. The C-1 was launched 11 times in 1991 but plans are to transfer most of its payloads to the newer and more capable F-1 Tsyklon vehicle within the next five years. The two remaining F-class boosters are the two stage F-1 and the three stage F-2 Tsyklon. The payload capability of the F-class boosters fills the gap between the A- & C-class boosters. The F-1 has been used almost exclusively for top secret military programs such as ASAT weapons, new offensive missiles and ocean reconnaissance. Due to the decline in these types of programs, the F-1 has recently been used very sparingly flying only once in 1991. The F-2 vehicle is formed from the F-1 by adding a third stage. Most of its missions were inherited from the older C-1 launcher and include military communications, reconnaissance and Elint as well as civilian meteorology, geodesy and space science. The F-2 booster flew 8 missions in 1991, all from Plesetsk into high inclination orbits. F-class boosters were derived from the SS-9 Scarp ICBM[49].

Two variants of the D-class Proton booster are presently utilized, the three stage Proton D-1 (SL-13) which can place over 20 metric tons into LEO and the four stage Proton D-1e (SL-12) used for high energy missions. The Proton was the first Soviet booster designed specifically for use as a launch vehicle and not derived from a ballistic missile. Developed in the mid 1960's, for over twenty years it was the Soviet Union's most powerful booster. The three stage SL-13 is used primarily to launch large space station modules and remote sensing satellites. Its sole mission in 1991 was to place the Almaz 1 radar satellite into LEO. By far the most frequently flown version of the Proton is the four stage

48 P. Clark, "The Sapwood Launch Vehicle, Revisited", Journal of the British Interplanetary Society, Volume 35, February 1982.

49 "Soviet Launch Vehicles", ESA Launch Vehicle Catalogue, European Space Agency, 1986, updated December 1990.

SL-12 used to place geosynchronous communication, remote sensing and navigation satellites into orbit and to put scientific spacecraft such as astro-observatories and planetary probes into space. Communication satellites launched directly into geosynchronous orbit by the SL-12 include those in the Gorizont, Raduga and Ekran series. The SL-12 also has launched many scientific spacecraft for solar system exploration including missions to the Moon, Mars, Venus and Halley's comet[50]. In 1991 the SL-12 flew 8 times. The present version of the Proton is designated Proton K and has a fourth stage, called the Block DM, that uses liquid Oxygen and Kerosene as the propellants. The Block DM was originally designed as the fifth stage for the N-1 Moon rocket. Two versions of this stage are now used on the Proton, one using standard Kerosene as the fuel and the other using the hydrocarbon fuel "Sintin" for increased specific impulse. A new fourth stage which uses liquid Hydrogen as the fuel is under development for the enhanced Proton KM version. The Proton KM will utilize the more energetic fuel and a larger payload fairing to increase payload capability to geosynchronous orbit to over 4 metric tons.

The first major new launch vehicles to be developed in the former Soviet Union since the 1960's are those in the J- & K-classes, the J-1 Zenit and K-1 Energia vehicles. The Zenit is a new two stage medium-lift vehicle intended to replace the A-class vehicles as the core Russian launch system. After 12 successful missions between 1985 and 1990, mostly in support of military Elint programs, the Zenit experienced three consecutive failures throwing its reliability into question. Finally in late 1992 a thirteenth successful Zenit mission was flown. The Zenit makes use of highly automated ground processing that builds upon the already impressive approach used by the F-class boosters. Consequently, less than 48 hour pad stay times with fueling and check-out operations requiring fewer than a dozen personnel are achieved[51]. The creation of a third stage for the Zenit booster from the Proton Block DM or new cryogenic fourth stage is likely in the near future. In the late 1980's a proposal to launch commercial satellites on Zenit vehicles from a site in Cape York, Australia was promoted but U.S. government refusal to support such a scheme led to its

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50 Proton Commercial Launch Vehicle: Mission Planner's Manual, Issue No. 1, Space Commerce Corporation, June 1989.

51 S. J. Isakowitz, International Reference Guide to Space Launch Systems, American Institute of Aeronautics and Astronautics, 1991.

eventual demise. The K-1 Energia heavy lift launch vehicle utilizes a modular design with 4 to 8 Zenit derived strap-on boosters around a central liquid Hydrogen and Oxygen fueled core to boost over 100 metric tons into space. Payloads for the vehicle include the Buran space shuttle, large space structures, and a proposed 20 ton geosynchronous communications platform. The stage and a half Energia vehicle puts payloads on a sub-orbital trajectory requiring an upper stage for final orbit insertion. Two types of upper stages, one for inserting LEO payloads and another for boosting satellites to geosynchronous orbit are under development. The Energia has been flown twice, once in 1987 on a sub-orbital test mission and once in 1988 to orbit the Buran shuttle. Several times larger than any other booster in the world, the Energia has had trouble finding payloads that require its immense lift capability. A two strap-on booster version, the Energia-M, that can place a more moderate 65 metric tons in orbit has been recently developed to expand the possible applications for the vehicle[52].

Besides the traditional launch vehicles, recent arms reduction treaties may allow hundreds of Russian SS-18, SS-19, SS-20 & SS-24 missiles to be converted to launch vehicle service. The two stage SS-18 Satan ICBM is the most capable of these systems and could place over four tons into LEO. There are 308 SS-18s in the former Soviet arsenal that are scheduled for decommissioning. In addition to converted missile launch systems, the Russians also have several air-launched space plane concepts in various stages of development. Both of these non-traditional approaches to providing launch services could offer important cost savings and increased capabilities in meeting the launch needs of Western users.

The diverse family of former Soviet launch vehicles are produced in large quantities using an assembly line approach and low labor costs to achieve significant cost advantages relative to Western vehicle manufacturers. By exploiting these potential cost savings or the greater lift capability that Russian vehicles offer, the U.S. space program could accrue substantial benefits. Short of utilizing complete launch systems, specific advanced technologies in such areas as ground processing and propulsion systems could be transferred from Russian systems for use in the U.S.. The propulsion systems used on the six major classes of former Soviet launch vehicles, along with the engines available from the canceled N-1 moon rocket, are shown in Table 2.3. Russian liquid rocket engine

52 "CIS/USSR Launchers", Interavia Space Directory 1992-1993, Jane's Information Group, 1992, p. 258.

Table 2.3 - Propulsion Systems on Former Soviet Launch Vehicles

| Stage | Engine | Fuel | Oxidizer | Specific Impulse (seconds at sea level) | Thrust (KN at Sea Level) |
|---|---|---|---|---|---|
| A-Class Boosters | | | | | |
| Each Strap-on (4) | RD-107 | Kerosene | LOX | 257 | 821 |
| Stage 1 Core | RD-108 | Kerosene | LOX | 248 | 745 |
| Stage 2 (SL-3) | RD-448 | Kerosene | LOX | 324 (vac) | 54.5 (vac) |
| Stage 2 (SL-4&6) | RD-461 | Kerosene | LOX | 330 (vac) | 298 (vac) |
| Stage 3 (SL-6) | ? | Kerosene | LOX | 340 (vac) | 67 (vac) |
| C-Class Booster | | | | | |
| Stage 1 | 2 x RD-216 | UDMH | Nitric Acid | 248 | 735 (each) |
| Stage 2 | ? | UDMH | Nitric Acid | ? | 157 (vac) |
| F-Class Boosters | | | | | |
| Stage 1 | ? | UDMH | $N_2O_4$ | 309 | 2450 |
| Stage 2 (SL-11) | RD-219 | UDMH | Nitric Acid | 293 (vac) | 883 (vac) |
| Stage 2 (SL-14) | ? | UDMH | $N_2O_4$ | 324 (vac) | 956 (vac) |
| Stage 3 (SL-14) | ? | UDMH | $N_2O_4$ | 331 (vac) | 78 (vac) |
| D-Class Booster | | | | | |
| Stage 1 | 6 x RD-253 | UDMH | $N_2O_4$ | 285 | 1,474 (each) |
| Stage 2 | 4x RD-0210 | UDMH | $N_2O_4$ | 327 (vac) | 583 (each) |
| Stage 3 | RD-0210 | UDMH | $N_2O_4$ | 325 (vac) | 630 (vac) |
| Stage 4 (SL-12) | ? | Kerosene | LOX | 352 (vac) | 85 (vac) |
| Stage 4 (Proton KM) | ? | Hydrogen | LOX | ? | 6.9 (vac) |
| J-Class Booster | | | | | |
| Stage 1 | RD-171 | Kerosene | LOX | 308 | 7,260 |
| Stage 2 | RD-120 | Kerosene | LOX | 350 (vac) | 834 (vac) |
| K-Class Booster | | | | | |
| Each Strap-on | RD-170 | Kerosene | LOX | 308 | 7,260 |
| Core | 4x RD-0120 | Hydrogen | LOX | 455 (vac) | 1,450 (each) |
| N-Class Booster | | | | | |
| Stage 1 | 30x NK-33 | Kerosene | LOX | 290 | 1,510 (each) |
| Stage 2 | 8x NK-43 | Kerosene | LOX | 346 (vac) | 1,760 (each) |
| Stage 3 | 4x NK-39 | Kerosene | LOX | 353 (vac) | 402 (each) |
| Stage 4 | NK-31 | Kerosene | LOX | 353 (vac) | 446 (vac) |

technology is the world's most advanced and technology transfer from these propulsion systems, particularly from the most recent RD-170 & RD-120 engines, could offer significant technological benefits to U.S. engine manufacturers[53].

## 2.2.2 Spacecraft

The spacecraft of the former Soviet Union can be broken down into three broad categories: manned systems, application satellites and scientific spacecraft. Each of these classes of spacecraft will be addressed in turn and their possible applications in cooperative ventures will be cited. One of the most impressive aspects of the Russian space program is its extensive experience with manned flight. Since orbiting the first human, Yuri Gagarin, on Vostok 1 in 1962, Russian cosmonauts have logged over 20 man-years in space. The original Vostok (East) capsule flew a total of 11 times between 1960 and 1963, 6 times with a single cosmonaut and the other 5 times with various payloads such as dogs and test equipment. Two modified Vostoks, the Voskhods, had three men crammed inside them and were flown in 1964 and 1965 to compete with the American Gemini program. The basic design of the Vostok capsule has been used on many subsequent Russian spacecraft including the Resurs-F and Photon satellites. In 1967 the much more capable Soyuz vehicle took over for Vostok in supporting manned flight. The Soyuz consists of three sections, the forward Orbital Module for carrying payload and equipment, the mid-section Descent Module for housing the cosmonauts during launch and re-entry, and the aft Service Module which contains the propulsion system, supporting tankage and electronics. Three version of the vehicle have flown accounting for 64 manned flights. The newest version, Soyuz-TM, began operation in 1987 and provides increased crew comfort and improved docking capability with the Mir space station. The Progress vehicle (and the improved Progress-T) is an unmanned derivative of the Soyuz designed for autonomous space station resupply. It first delivered cargo to Salyut 6 in 1978 and continues to fly every couple of months to Mir to supply it with food, propellant, equipment and expendable gases. The final manned transport system of the former Soviet Union is the Buran space plane. Similar to the U.S. Space Shuttle, Buran has flown only once in 1988 and its high operating

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53 "Soviets Look to Market Energiya Engines", Space Business News, Pasha Publications, September 4, 1989, pp. 6-7.

costs leave its future in doubt. Plans are to dock the Buran with Mir in the next couple of years but whether this will occur is uncertain.

The core of the Russian manned space effort has been its space station programs. Beginning with Salyut 1 in 1971, the Russians have followed a determined path to master long duration manned operations in space. Two parallel space station programs competed throughout the 1970's, the military Salyuts 2, 3 & 5 (also called the Almaz stations) and the civilian Salyuts 1, 4 & Cosmos 557. These stations were only marginally successful and none was occupied for more than 100 days. The two efforts were merged in 1977 to create the Salyut 6 station and follow-on Salyut 7 in 1982. These two stations were occupied for a total of almost 5 years by 46 different individuals and were supplemented by attached modules Cosmos 1443 and Cosmos 1686. Their evolution led directly to the Mir station's launch in 1986. Mir's principal advantage over the Salyut 7 is its modular design around a forward docking node that contains five open ports for the attachment of future modules. Since its launch the Mir complex has grown through the addition of the Kvant astronomical module, the Kvant-2 life support and EVA module and the Kristall materials processing module. Plans are to attach the Spektrum atmospheric studies module and the Priroda remote sensing module within the next two years to complete the complex. The major missions of Mir are to investigate the effects of long duration spaceflight on man, to utilize microgravity for scientific and commercial purposes, to monitor processes on Earth and to develop experience in space operations. Mir has been permanently manned since February 1986 except for a six month period at the end of 1986 and a three month period in mid 1989[54]. In 1987-88, cosmonauts Titov and Manarov spent over a year (366 days) on the Mir station. Maintaining Mir is becoming increasingly difficult as the station ages and projections are that it will need to be replaced within the next two to three years. At present, over one half of the cosmonauts' time is spent on maintenance operations. The form that the new Mir-2 will take is still being debated but possibilities for combining the Mir and Freedom space station programs have stimulated much interest because of the potential cost savings and political benefits that such cooperation would afford. A summary of operating Soviet spacecraft including manned systems in given in Table 2.4.

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54 B. J. Bluth, Soviet Space Stations As Analogs - Volume II MIR, First Edition, NASA Headquarters, August 1991, pp.17-19.

Table 2.4 - Operational Spacecraft of the Former Soviet Union

| Spacecraft | First Launch | Launches to Date | Description |
|---|---|---|---|
| Manned Systems | | | |
| Mir (Peace) Space Station | 1986 | 4 (modules) | Permanently Manned Space Station |
| Soyuz (Union) | 1967 | 68 | Manned Transport for Mir Station |
| Progress | 1978 | 54 | Unmanned Cargo Carrier for Mir |
| Buran (Blizzard) Shuttle | 1988 | 1 | Energia Launched Space Plane |
| Communications | | | |
| Gorizont (Horizon) | 1978 | 24 | GSO, 9 operating, TV & phone link |
| Raduga (Rainbow) | 1975 | 30 | GSO, 8 operating, gov't services |
| Ekran (Screen) | 1976 | 19 | GSO, 3 operating, Direct Broadcast TV |
| Luch (Beam) | 1985 | 4 | GSO, 2 operating, Satellite Data Relay |
| Molniya (Lightning) | 1965 | 141 | SEO, 16 operating, high latitude link |
| Locsyst/Gonets | 1985 | 72 | Low Alt., Military Store & Forward |
| Navigation | | | |
| Tsikada/Nadezhda (Hope) | 1968 | > 60 | LEO, Transit-type, Cospas, 4 operating |
| GLONASS | 1982 | 57 | Mid Orbit, GPS-type, 15 operating |
| Earth Observation | | | |
| Meteor | 1969 | 56 | LEO, Weather, Visible/IR, 4 operating |
| Prognoz (Nature) | 1988 | 2 | GEO, Resource, Visible/IR, 2 operating |
| Resurs-O | 1985 | 5 | LEO, Resource, Visible/IR, 1 operating |
| Resurs-F | 1977 | 13 | LEO, Resource, Short Life Photo Return |
| Okean-O | 1983 | 7 | Oceanography, SA Radar, 3 operating |
| Almaz (Diamond) | 1987 | 2 | SA Radar, 15m resol., none operating |
| Microgravity | | | |
| Photon | 1988 | 4 | < 500 kg payload, 2 week missions |
| Resurs-F Capsule | 1977 | 13 | < 35 kg payload secondary payloads |

Russian application satellites fall into four major classes: communication, navigation, Earth observation and microgravity processing. The largest application satellite program both in terms number of missions and resource expenditure, is the telecommunications program. The Russians maintain communication systems in three main orbits: geosynchronous, highly elliptical and low altitude. Most American communication satellites are placed in geosynchronous orbits allowing them to hover over a fixed point on the equator and relay signals throughout the country. The Russians have the Gorizont and Raduga satellites which operate similarly to U.S. geosynchronous communication satellites except that they have a shorter design life (only 3 years) and carry fewer transponders[55]. These shortcomings will be overcome somewhat by the Express satellite, Gorizont's greatly improved successor, whose planned first launch is in 1995. A version of the Express satellite, the Romantis, is being considered for a joint Russian-German venture to provide telecommunication services in Eastern Europe. The sparse population distribution in Siberia makes standard geosynchronous communication networks impractical in that region. Homes are too far apart for a central dish to receive a satellite link and economically distribute it to end users by ground lines. To solve this problem the Russians developed the world's first Direct Broadcast Satellite, the Ekran, whose signals are received directly by over 5,000 end users in small communities throughout Eastern Russia using simple antennae[56]. In 1994, the more powerful Gals/Gelikon system is to begin replacing the Ekrans offering more channels and a longer operating life.

The Russian population is not only sparsely distributed but also resides at high latitudes that cannot be well serviced by satellites over the equator. This situation led to the development of Molniya satellites that use highly elliptical and inclined orbits to seemingly hang over northern latitudes for large parts of the day. Since most contact occurs with Molniya satellites when they are on the distant edges of their elliptic path, large 12 meter diameter dishes are required by the Orbita ground stations that communicate with the Molniyas. Three generations of Molniya satellites make this system the oldest and most widely used Russian communications network. Low altitude satellites presently play a relatively small role in civilian communications but this situation may soon change as the military Locsyst/Gonets system is offered commercially. Another new civilian use for low altitude satellites is the proposed Marathon system intended to exploit the burgeoning mobile communications market. In addition to low altitude satellites, Marathon will employ the geosynchronous Arcos and

55 D. Hart, The Encyclopedia of Soviet Spacecraft, Bison Books Corporation, 1987, pp. 26 & 83.

56 A. Dula, Opportunities From Soviet Industry - A Commercial User's Guide, Space Commerce Corporation, distributed at 1989 Paris Air Show, pp. 16-17.

the Molniya-type Mayak satellites to create a worldwide mobile communications network. The final Russian communication service which bears mentioning is the Luch system, which includes dedicated satellites as well as transponders on Gorizont and Raduga satellites, for relaying data between the ground and in-orbit spacecraft.

Russian navigation systems closely parallel those in the U.S. with an older low altitude Transit-type system, Tsikada and a new Global Navigation System (GLONASS) that is almost identical to the U.S. Global Positioning System (GPS). The Tsikada constellation compliments a similar military network that also uses Doppler ranging to locate the position of ships at sea to within 80-100 meters. Since 1982, Tsikada spacecraft have been carrying transponders to support the Russian segment of the international search and rescue effort (COSPAS). Recently the name Nadezhda has been used to designate these COSPAS related satellites. COPAS and its U.S. counterpart SARSAT are credited with saving over 2,000 lives since they began operation a decade ago. GLONASS satellites are far more sophisticated, orbiting at an altitude of over 19,000 kilometers, so that they are able to determine position to within 10-20 meters and velocity to within .15 m/sec. A complete constellation of 21 spacecraft is expected in orbit by 1995, but at present only 13 GLONASS satellites are operational. The extensive similarity between the GLONASS and GPS systems provides an opportunity for developing receivers compatible with both systems that have enhanced performance and reliability. The U.S. firm Honeywell is developing just such a receiver and intends to flight test it for aircraft navigation in 1993.

The Russian Earth observation program supports two main activities: meteorology and remote sensing of Earth resources. The principal satellites used for weather forecasting are the polar orbiting Meteors, three generations of which have been developed over the last 25 years. To complement this capability, the Russians plan to launch their first Geosynchronous Orbit Meteorological Satellite (GOMS) in 1993. The former Soviet Union makes use of a similar pairing of geosynchronous and low altitude polar spacecraft, the Prognoz and Resurs-O respectively, for meeting its resource remote sensing needs. The Resurs-O provides multi-spectral digital images similar to the U.S. Landsat or French Spot satellites[57]. The Russians also operate two types of radar satellites, the Okean-O

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57 Yu. Poletayov & P. Sergeyuk, Commercial Uses of Space Exploration, Glavkosmos Publishing, Moscow, 1989, p. 39.

which monitors ice formation in northern seas and the Almaz which provides all-weather general purpose imagery. Originally designed as a military surveillance platform, the 18 ton Almaz offered the international community the first commercially available source of Earth radar images[58]. A unique Russian capability is provided by the Resurs-F satellites which return high resolution photographic film to Earth for use in resource assessments. The Resurs-F is a civilian version of Russia's military photo reconnaissance satellites which have flown hundreds of space missions. This remote sensing spacecraft is also capable of carrying small microgravity experiments as secondary payloads.

The principal microgravity processing spacecraft, Photon, is derived from the same basic design as the Resurs-F. Several standardized material processing units have been developed for use on this spacecraft or on Mir's Kristall module. These include furnaces of the Zona, Splav and Konstanta series for growing protein and semiconductor crystals and the Kashtan electrophoresis unit for biological materials processing[59]. NPO Lavochkin intends to introduce a new microgravity spacecraft in 1993 to compete with Photon in what they expect to be an expanding microgravity processing market. KB Photo is also not standing still and intends to complete development of its Photon successor, the Nika-T, by 1994. The Russians have the world's most well developed microgravity processing infrastructure that has only begun to be exploited by West, mostly by U.S. and German firms.

The former Soviet Union has a long and impressive history in the scientific exploration of outer space. A summary of its most important missions to date is included in Table 2.5. The Soviet moon program included more than two dozen unmanned orbiters, landers and rovers and culminated in three missions which returned samples of lunar soil. Although hundreds of millions of rubles and millions of man-hours were expended on the manned lunar program, it was never successful and was finally terminated in 1974. Efforts to explore Mars and its moons have resulted in similar disappointments with 10 mostly unsuccessful missions to Mars in the 1960's and 1970's and a pair of unsuccessful probes to the Martian moon Phobos in 1988-89. On the contrary, Russian exploration of Venus

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58 ALMAZ Radar Remote Sensing Satellite -- Buyer's Guide, Space Commerce Corporation, Houston, Texas, 1990, pp. 2-3.

59 Commercial Space Services Rendered by Glavkosmos of the USSR, set of advertising brochures, Moscow, 1990.

Table 2.5 - Major Russian Scientific Spacecraft

| Spacecraft | Years Flown | Total Flights | Description |
|---|---|---|---|
| Luna | 1959-76 | 25 | Explored Moon with Rovers- Returned Samples |
| Mars/Phobos | 1962-89 | 13 | Explored Mars & Phobos (mostly unsuccessful) |
| Venera/Vega | 1961-1985 | 26 | Explored Venus with Landers & Radar Mapper |
| Cosmos | 1962-1991 | > 2,170 | Code Name- Experimental or Military Missions |
| Intercosmos | 1969-91 | 26 | Solar, Terrestrial and Space Physics |
| Astron/Granat | 1983-1989 | 2 | Ultraviolet & X-ray Space Telescopes |
| Gamma | 1990 | 1 | Russia's First Gamma-Ray Observatory |

and its affiliated observations of Comet Halley have been very effective. Russian spacecraft have overcome an incredibly hostile environment to land softly on the surface of Venus, release balloons into its atmosphere and radar map many important surface features. However, following the highly successful Vega missions in 1985, Russian planetary scientists turned away from Venus to pursue Martian exploration with new vigor[60]. Plans to send missions to Mars in 1994 and 1996 that utilize advanced equipment such as atmospheric balloons, robotic rovers and surface penetrators have generated much international interest and support. Martian exploration has become a focal point for international cooperation. In addition to planetary exploration, many Russian spacecraft have been used to investigate astronomy and space physics. Some of these missions were included in the supposedly scientific Cosmos series which in reality is a name used predominately as a cover for military or developmental spacecraft. Over 90% of all Russian spacecraft have flown under the Cosmos designation. Intercosmos satellites compose the largest truly scientific spacecraft series and have carried dozens of instruments to analyze the space environment. The Russians are now developing a new series of space observatories to supersede the Astron/Granat type (based on the Venera planetary bus) and the Gamma type (based on the Soyuz vehicle). The new Spektrum series will begin flying in 1995 and is designed specifically for use in astronomical observing in the X-ray, gamma ray, ultraviolet and infrared spectra. Opportunities for flying foreign instruments on these new spacecraft has generated much international interest.

60 A. Proskurin, Soviet Cosmonautics: Questions and Answers, Novosti Press Agency, Moscow, 1988, pp. 119-123.

## 2.3 Major Research, Production & Support Institutions

Thousands of institutions combine their efforts to implement the Russian space program. Obviously explaining how each of these interact is neither necessary nor feasible. However, by examining in some detail the most important institutions, it is possible to gain a clearer conception of how the Russian space program operates and what aspects of its organization are likely to be problematic in cooperative ventures. The following overview first discusses space research institutes, followed by industrial enterprises and concludes with a synopsis of Russian space infrastructure. The bulk of the discussion focuses on the industrial enterprises since they represent the majority of institutions both in number and in resource use. Three general types of organizations are involved in Russian space activities: research institutes, design bureaus and series production plants. Unlike in most U.S. firms, the research, design and manufacturing efforts in the former Soviet Union were split among different organizations. To help overcome the inefficiencies inherent in this approach, during the 1970's & 1980's many research institutes, design bureaus and factories were merged together to form Scientific-Production Associations (NPOs). However, quite a few organizations remained independent and retained their former designations of Design Bureau (KB), Experimental Design Bureau (OKB), Scientific Research Institute (NII) or All-Union Scientific Research Institute (VNII). These acronyms will be used frequently in the following discussion.

### 2.3.1 Research Institutes

Almost all basic research and most applied research in the former Soviet Union is conducted in large centralized research institutes located in large cities far away from the industrial sites where the research is supposed to be applied. Although the research establishment created by Soviet central planning was undoubtedly the largest in the world, it was far from the most prolific. The research institutes of the former Soviet Union are grouped into three main hierarchies: (1) the academy system, (2) the military & industrial system and (3) the educational system[61]. The space research activities within each of these

61 L. R. Graham, "Chapter 9: The Organizational Features of Soviet Science", Science in Russia and the Soviet Union, Cambridge University Press, 1993, pp. 180-181.

systems will be discussed in the following sections along with the primary institutes which support space activities.

#### 2.3.1.1 Academy of Science Institutes

The Academy of Science system is the most prestigious portion of the former Soviet research establishment. Headed by Yuri S. Osipov, the Russian Academy of Sciences (formed in December 1991 from the old U.S.S.R. Academy), oversees the operation of some 250 research institutes employing over 125,000 researchers. Each of the other republics also has their own academy of sciences. The title of "Academician", given to all members of the academy (there are approximately 400 full members at present) is the most respected professional title in Russia. Academicians tend to be either the director or deputy director of their institute. The director of each institute is provided with a block of funding from the central academy to support whatever research efforts he sees fit. There is no peer review process or multiple sources of funding available for researchers comparable to the system in the U.S.. The Academicians have unqualified authority in the research environment similar to the Chief Designers in the industrial environment.

Of the 250 institutes in the academy system, only about two dozen are involved to any significant extent in space activities. The most important academy institute for space is undoubtedly the Space Research Institute (IKI) located in Moscow. Headed by Albert A. Galeyev, IKI is the lead institute for space science programs responsible for providing overall scientific direction and for producing scientific instruments and equipment. Its areas of research include gamma ray, X-ray & infrared astronomy, lunar & planetary probes, solar studies, plasma physics and geodesy. From 1973 until 1988 the institute's director was Roald Z. Sagdeyev, who left to emigrate to the U.S., marry President Eisenhower's grand daughter and become a professor at the University of Maryland. IKI works very closely with the Babakin Center of Lavochkin Association in the production of spacecraft for scientific purposes. Babakin is responsible for the engineering and production of the spacecraft while IKI performs all scientific work and produces the scientific instruments. IKI's main design and production facility for space equipment is the Special Design Bureau in the Kirgizian capital of Frunze[62]. Since the break-up of the Soviet Union the Frunze bureau has been transferred to the Kirgizstan Ministry of Industry removing a vital manufacturing facility from IKI and leaving the Frunze facility without its major customer. The future of the Frunze facility's relationship with IKI is presently uncertain[63]. Other Academy of Science institutes, besides IKI, with involvement in space activities are summarized in Table 2.6[64]. Most of these institutes are located in Moscow but a few have facilities in St. Petersburg.

Table 2.6 - Academy of Science Institutes Involved in Space Research

| Institute | Research Area |
|---|---|
| Vernadsky Institute of Geochemistry | Geochemistry & Planetology |
| Keldysh Institute of Applied Mathematics | Trajectories & Orbit Calculations |
| Lebedev Institute of Astrophysics | Astronomy, Space Geodesy & Solar Studies |
| Izmiran Institute of Radiowave Propagation | External Geophysics |
| Control Problems Institute | Spacecraft Control Theory |
| Problems of Mechanics Institute | Orbital Mechanics |
| Academy of Sciences Computer Center | Computer Science |
| Institute of Lake Studies (in St. Petersburg) | Gamma Ray Astronomy |

#### 2.3.1.2 Industrial Institutes

The industrial institutes perform the most applied research and in the past were funded directly by the industrial ministry that they supported. With the disbanding of the Ministry of General Machine Building following the collapse of the Soviet Union, most of the space industry research institutes were put under the control of the RSA. The RSA's main research institutes are: (1) the Central Scientific Research Institute of Machine Building (TsNIIMASh), (2) the Scientific Research Institute of Thermal Processes (NII-TP), (3) the Scientific Research Institute of Chemical Machine Building (NII-KhiMASh) and (4) the Economics & Production Planning Institute (AGAT). TsNIIMASh (formerly known as NII-88) is by far the largest and most important of these institutes. It's extensive facilities

62 A. Barshay, "Frunze Special Design Bureau Experiencing Difficulties with Local Authorities", Sotsialisticheskaya Industriya, May 12, 1987, p. 4.

63 Yu. Gruzdov, "Space's Problems on the Ground: There's a Risk But Both Kirgizstan and the CIS Would Win", Slovo Kirgizstana, March 3, 1992, p. 3.

64 Much of the information for this table is from an article by G. Debouzy in The Cambridge Encyclopedia of Space, Cambridge, England, 1990, p. 318.

in the Moscow suburb of Kaliningrad employ over 8,000 people and include supersonic wind tunnels, thermal-vacuum chambers, propulsion test stands and structural test equipment. Besides its role in research & technology development, TsNIIMASh also provides systems engineering & program planning support to the RSA and oversees the operations of the Spaceflight Control Center (TsUP). TsNIIMASh was the original rocket development center which produced the R-1 through R-9 missiles that were later modified to create the Soyuz family of launch vehicles. Sergei Korolyov, the father of Soviet rocketry, worked at TsNIIMASh until 1956 when he founded OKB-1 to design space launchers and moved his operations across the street to the present site of NPO Energia. TsNIIMASh is the lead research center in the fields of systems engineering, guidance & control, structures, thermodynamics and plasma physics[65]. Most propulsion system R&D is done at NII-TP and NII-KhiMASh. NII-TP performs basic research into gas dynamics, combustion and other propulsion related processes at its Moscow facilities. NII-KhiMASh is the lead institute for testing of advanced rocket propulsion systems and its facilities in Sergei Posad (Zagorsk), about 50 kilometers from Moscow, include large liquid rocket engine test stands. Each of these institutes employs between 2,000 and 3,000 people and like TsNIIMASh, assist the RSA in technology planning and the preparation of product specifications within their field of expertise. The final institute under RSA control, AGAT, is responsible for performing economic analyzes of the benefits and costs of space activities. It employs over 1,000 people in a massive and costly bureaucracy whose goal ironically is to demonstrate the economic efficiency of the space program.

There are several other industrial institutes besides those under the RSA who play a significant role in space activities, most importantly those affiliated with the aviation and nuclear power industries. The lead aviation research center is the Central Aero-Hydrodynamics Research Institute (TsAGI) located in Zhukovsky, about 50 kilometers East of Moscow. Formed in 1918, it has extensive facilities for testing aircraft and satellites and employs over 10,000 people on its R200 million annual budget[66]. TsAGI is the equivalent in the aviation industry to TsNIIMASh in the space industry. It has recently been

65 G. Uspensky, Department Head at TsNIIMASh, interviewed in his office in Kaliningrad, October 21-22, 1992.

66 G. Zagainov, Director of TsAGI, presentation given in Washington, DC, December 1, 1991.

pursuing joint ventures with Western European and U.S. firms which have resulted in agreements to perform wind tunnel and thermal-vacuum tests at TsAGI on ESA's Hermes and the British Hotol vehicle designs. In addition to TsAGI, other aviation industry institutes of importance to space activities are the Central Institute of Aviation Motors (TsIAM), the All-Union Institute of Aviation Materials, the Central Aviation Systems Institute and the Flight Research Institute (LII) in Zhukovsky.[67] The town of Zhukovsky is the hub of the aviation industry much as Kaliningrad is the hub of the space industry. In the nuclear industry, the Kurchatov Institute in Moscow has played a major role in space through its development of the Topaz-2 space based reactor. In addition to its research and design center in Moscow which employs several thousand people, the Kurchatov institute also oversees the production and testing of nuclear reactors and weapons at its facilities in Semipalatinsk, Kazakhstan.

#### 2.3.1.3 Educational Institutions

Educational institutions such as universities and technical institutes provide the final segment of the research establishment in the former Soviet Union. Educational research in general, and university research in specific, is not nearly as important in Russia as it is in the U.S. where universities perform most of the nation's basic research in the scientific and engineering fields. The lion's share of fundamental research in Russia occurs in the Academy of Science system leaving the universities and technical institutes with only a minor research role. None the less, some important space research is performed in educational institutions and these organizations retain their influence on the space industry by supplying most of its trained personnel. Technical education in the former U.S.S.R. reflects the Russian preference for relying on tried and true designs. Even undergraduate students take very focused courses in how to design specific components such as gas generators and hydraulic actuators. These courses often consist of tracing designs from hardware in a laboratory to learn accepted design practices. Little emphasis is put on furthering creativity or on promoting student interests in topics outside of their specific field. The result is an exceedingly narrow education with no instruction in humanities nor development of communication skills.

67 "Five Research Facilities Band Together To Form Independent Association", Aviation Week & Space Technology, November 18, 1991, pp. 48-49.

The most important educational institution for the space industry is the Moscow Aviation Institute (MAI). Like most Russian institutions it is large and bureaucratic. A total of around 20,000 students, at both the graduate and undergraduate level, study in MAI's nine colleges. The two colleges most deeply involved with space activities are the College of Aerospace Propulsion (#2) and the College of Cosmonautics (#6). The College of Cosmonautics has about 2,500 students and 1,000 staff including professors, lecturers, and research assistants distributed in it nine departments[68]. Its instruction covers most areas of space vehicle technology with departments in systems design, structures, controls, fluid dynamics, and life support systems. The College of Aerospace Propulsion is the center for training in both jet and rocket propulsion systems. MAI graduates most of the aerospace engineers employed by the aviation and space industries and also plays an important role in providing technical advice and research support to these industries. The economic turmoil in Russia has resulted in declining enrollments and severe shortages of funding at MAI. To combat this problem, international collaboration is being sought in a wide range of areas such as educational exchange programs, international short courses, and joint research projects. Within the College of Cosmonautics, the Cosmos Association has been formed by a group of professors to help promote such activities. Besides MAI, several other educational institutions play an important role in space research and education and bear mentioning here. These institutions are the Bauman Higher Technical School, the Moscow Physical Technical Institute, the Moscow State Technical University, the Moscow Institute of Geodesy, the Institute of Applied Mechanics, and Moscow State University, all in Moscow and the St. Petersburg Mechanical Institute. St. Petersburg is also home to the Mozhaysky Military Engineering Institute which is responsible for training the officers of the military space units who man the launch sites, control centers and tracking stations throughout the former Soviet Union[69].

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68 Y. Zakharov, Vice Dean of the College of Cosmonautics at Moscow Aviation Institute, interviewed at MAI in Moscow, October 30, 1992.

69 A. Radionov, "We Describe for the First Time: Whom the Secret Institute Trains", Krasnaya Zvezda, First Edition, January 4, 1991, p. 4.

## 2.3.2 Production & Design Organizations

The following sections will describe each of the principal enterprises that produce space hardware in the former Soviet Union. The purpose of these discussions is to provide a broad overview of the organization of the Russian industry as well as to provide some details on the capabilities of individual enterprises. Although most contact to date has been with former Soviet policy making and administrative agencies, as cooperation becomes more extensive interfaces are likely to broaden to more fully include the production and design enterprises. For this reason and since these enterprises are responsible for producing and utilizing most space technologies in the former Soviet Union, their discussion in this section is given greater weight.

### 2.3.2.1 Launch Vehicle Producers

Although the space industry of the former Soviet Union consists of over 2,000 organizations, it is dominated by only a few huge production enterprises that produce all launch vehicles and many important satellite systems and spacecraft. Most of these enterprises were started in the 1950's by the Chief Designers Korolyov, Chelomei and Yangel, whose names are now famous throughout Russia. In the 1960's the "Battle of the Chief Designers" raged in the space industry as each of these strong leaders pitted their bureaus against each other for dominance of the Soviet space program. Other important space industry leaders who participated in this infighting were Glushko, Chief Designer for Propulsion, and Babakin, Chief Designer for Planetary Probes. These men and their organizations will be discussed in the following sections.

*NPO Energia*

Headed by Chief Designer Yuri P. Semenov, NPO Energia is the largest and most important space production enterprise in the former Soviet Union. It is responsible for building and operating all manned space systems, and produces a wide variety of spacecraft and launch vehicles. NPO Energia is headquartered 20 kilometers northeast of Moscow in the suburb of Kaliningrad. Located in Kaliningrad are the Central Design Bureau of Experimental Machine Building (TsKBEM), production facilities for the Soyuz-TM and Progress-M spacecraft, test facilities and several research institutes[70]. The TsKBEM is the lead design bureau in NPO Energia responsible for overall design and management of the Energia vehicle, the Buran space shuttle and the Mir space station. NPO Energia also has major divisions in Samara (Kubyshev) and at the Baikonur cosmodrome along with many minor divisions scattered around the country. In Samara is the Central Specialized Design Bureau (TsSKB) and its subordinate KB Photon along with the Progress manufacturing plant and related research and test facilities. The TsSKB designs and oversees manufacturing at the Progress plant of the A-series boosters Vostok, Soyuz and Molniya (SL-3, 4 & 6 respectively). KB Photon designs many Earth observation and microgravity satellites including those in the Resurs-F, Photon, Nika-T and Bion series, all of which are produced at the Progress plant. In addition, large components for the Energia vehicle such as propellant tanks and engine parts are also manufactured in Samara. The design bureaus in Samara employ about 5,000 people while the Progress plant employs nearly 25,000[71]. At Baikonur are the final assembly and check-out facilities for all spacecraft and boosters produced in Kaliningrad and Samara. Total employment at NPO Energia probably exceeds 50,000 people.

NPO Energia was founded by the Chief Designer, Sergei P. Korolyov and has roots going back to the very beginning of the Soviet space program. The industrial area of Podlipki (known since the end of the Second World War as Kaliningrad) was originally laid out in 1926 as an artillery factory. Following the war, Korolyov was put in charge of obtaining German rocket experts and bringing them to Kaliningrad to help develop Russian missiles. In 1946, NII-88 (which later became TsNIIMASh) was founded in Kaliningrad as a research center for rocket development. Korolyov worked at NII-88 until 1956 when OKB-1 was founded just across the street with Korolyov as its Chief Designer. Under Korolyov's leadership all early Russian ICBMs from the R-1 to R-7 were developed[72]. Later in his career Korolyov led OKB-1 away from military work due to his interest in the manned exploration of space.

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70 C. Farrenetta,Manager, Energia USA, interviewed at his office in Herndon, Virginia, November 23, 1992.

71 "Conversion Results at Samara's Progress Plant", Space News, February 10, 1992, p. 26.

72 N. Zelenshikov, Deputy Chief Designer, NPO Energia, interviewed at "The MIT Forum on International Cooperation", Washington, D.C., March 28, 1991.

Most space production enterprises in the former Soviet Union were in one way or another spun-off from Korolyov's OKB. In particular, the TsSKB in Samara and its associated design bureaus and plant were created as a branch of OKB-1 in 1959 under the leadership of Dmitry I. Kozlov. Kozlov remains the Chief Designer at the Samara facilities to this day. Korolyov was not so lucky, dying during a botched operation in January1966. At that time the TsKBEM (OKB-1's new name) was just beginning the N-1 manned lunar program and the loss of Korolyov's leadership is cited by many as a major reason for that program's failure. Korolyov's deputy, Vasily P. Mishin, took over the TsKBEM in 1966 and led the enterprise until 1974 when he was forced out of power by Valentin P. Glushko. Glushko had been a critic of the moon program's design and he used its failure to rest control of the TsKBEM from Mishin and combine Korolyov's old bureau with his own GDL-OKB to form NPO Energia. Upon taking control, Glushko promptly canceled the N-1 program and began work on the Energia/Buran launch system. Glushko died in January 1989 and was succeeded by his two deputies Boris I. Gubanov and Yuri P. Semenov[73]. Semenov eventually became Chief Designer and separated Glushko's old GDL-OKB off as NPO Energomash.

As is occurring all over the Russian space industry, declining orders and reduced budgets are forcing NPO Energia to look to international sources for funding and to convert much of its production to non-space goods. Energia has done relatively well compared to other Russian enterprises in obtaining foreign funding for its operations. It now receives hard currency funding directly from NASA, ESA, and several private companies to support its work in manned flight and microgavity research. In an unprecedented move, complete control of the Mir station was ceded to NPO Energia by the RSA so that whatever measures necessary could be taken to raise funding for the station's operation. To date this has included selling Mir visits to representatives of France, Germany, Japan, England and Austria with several new deals in the works. However, foreign funding has not stopped the need for conversion of production at Kaliningrad and Samara to dough mixers, pressure cookers, milk-boilers, vacuum cleaners and medical equipment. Some 30% of all workers are now involved in non-space

73 V. Golovachev, "Rocket Center Reveals Secrets: Little-Known Pages From the Histroy of the Space Program", Trud, November 22, 1989, p. 4.

activities which represent over 80% of profits. The great space design bureau of Sergei Korolyov now survives by churning out pots and pans[74].

*KB Salyut*

Headed by Chief Designer Dmitry A. Polukhin, KB Salyut is the former Soviet Union's principal designer of large space station modules, as well as a major designer and developer of space boosters and satellites. It is the lead design bureau in NPO Experimental Machine Building which also contains KB Begoragzon, two affiliated experimental manufacturing plants, and flight and ground test divisions.[75] A movement is now underway to use the famous name of Salyut for the entire scientific and production organization and do away with its nearly meaningless present title of Experimental Machine Building. The entire organization employs about 9,000 people, the majority of which are scientists or engineers. Its chief customers are the RSA, Ministry of Defense (MoD), other ministries, NPO Energia and foreign agencies. The design bureaus and their related test and production facilities perform all functions necessary for the development of new space systems including the production and testing of prototypes. Once the design is sufficiently mature, it is handed off along with detailed production specifications to a series production plant. In KB Salyut's case, most mass production goes to the Khrunichev plant which is located right next door to its central facilities in the western Moscow district of Fili.

KB Salyut began in 1951 as part of Vladimir M. Myashishchev's OKB-23 specializing in the design of long-range strategic bombers such as the M-4 Bison and operating out of Fili Aviation Plant No. 23. In 1960, both the Fili plant and Myashishchev's OKB where absorbed into Vladimir N. Chelomei's OKB-52 switching their emphasis from aircraft to rocket development. Chelomei was one of the big three Chief Designers along with Korolyov at OKB-1 and Yangel at OKB-3. Chelomei founded OKB-2, his first design bureau, in the summer of 1944 for the purpose of producing a Russian equivalent of the German V-1 "Buzz Bomb". In 1953, OKB-2 was liquidated on Stalin's orders due to unspecified "intrigues" leaving Chelomei without a bureau and sending some of

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74 S. Omelchenko, "Space and Commerce", Delovoy Mir, No. 127, July 4, 1992, p. 7.

75 D. A. Polukhin, General Designer, KB Salyut, interviewed at "The MIT Forum on International Cooperation" in Washington, D.C., March 27, 1991.

OKB-2's people to Myashishchev's bureau.[76] Ironically seven years later, many of the people who had left Chelomei to go to Myashishchev's bureau, found themselves back under Chelomei's iron leadership in his new design bureau OKB-52, often contrary to their wishes. One of these people was KB Salyut's present Chief Designer, Dmitry Polukhin[77]. Chelomei was reinstated as a Chief Designer by Khrushchev in 1959 and formed OKB-52 for the development of space systems by cannibalizing several aircraft design bureaus including those of Myashishchev and Lavochkin (to be discussed later). For over twenty years KB Salyut operated as part of the Chelomei organization. After Chelomei's death in 1984, his organization was separated into KB Salyut led by Polukhin and NPO Machinostroyenia led by Yefremov. For a short time during the 1980's, KB Salyut was a division of NPO Energia but for the last few years it has been the lead design bureau of the independent NPO Experimental Machine Building.

KB Salyut's primary experience is in the development of large manned space systems and booster rockets. It developed the civilian Salyut space stations 1, 4, 6 & 7, the Mir space station including the attached modules Kvant-1, Kvant-2 and Kristall, and the soon to be attached Piroda and Spektre modules. Although NPO Energia is the lead organization for the entire Mir program, KB Salyut is the lead on most of the individual modules used in the station's construction. KB Salyut is also the developer of the Proton launch vehicle which is Russia's primary vehicle for launching heavy payloads to low Earth orbit, geosynchronous satellites and interplanetary spacecraft.

Spiraling inflation and the decline in demand for its space products are at present severely impacting KB Salyut. Over the last 3 years it has lost some of its best people (20%-30% of the total work force) due to low wages and the uncertain future which it offers its employees. To help stem this tide, conversion efforts are being given high priority as are foreign sales. The controversial sale to India of upper stage cryogenic engine technology similar to that being developed for the new Proton fourth stage, provides 60% of KB Salyut's total current funding and will extend for three more years. Although the Indian deal has caused outrage in the U.S. and claims that agreements on non-proliferation of missile technologies to developing countries have been violated, the

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76 C.P. Vick, The Soviet Civil/Military Space Missile & Aircraft Industry, June 1992, p. 42.

77 A. Tarasov, "Cosmonautics of the Future: Choice of Paths and Orbits", Pravda, Second Edition, May 17, 1990, p. 3.

management of KB Salyut denies such violations and argues it is their only choice for survival.[78] Conversion efforts are proceeding slowly, sources of government funding are drying up, and all Western contacts on space station technologies have been monopolized by NPO Energia leaving few choices for KB Salyut in determining how to survive.

*Khrunichev Plant*

Headed by General Director Anatoly I. Kriselev, Khrunichev plant is a major manufacturing site for large manned & unmanned space stations, rocket boosters, and satellites. It mass produces hardware predominantly for the old divisions of Chelomei's design bureau, KB Salyut and NPO Machinostroyenia, although it is free to obtain its designs from other sources.[79] The plant employs some 15,000 people at its sprawling facilities in Fili, approximately one third of which are skilled technicians or engineers. Until 1989 the plant officially consisted of only a "post office box" at which its mail was received, everything else about it being secret. But since its declassification 3 years ago, over 221 delegations from all over the world have visited its immense facilities.[80] These facilities provide a full service production capability which may include machining, forging, casting, welding or chemical processing operations. Khrunichev works closely with the design bureaus who typically provide the specifications for the hardware it produces, however such support is becoming less important as the plant converts more to simple consumer goods[81].

The plant was formed in 1917 by the "Russo-Balt" Society to produce automobiles. In 1922, the German aircraft firm Junkers was given the plant and it constructed the main assembly buildings for the production of U-20 airplanes. In 1927 the Germans were kicked out and production of Russian planes by the designer Andrei N. Tupolev was begun. Aircraft production was the main stay of the plant until 1961 when it was named after the former Minister of Aviation,

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78 Y. N. Groshev, Deputy General Designer, KB Salyut, interviewed at KB Salyut headquarters in Moscow, October 26, 1992.

79 G. Lomanov, "Bicycles for Children and Orbiting Modules", Sotsialisticheskaya Industriya, September 22, 1989, p. 2.

80 Y. Bogatikova, "Details for Poisk: Fobos, Proton, Druzhok, and Others", Poisk, No. 22, Moscow, May 23-29, 1992, p. 3.

81 Khrunichev Enterprise, advertising brochure.

Mikhail Khrunichev, and converted to rocket and spacecraft production.[82] For over 30 years the plant has been specializing in the manufacture of large space stations, both manned and unmanned, as well as in booster and missile production. All Salyut space stations, Mir space station modules, Cosmos manned modules, Almaz radar satellites, Proton Launchers and most SS-19 missiles were produced at Khrunichev.

Reduction in military and space orders as well as acute problems in obtaining supplies, particularly from non-Russian enterprises, is forcing major adjustment at the Khrunichev facility. Proton production remains relatively high at nine vehicles per year according to the Khrunichev management, but it is highly uncertain if all of these vehicles will be needed.[83] Manufacturing of the Piroda and Spektre modules is nearing completion but follow-on work on Mir-2 remains uncertain, as is additional production of Almaz satellites. The cessation of military production of SS-19 missiles several years ago has relaxed secrecy constraints, and allowed international contacts and conversion to begin in earnest. In 1989, 70% of Khrunichev's production was of space products but this fraction had dropped to around 30% by the end of 1992. Under its conversion program, Khrunichev has begun production of medical equipment, general aviation airplanes, remotely operated vehicles as well as a whole host of consumer products. To deal with supply problems, Khrunichev is increasingly sourcing only from domestic Russian suppliers.

*NPO Yuzhnoye*

With primary design and production facilities located in Dnepropetrovsk, Ukraine, NPO Yuzhnoye (Southern), is the largest ballistic missile production enterprise in the former U.S.S.R.. It is also a major manufacturer of launch vehicles, satellites and components for space systems produced by other enterprises. NPO Yuzhnoye is a fully integrated developer of missile and space systems containing multiple design bureaus, test facilities and production plants. Yuzhmash, the main manufacturing plant in Dnepropetrovsk, has over 2 million square feet of floor space for final assembly of products. The Dnepropetrovsk complex is complimented by a factory and test facility in Pavlograd, Ukraine

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82 V. Umnov, "The Secret at Fili", Komsomolskaya Pravda, September 14, 1989, p. 1.

83 A. V. Lebedev, Deputy General Designer of Khrunichev Enterprise, interviewed at Khrunichev facilities in Moscow, October 23, 1992.

which builds and tests components such as rocket motors. The total employment at NPO Yuzhnoye is greater than 35,000 people and it operates on an annual budget exceeding R100 million.

NPO Yuzhnoye is a descendent of OKB-3 which was formed in 1954 by Academician Mikhail K. Yangel, as the first major off-shoot of Korolyov's bureau. Korolyov had a general mistrust of hypergolic fuels due to their materials compatibility and handling problems. His lack of enthusiasm for such a militarily promising technology as hypergolic propellants led many Generals to distrust him and to push for the forming of a new design bureau that Korolyov did not dominate. Consequently Yangel, one of Korolyov's deputies, was promoted to Chief Designer and put in charge of OKB-3 to develop hypergolic fueled missile technology. Originally much of the production work at Yuzhmash was of R-7 boosters and other hardware for the Korolyov bureau. However in 1959, the Korolyov bureau opened a new dedicated factory in Samara (Kuibyshev) leaving Yuzhmash to concentrate on the production of missiles and spacecraft that were being developed by Yangel at OKB-3. None the less, to this day Yuzhmash continues to supply many important components for NPO Energia launchers and spacecraft.[84] In October 1961, a terrible explosion during the test of an R-16 ICBM on the pad at Baikonur cosmodrome killed many of the best designers at OKB-3. Yangel himself narrowly escaped being killed in the tragedy. In 1971, following Yangel's death, control of OKB-3 shifted to Academician Vladimir F. Utkin. Utkin ran OKB-3 for nearly twenty years and in the early 1980's amalgamated the bureau with its associated factories and test facilities to form NPO Yuzhnoye. In 1990, Leonid Kuchma became General Director but his term of control was cut short by his election on October 13, 1992 as Ukraine's new Prime Minister.[85] Kuchma's departure left control of NPO Yuzhnoye in the hands of Stans'slav N. Konyushkov and put a friend of Yuzhnoye in a very high place in Ukrainian politics.

NPO Yuzhnoye pioneered the research into storable and hypergolic fueled rockets in the U.S.S.R. through the development of the SS-4, SS-5, SS-7 and SS-9 missiles in the 1960's.[86] This missile technology led to the development of the SS-

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84 C.P.Vick, The Soviet Civil/Military Space Missile & Aircraft Industry, June 1992, pp. 45-46.

85 "Ukraine's New Leader Has Space Background", Space News, November 2-8, 1992, p. 12.

86 C. M. Rebrov, "Profile of a General Designer: The Owl of Minerva Appears at Night", Krasnaya Zvezda, First Edition, March 23, 1991, p. 5.

18 Satan and SS-24 Scalpel ICBMs and the Cosmos(SL-7/8), Tsyklon (SL-11/14), and Zenit (SL-16) boosters. All of these liquid fueled launchers, along with the strap-on boosters for the Energia vehicle that are derived from the Zenit, were manufactured at NPO Yuzhnoye until recently. Propulsion systems such as the Tsyklon Stage 3 engine and Vernier control engines for several other vehicles are also the products of the enterprise. Besides launch systems, NPO Yuzhnoye has produced an impressive list of spacecraft including the Okeans, some of the earlier Meteors, over 200 Cosmos & Intercosmos, and a whole host of military satellites such as the Rorsats & Eorsats. The main emphasis of NPO Yuzhnoye's satellite work is in the production of non-photographic Earth observation spacecraft.[87]

The situation of NPO Yuzhnoye is unique among the major enterprises that previously formed the Soviet space industry because Yuzhnoye is in Ukraine and not in Russia. It is now separated from its former partners in the space program by national borders and is controlled by a somewhat hostile Ukrainian government. In December 1991, the independently minded Ukrainians decided to suspend all military and space production at NPO Yuzhnoye by March 1992 since the Russian government would no longer provide funding. Space production was to be replaced by conversion to aircraft, trolleybus, and consumer goods manufacturing. Recently however, after realizing the Draconian effects of simply halting all space manufacturing, the Ukrainian government has backpedaled some and agreed to fund a limited amount of space work at NPO Yuzhnoye. This has not however stopped the continuing decline in Yuzhnoye's production capability which has become irreversible. Much of this decline in capability is due to the loss of individual expertise from people who have left the enterprise to find work which pays more than the R2,000 (less than $10 at present exchange rates) per month offered to Yuzhnoye engineers[88].

*NPO Polyot*

Headed by General Director V. Zaitsev, NPO Polyot (Flight) is an important designer and manufacturer of launch vehicles, satellites, propulsion systems and

87 V. Mishchenko, "It Is No Longer Secret: The Work Horses of Space", Pravda Ukrainy, Kiev, Ukraine, April 20, 1991, p. 3.

88 G. Klimov & A. Senin, on "Novosti" newscast, Moscow First Television Channel, 1100 GMT, May 18, 1992.

other space hardware located in Omsk, Siberia. The association consists of a design bureau, several research institutes, a manufacturing plant, test facilities and a training institute for engineers. Its primary rocket engine test facilities are located 55 kilometers from Omsk in the town of Krutaya Gorka. Much of Polyot's work is done in support of programs headed by the three main enterprises previously discussed. NPO Polyot is also a major producer of consumer goods with annual consumer sales exceeding R120 million.

NPO Polyot's predecessor, the Omsk Aviation Plant, was formed in 1941 when two Moscow area plants were evacuated to Siberia and merged together. During the Second World War it produced Tupolev TU-2 dive bombers and Yakolev Yak-7 and Yak-9 fighters. In 1969, Cosmos (SL-8) production was transferred from Yangel's bureau to Omsk beginning the enterprise's shift from aircraft to space production. The plant specialized in booster engine technology and Cosmos production and in the 1970's took the name NPO Polyot. Like many enterprises in the space industry, even NPO Polyot's existence was secret until very recently.[89] NPO Polyot now produces Cosmos boosters, thrust chambers and other components for large liquid engines such as the RD-170, and satellites used in the Glonass, Cospas, Nadezda and Tsikada systems. Most of its satellites support the Russian navigation or search & rescue programs. Domestic orders for space products at NPO Polyot are less than half what they were just two years ago forcing the enterprise to seek international sales or conversion to non-space production for self preservation. International marketing has resulted in production of the Aryabhata and Bhaskara 1 & 2 satellites for India and the Sneg spacecraft system for France. Conversion efforts include the production of: the AN-74 multi-purpose Arctic research aircraft which is to begin this year, the Sibir-6 washing machine over 5 million of which have been sold since 1985, and equipment for the food processing and construction industries.[90]

#### 2.3.2.2 Principal Spacecraft Producers

This section discusses the major production enterprises of the former Soviet Union that focus on spacecraft and satellite manufacturing. They comprise the second tier of the space industry usually operating in a subordinate position to the enterprises previously discussed. However, this situation has begun to

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89 Y. Shapkov, "Top Secret: Polyot Flies High", Pravda, Second Edition, January 16, 1990, p. 8.

90 NPO Polyot advertisement in Sovietskaya Rossiya, Moscow, March 20, 1991, p. 4.

change as market forces are introduced into the space industry allowing each enterprise to assert its independence and compete for government and international contracts on more equal terms.

*NPO Lavochkin*

Headed by General Director Anatoly M. Baklonov, NPO Lavochkin is the sole producer in the former U.S.S.R. of planetary and deep space probes. Its main research, design, production and testing facilities are located in the Moscow suburb of Khimky where it employs nearly 12,000 people. Babakin Center, headed by Roald Kremenov, is a division of Lavochkin with a staff of 600, responsible for spacecraft design and international cooperation[91]. Besides the Khimky facilities, Lavochkin also has operations at the deep space tracking centers in Yevpatoria and Bear Lake. NPO Lavochkin has a long and impressive line of products which fall into five main categories: Lunar probes, Venus probes, Mars probes, space observatories and other exploratory spacecraft. Its Lunar probes include the two Lunokhod rovers which traversed the moon's surface in the early 1970's and the Luna-24 spacecraft which returned Lunar soil to the Earth in 1976. Its Venus probes include those in the Vega and Venera series which soft landed on Venus and radar mapped much of the planet's surface. Its probes to Mars have been very ambitious although to date not very successful. They include a series of Mars landers and orbiters, the Phobos 1 & 2 spacecraft and the upcoming Mars '94 & '96 missions. NPO Lavochkin produces several space observatories including the ultraviolet observatory Astron, the gamma & X-ray observatory Granat and the new Spectrum series for observations at a wide range of frequencies. In addition, Lavochkin has developed a few other exploratory spacecraft which are worthy of note. These include the Vega probe to study Halley's comet and the Prognoz (Forecast) series for monitoring interaction of solar radiation and the Earth's magnetosphere[92].

Founded in 1937 as an aircraft manufacturing company, Lavochkin Association produced over 22,000 "La" fighter planes during the war under the direction of its Chief Designer Semen A. Lavochkin. In the 1950's the company developed rocket powered winged missiles which eventually lost out in the

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91 Y. I. Ivanovsky, Chief of Systems Design at Babakin Center, interviewed at Babakin facilities in Khimky, October 28, 1992.

92 Lavochkin Association, advertising brochure.

competition for military contracts to Korolyov's strictly ballistic R-7 missile design. In 1965 Georgi N. Babakin took over the enterprise and shifted its activities from aircraft to spacecraft production. A group of experts in interplanetary space travel were spun-off from Korolyov's OKB-1 to form the nucleus of the new spacecraft design bureau under Babakin[93]. The enterprise's new emphasis on space exploration resulted in the long series of accomplishment enumerated in the previous paragraph. Babakin died in 1971 and since then the association has been run by a series of different Directors. Most programs are performed in cooperation with the Academy of Sciences (particularly IKI), with Lavochkin producing the spacecraft and an Academy institute producing the scientific instruments. Recent funding shortfalls have caused Lavochkin to delay programs and have resulted in the loss of some key personnel. However, since planetary exploration is considered a clearly peaceful pursuit, the enterprise has been relatively successful in attracting international support for its projects. Lavochkin in not nearly as financially desperate as other organizations in the former Soviet space industry[94]. None the less, NPO Lavochkin is engaged in several commercial projects such as the Lavochkin microgravity research satellite and conversion of SS-20's to commercial launchers to help earn hard currency.

*NPO PM (Prikladnoi Mekhaniki)*

Headed by Academician Mikhail F. Reshetnev, NPO Prikladnoi Mekhaniki (Applied Mechanics) has produced almost all of the former Soviet Union's communications satellites. It is also a major producer of submarine launched ballistic missiles and spy satellites which fly under the generic Cosmos designation. This strong military affiliation helps explain why NPO PM is located in the small town of Zaozernyy, one of the ten "closed cities" of the former U.S.S.R.[95]. The enterprise consists of two design bureaus, research institutes, test stands and the Krasmash dedicated production plant all of which are located about 70 kilometers north of Krasnoyarsk in the forests of Siberia. Nuclear weapons are also produced near the satellite manufacturing enterprise helping to enhance the area's military secrecy. NPO PM was formed in the early

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93 V. Serebrennikov, Deputy Chief Designer of NPO Lavochkin, interviewed at "The MIT Forum on International Cooperation" in Washington, D.C., on March 27, 1991.

94 A. Popov, on "Utro" program, Moscow First Television Channel, 1845 GMT, July 14, 1992.

95 V. Pyrkh, "The City Behind Steel Gates", Sotsialisticheskaya Industriya, August 9, 1989, p. 3.

1960's when Sergei Korolyov sent Mikhail Reshetnev to Siberia to found a bureau for developing communications and intelligence satellites. Reshetnev has been its Chief Designer ever since.

Communications satellites produced at NPO PM include the Molniya semi-synchronous satellites over 135 of which have been launched, the Gorizont (Horizon) and Raduga (Rainbow) geosynchronous satellites about 25 of which have been orbited, and the Ekran direct broadcast satellites 19 of which have flown since the mid 1970's[96]. Luch (Beam) data relay transponders and spacecraft are also build by NPO PM for relaying communications from Russian manned spacecraft and for other data relay missions. New communications systems under development at NPO PM include the Express satellites to replace the Gorizonts, the Gals/Gelikon satellites to replace the Ekrans, and the Arcos system for providing mobile communications. For the first time NPO PM is beginning to face competition from other design bureaus such as Energia, Yuzhnoye and Lavochkin in the communications area. This is making the organization much more aggressive in its pursuit of international sales and funding. NPO PM also produces Glonass navigational satellites and many early warning, communications and reconnaissance satellites for the military. Its military production has included approximately one third of all the Cosmos satellites that have been launched to date. Conversion efforts are underway at NPO PM but they are relatively small when compared to those taking place in the missile and launch vehicle production enterprises.

*VNII EM (Elektromekhaniki)*

Led by Chief Designer Nikolai K. Sheremetyevsky, VNII Elektromekhaniki is the former Soviet Union's leading producer of meteorological and Earth resources satellites. Its facilities in the suburb of Istra, east of Moscow, include the main research and design institute as well as a dedicated production factory. VNII EM has been producing spacecraft for the Meteor series of polar orbiting meteorological satellites since 1969. Three generations, encompassing more than 50 satellites of the Meteor design have now been flown. The enterprise is presently developing its first geosynchronous weather satellite, the GOMS

96 "USSR Communication Satellites", Interavia Space Directory 1991-92, Jane's Information Group, 1991, pp. 408-411.

(Geostationary Orbiting Meteorological Satellite) which has experienced funding delays but is expected to be launched in 1993[97].

VNII EM began its production of Earth resources satellites by building the Meteor 1-31 Priroda in the early 1980's. In 1988 it launched its fifth Resurs-O satellite to complete the operational constellation. The Resurs-O satellite is a multi-spectral digital Earth observing satellite which flies in a sun-synchronous orbit similar to the U.S. Landsat. The digital Resurs-O should not be confused with the photographic return satellite, Resurs-F, produced by NPO Energia's KB Photon. Besides complete satellite systems, VNII EM also produces instruments for other Earth observing platforms such as Almaz and Mir. The enterprise's funding channel from the government have been sporadic recently leading VNII EM to seek international joint ventures and to use conversion to provide supplemental support. For example, it has combined forces with General Electric to produce CAT scanners for hospitals in Eastern Europe and hopes to make strong profits from this venture to support its core activities.

*NPO Machinostroyenia*

Headed by General Designer Gerbert A. Yefremov, NPO Machinostroyenia is Russia's major producer of heavy unmanned orbital stations, mainly for use in Earth observation. The design and research bureaus of the enterprise are located in the Reutov district of Moscow, about 10 kilometers east of the city's center. Most series production of NPO Machinostroyenia designs is performed at the Khrunichev plant in Fili, although arrangements with other factories are possible. The organization was originally a part of Chelomei's OKB-52 where it was responsible for developing the Almaz space station design, which competed with a design from Chelomei's other bureau, KB Salyut, for application in the manned space program. Machinostroyenia's design was used on the military space stations Salyut 2, 3 & 5, but it eventually lost out to KB Salyut for use on Salyut 6 & 7 and on the Mir space station. Following Chelomei's death in 1984, the two design bureaus were separated off into the independent enterprises KB Salyut and NPO Machinostroyenia. Since that time, NPO Machinostroyenia has used its background in the development of manned stations to become the major producer of large unmanned Earth observation platforms, both for military and

97 "Russians Plan 1993 Launch of GOMS Weather/Telecom Satellite", Aviation Week & Space Technolobgy, June 1, 1992, p. 70.

civilian use[98]. It designed the Almaz-1A radar imaging satellite whose images were marketed in the U.S. by Space Commerce Corp., Almaz Corp. and Spot Image. However, the early re-entry of the Almaz-1A on October 17, 1992 after only a year and a half in orbit leaves NPO Machinostroyenia's commercial future in doubt[99]. There are plans to launch an improved Almaz-1B but funding constraints may make this impossible. For now NPO Machinostroyenia is relying on its military orders and conversion to consumer goods to keep the organization solvent.

*NPO Molniya*

Headed by General Director Gleb E. Lozino-Lozinsky, NPO Molniya (Lightning) is the former Soviet Union's leading designer and manufacturer of hypersonic vehicles and space planes. Its central design and production facilities are located in the Tushino district of Moscow but it also has operations at its separate Myashishchev and Bourevestnik divisions. The enterprise began in the 1960's as a design group in the famous Mikoyan OKB (producer of MiG fighters) responsible for developing hypersonic aircraft and manned space plane technology. In 1975 the group was spun-off under Lozino-Lozinsky's leadership forming NPO Molniya and began concentrated development of a space shuttle system. All of Mikoyan's remaining space work was transferred to NPO Molniya in 1981[100]. Besides its expertise in hypersonics, NPO Molniya is also very active in the development of air-to-air and air-to-surface missile technology.

The enterprise's most important space activity is development and production of the Buran (Blizzard) space plane. It works very closely with NPO Energia, the lead enterprise for manned space operations, on this program. NPO Molniya, with its background in aviation and hypersonics, is responsible for the development of the space plane itself while NPO Energia is responsible for its launch and operation. However, since Buran's automated maiden flight in 1988, funding constraints have caused the program to be put on the back burner and when the vehicle will fly again is uncertain. NPO Molniya has responded by converting most of its resources to the production of a small six-seat civil aviation

98 Moscow Second Television Channel, Editorial Report, 1615 GMT, May 23, 1991.

99 V. Kiernan, "Almaz Falls From Orbit", Space News, October 26, 1992, pp. 1 & 28.

100 G. E. Lozino-Lozinsky, General Director of NPO Molniya, interviewed at the National Press Club in Washington, D.C., on July 16, 1992.

aircraft[101]. At present, the future of the Buran program and of NPO Molniya's role in the space program remains in doubt.

### 2.3.2.3 Major Component Suppliers

The final category of space enterprises to be discussed are the producers of major launch vehicle and spacecraft components, most importantly the rocket engine manufacturers. Although they generally operate as subcontractors to the vehicle and spacecraft integrators, they often have substantial influence due to their critical importance to program success.

*NPO Energomash*

Headed by Boris I. Katorgin, NPO Energomash is the former Soviet Union's lead enterprise for developing and producing large liquid rocket engines. At its Khimky plant outside Moscow are located complete facilities to research, design, produce and test high thrust liquid rocket engines. Most impressive are its completely enclosed full scale engine test stands which provide sufficient exhaust scrubbing and noise dampening to allow firings within a mile of residential neighborhoods. Energomash has other large engine test stands at its NPO Start division in Yekaterinburg (Sverdlovsk). The enterprise also maintains a manufacturing facility in Perm where the RD-253 Proton engine is assembled[102]. The history of Energomash is tightly bound to that of its Chief Designer of many years, Valentin P. Glushko. Begun as the Leningrad Gas Dynamics Laboratory (GDL) in 1928, Glushko entered the enterprise in the early 1930's to develop electric rocket engine technology. He quickly moved to a leadership position and during the War led the organization's development efforts on liquid rocket engines with Sergei Korolyov as his deputy. Later disputes with Korolyov would cause divisive battles within the Soviet space program. In 1974, Glushko succeeded in merging his OKB-GDL with the former Korolyov bureau, OKB-1, to form NPO Energia. Glushko led the combined organization in the development of the Energia launch vehicle until his death at the end of 1988. At that time the former Korolyov and Glushko bureaus were

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101 G. Fadeyeva & A. Kornilov, on "Vesti" newscast, Moscow First Television Channel, 1600 GMT, May 22, 1992.

102 Y. Shatalov, "Space and the Market: Proton is Flying Toward a Deep End", Rossiyskaya Gazeta, October 7, 1992, p. 3.

again separated producing the present NPO Energia and NPO Energomash enterprises[103]. NPO Energomash works closely with the rocket engine research institutes of the RSA in its development work and with several supporting manufacturing enterprises, such as NPO Polyot, in its production work. However, nearly 95% of all the parts used in its engines, including seals, valves and castings, are produced in-house at the Khimky facilities[104].

The first stage engines for all operational Soviet launch vehicles are produced by NPO Energomash except for Energia's core engine which is produced by KB Khimavtomatika. Most large liquid fuel missile propulsion systems are also made by Energomash. Its products include the RD-107 & RD-108 which power respectively the strap-ons and core stage for the Vostok, Soyuz and Molniya vehicles, the first and second stage engines for the Cosmos and Tsyklon launchers, the RD-253 Proton first stage engine, and the RD-171 & RD-120 first and second stage engines for the Zenit vehicle. A simplified version of the RD-171 (the RD-170), the most powerful rocket engine ever built, is also used to power the strap-on boosters for the Energia vehicle. The high performance, ease of maintenance and compact size of the RD-170 makes it the world's most advanced rocket propulsion system. Besides its production engines, NPO Energomash also has several engines in development of potential interest to the West. Most significant of these is the RD-701, a tripropellant engine designed to operate in two modes for powering a single stage to orbit vehicle or a reusable space plane. Approximately 80% of the development work has been completed on the RD-701[105]. To replace its declining sales due to a reduced number of Russian launches, NPO Energomash has implemented conversion to consumer production and pursued international collaboration. On October 26, 1992 Pratt & Whitney was given exclusive U.S. rights to use and market Energomash technologies. NPO Energomash hopes this joint venture will provide an opening to the U.S. market so that it can begin to earn hard currency income from its vast store of world class technologies.

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103 M. Chernyshov, "The Work of Valentin Glushko", Space Flight, March 1991, pp. 88-90.

104 J. Reardon, President of Energo, Inc., US Representative of NPO Energomash, interviewed at his office in Revere, Massachusetts on November 12, 1992.

105 J. Lenorovitz, "NPO Energomash Seeks Funding to Complete Rocket Engine Work", Aviation Week & Space Technology, November 2, 1992, p. 28.

*Other Propulsion System Manufacturers*

KB Khimavtomatika (Automated Chemical Processing) is the second most important propulsion system supplier in the former U.S.S.R.. Headed by Academician Alexander D. Konopatov, it is the leading producer of second and third stage engines for missile and launch vehicle applications. Its design, production and test facilities are located in the city of Voronezh, approximately 800 kilometers south of Moscow[106]. The enterprise began in the 1950's under the direction of Semyin A. Kosberg, with the goal of developing liquid rocket propulsion for use on aircraft. Konopatov took over upon Kosberg's death in 1965 and continued the firm's transition into an upper stage engine manufacturer. In 1974 the enterprise was reorganized and renamed KB Khimavtomatika. It produces the RD-448 (Vostok Stage 2), RD-461 (Soyuz & Molniya Stage 2), RD-0210 (Proton Stages 2 & 3) and Molniya Stage 3 engines. Its most recent development has been the RD-0120, the large cryogenic core engine for the Energia launch vehicle and KB Khimavtomatika's first booster engine. Conversion efforts and sales to international customers are being pursued to supplement declining funding from the Russian government. The enterprise's name may soon be changed to something more representative of its true activities (unlike the deceptive title Khimavtomatika), possibly to KB Kosberg.

NPO Trud (or KB Kuznetsov) produced most of the engines for the failed N-1 rocket at its facilities outside of Samara, but nearly all of its rocket engine development work ceased with the termination of the N-1 program in 1974. The sole exception has been its continued production of the Proton Stage 4 (Block DM) engine. The enterprise, led by Chief Designer Vladimir N. Orlov, has since concentrated on the production of aircraft engines and small attitude control thrusters. Besides its large design bureau, NPO Trud also contains the dedicated Frunza factory and extensive test facilities (including large engine test stands) which are also used by NPO Energia's TsSKB. The enterprise began as an aircraft engine developer in the 1940's and for many years was headed by Nikolai D. Kuznetsov. During the 1960's Korolyov assigned production of the moon rocket engines to Kuznetsov following a dispute with Glushko, who would have been the more suitable choice. NPO Trud still has in storage 62 NK-33 (N-1 Stage 1), 12 NK-43 (N-1 Stage 2), 10 NK-39 (N-1 Stage 3) and

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106 V. Stepnov, "It Is Not Only Flames That Fly Out From a Rocket Nozzle", Pravda, First Edition, May 21, 1990, p. 2.

10 NK-31 (N-1 Stage 4) engines remaining from the Moon program that it would like to sell to generate some badly needed cash for its operations[107].

KB Isayev is the major supplier of spacecraft propulsion in the former U.S.S.R. having developed over 100 liquid engines for spacecraft and missile terminal stage propulsion. It is led by Chief Designer Nikolai I. Leontyev and has design and production facilities near NPO Energia in Kaliningrad The enterprise was started in 1944 by Alexei M. Isayev to perform research on storable liquid rocket engines. Over the years it has produced engines for attitude control and mid-course correction on planetary probes, lunar and planetary landers, manned spacecraft, orbital stations and military systems. Its most recent work includes the development of a new cryogenic Stage 4 engine for Proton. Related to this effort is a joint program with KB Salyut and the Indian Space Research Organization to transfer cryogenic engine technology to Indian. This activity and its alleged violation of missile technology non-proliferation agreements has gained KB Isayev much negative notoriety in the U.S.[108].

KB Fakel is the primary producer in the former U.S.S.R. of plasma thrusters and ion injectors for space applications. Its design center and manufacturing facilities are located in the city of Kaliningrad on the Baltic Sea (the former Germanic city of Koningsburg not the suburb of Moscow). Fakel performs all engineering design and production of plasma thrusters while most fundamental research in this area is done within several departments of TsNIIMASh and at the Research Institute for Applied Mechanics and Electrodynamic (RIAME) of the Moscow Aviation Institute (MAI)[109]. Over 50 plasma thrusters have been produced and flown in space since 1972 when a Meteor satellite first carried such a device. Russia is the only nation in the world to fly operational plasma thrusters. All of Fakel's devices are based on the same well-proven technology of Stationary Plasma Thrusters (STP) and range in power from 600 to 6,000 watts. Kiser Research of Washington, D.C. is marketing Fakel thrusters in the U.S.[110]

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107 J. Lenorovitz, "Trud Offering Liquid-Fueled Engines From N1 Moon Rocket Program", Aviation Week & Space Technolobgy, March 30, 1992, pp. 21-22.

108 C. V. Baberdin, "An Oufit in Podlipki. Why the United States Is Unhappy About the Commercial Contacts of the Glavkosmos", Krasnaya Zvezda, June 16, 1992, p. 2.

109 N. A. Maslennikov, Deputy Chief Designer of KB Fakel, interviewed in Moscow, October 21, 1992.

110 Kiser Research, Inc., advertising brochure.

and Loral Space Systems of Palo Alto, California also has a joint venture with Fakel to use its plasma thrusters on their satellites.

*Non-propulsion Component Suppliers*

There are literally hundreds of component and equipment suppliers to the major space production enterprises. The vast majority of these suppliers are in Russia with Ukraine and Belarus being the next two most significant supplier locations. A summary of the most important supplier enterprises and their products is included below in Table 2.7. Having presented the most important launch vehicle, spacecraft and component suppliers to the former Soviet space program, we conclude this outline of the space industry. The next section will complete our institutional overview by describing those organizations that provide infrastructural support to space operations.

Table 2.7 - Leading Non-Propulsion Component Suppliers

| Name of Enterprise | Location | Major Products |
|---|---|---|
| NII Kosmisheski Pribor (Space Devices) | Moscow | Wide Range of Satellite Payloads |
| NPO Elektropribor | Kharkov | Avionics & Onboard Computers |
| Moskovskaya Energetitsheski Institute | Moscow | Solid State Recorders for Space |
| PO Komunar | Minsk | Inertial Guidance Systems |
| NPO Radio | Moscow | Telecommunications Payloads |
| NPO Istok | Fryazino | Traveling Wave Tube Amplifiers |
| NPO Musson | Sevastopol | Mobile Communication Terminals |
| NPO Polyus | Tomsk | Power Supplies & Orientation Systems |
| NPO Istochnik | St. Petersburg | Spacecraft Batteries |
| NPO Kvant | Moscow | Solar Arrays for Space Applications |
| NPO Krasnaya Zvezda (Red Star) | St. Petersburg | Nuclear Power Systems |
| Zvezda (Star) | Tomilino | Space Suits & EVA Systems |
| NII Chimash | Moscow | Spacecraft Life Support Systems |
| NPO Kompozit | Kaliningrad | Advanced Materials & Instruments |
| NII Grafit | Obninsk | Carbon-Carbon Composite Structures |
| NPO Elas | Zelenograd | Astronomical Instruments |
| Splav Technical Center | Moscow | Microgravity Research & Payloads |
| NPO-NTs (Scientific Centers) | Zelenograd | Electronics & Microgravity Equipment |
| NPO Saturn | Moscow | Turbomachinery & Gas Generators |
| NPO Tekhnomash | Kaliningrad | Engineering Consultancy |

## 2.3.3 Spaceflight Support Facilities

With a demonstrated capability to launch over a hundred missions a year, often with several on the same day, the former Soviet space infrastructure is large and very capable. The majority of its facilities including the cosmodromes, most of the control & tracking network, and the cosmonaut training center are operated by the Ministry of Defense Space Units. The principal exception to this rule is the civilian Flight Control Center in Kaliningrad which is administered by TsNIIMASh, an RSA controlled institute, and run mainly by NPO Energia staff.

### 2.3.3.1 Launch Sites (Cosmodromes)

The Baikonur Cosmodrome (also called Tyuratam), located at 45.6° North latitude, is the principal launch complex responsible for all manned, planetary and geosynchronous missions. It is the only facility capable of launching the Proton, Zenit and Energia vehicles and can support the flight of all other Soviet vehicles except for the small SL-8 Cosmos. Due to range safety constraints at other cosmodromes, it is also the unique site in the former Soviet Union for launching spacecraft into retrograde orbits. Baikonur, named for a city over 370 kilometers away to deceive Western specialist, is the original cosmodrome from which both Sputnik and Gagarin were launched. Located on a 7,360 $km^2$ site east of the Aral Sea in Kazakhstan, the launch complex has recently been given much attention as the newly independent republics of Russia and Kazakhstan struggle over its control. Most of the workers at Baikonur live in Leninsk, a nearby city of 100,000 mainly Russian people[111]. The launch complex is staffed primarily by soldiers, most of which are draftees, who rioted in early 1992 to protest poor living conditions in the city. Rocket stages and spacecraft are transported to Baikonur by rail or air for final assembly on site. Separate assembly buildings and pads exist for the Proton, Zenit, SL-11, Soyuz/Molniya, and Energia/Buran launch systems. There is also a Buran shuttle airstrip with a microwave system for fully automated landings[112]. Soyuz and Progress spacecraft processing is done in the same building with the Soyuz launchers. Payload processing facilities for commercial customers are available in the

111 A. Lapin, "The Burans' and Shaft Diggers: Report From a City That's Not on the Map", Komsomolskaya Pravda, September 13, 1989, p. 4.

112 I. Kabak, "The Cosmodrome Without the Halo: Baikonur Covers 7,360 Square Kilometers", Argumenty I Fakty, No. 15, April 1991, p. 6.

Proton integration complex. Unlike at Western launch sites, vehicles are assembled and transported horizontally before final erection on the launch pad. The recent history of launch activity at Baikonur and the other cosmodromes is shown in Table 2.8.

Table 2.8 - Annual Launch Rates from the Former Soviet Cosmodromes

| Cosmodrome | Total to Date | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 |
|---|---|---|---|---|---|---|---|---|
| Baikonur | 896 | 22 | 27 | 29 | 43 | 47 | 35 | 35 |
| Plesetsk | 1,366 | 37 | 48 | 45 | 47 | 47 | 56 | 62 |
| Kapustin Yar | 83 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| CIS Total | 2,345 | 59 | 75 | 74 | 90 | 95 | 91 | 98 |

The Plesetsk Cosmodrome, located at 62.8° North latitude, is the world's busiest launch facility responsible mostly for polar orbit and high inclination missions. The complex is the former Soviet Union's leading military space center supporting spy satellite launches and missile testing and guarded by a ring of surface-to-air missiles. Located 170 kilometers south of Archangel in the Northwest corner of Russia, Plesetsk was not officially acknowledged until 1983 after more than 900 launches[113]. Most of the cosmodrome's staff live in the nearby city of Mirnyy. Unlike in the U.S., the Russians launch over land allowing spent stages to fall on sparsely populated areas. The stories of shepherds making their homes in old propellant tanks and reindeer breeders feeding their flocks from charred nose cones are common throughout Archangel Oblast. Although the people have learned to live with the "gifts from the sky", recent environmental concerns have led to extensive clean-up efforts around Plesetsk[114]. The cosmodrome consists of nine operational pads (as of late 1991) which can support five different launch vehicles. The most powerful vehicle launched from Plesetsk is the SL-6 Molniya and the newest is the SL-14 Tsyklon. Plesetsk's fleet is only able to launch payloads weighing less than 7,000 kg. Just as at Baikonur, all vehicle processing is done horizontally and is rapid and highly automated. For example, the SL-14 is launched just three hours after delivery to the pad. Two new SL-16 Zenit pads are under construction with a planned

113 N. L. Johnson, The Soviet Year in Space - 1989, Teledyne Brown Engineering, February 1990, p. 10.

114 V. Bokan, "A Cosmodrome is Not a Harmful Neighbor", Patriot, No. 7, Feb. 1992, p. 5.

completion in 1995. This new capability may foreshadow further expansion at Plesetsk as the Russians transfer operations from the now foreign Baikonur to sites within the Russian Republic.

Kapustin Yar (also known as the Volgograd Station) was the first rocket development center and is now a minor launch facility. Originally built in the mid 1940's to test captured German V-2 rockets, the center played an important part in the development of Russian ballistic missile technology. The 6,900 $km^2$ facility is located on the banks of the Volga river 965 kilometers Southeast of Moscow. A total of 83 orbital missions have originated from Kapustin Yar but since 1987 it has not launched a single spacecraft. The SL-8 Cosmos is the only launch vehicle that can presently be flown from Kapustin Yar.

#### 2.3.3.2 Flight Control & Tracking Network

The hub of the spacecraft control & tracking network is the Control Center. The former Soviet Union maintains two main Control Centers, one for manned spacecraft and scientific probes and the other for military and application satellites. The Spaceflight Control Center (TsUP) located in the Moscow suburb of Kaliningrad, is the manned and scientific operations center. It is administered by TsNIIMASh, but most of its controllers are from industrial enterprises, primarily NPO Energia. Established in 1970, it presently employs about 2,000 people in its two main Control Rooms and five smaller support rooms. One of the main Control Rooms is dedicated to Mir space station operations. It has three adjacent smaller rooms used for controlling autonomous flight of the Soyuz and Progress vehicles and for providing private communications between cosmonauts and their families. The other main Control Room supports Buran flight operations and it has two smaller support rooms which are used to control scientific probes such as those to Phobos and Mars[115]. Most Mir controllers work 24 hour long shifts except for those involved in dangerous operations who work only twelve hours at a time. Although these are strenuous hours, the tension is somewhat mitigated by the fact that most of a controller's day is spent waiting to communicate with Mir. Since many of the space support ships were returned to port to save money, contact with Mir now occurs only about 10 times a day for less than an hour at a time leaving the controllers idle for most of the day. Poor

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115 B. Mouzytchouk, Deputy Director of the Spaceflight Control Center (TsUP), interviewed in his office in Kaliningrad, October 21, 1992.

pay and working conditions led to rumors in January 1992 of an impending strike at TsUP which was only averted by a last minute raising of controllers' salaries[116].

The Golitsyno-2 Spaceflight Control Center located in the forests surrounding Moscow is responsible for controlling the 160 satellite constellation that the Russians maintain in Earth orbit. Until April of 1992 this facility was top secret and the 20,000 person town which was built-up to support its operations did not appear on any map. Over 1,000 contacts with spacecraft each day are processed by Golitsyno's military personnel to maintain all communication, navigation, remote sensing and military satellite systems[117]. The two main Flight Control Centers are supported by the Yevpatoria facility in Crimea, an old retired control center that is now used primarily as a back-up. The Long Range Space Communications System (TsDUC) also headquartered in Yevpatoria, has principal communication responsibility for high Earth orbit and deep space missions, similar to the U.S. Deep Space Network.

If the Control Centers are the brains of the flight control system, the communications antennae network is its eyes and ears. The most powerful network is TsDUC with 70 meter dishes in Yevpatoria and Ussurisk and a 25 meter dish in Ulan Ude. A 70 meter radio telescope is also being built on the Suffa Plateau in Central Asia to support the TsDUC system. "More than 30 fixed-site and mobile control and telemetry facilities scattered over the territory of the U.S.S.R. and the world's oceans"[118] keep the Control Centers in contact with the spacecraft being controlled. Molniya communications satellites play a central role in relaying information from these diverse sites to the central Control Centers. Since Low Earth Orbit satellites are only over Russian territory for 9 out of every 24 hours each day, a flotilla of space communication ships were built to provide around the clock communications coverage. The flotilla included more than 10 vessels led by its flagship, *Cosmonaut Yuri Gagarin,* which carried 75 antennae, two of which are 25 meters in diameter. The recent deployment of Luch data relay satellites has reduced the demand for communications ships.

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116 V. Gubarev, "Space Strike – A Final Cry for Help", Pravda, January 28, 1992, p. 1.

117 V. Baberdin & I. Ivanyuk, "Golitsyno-2: Center of Secret Space Orbits", Krasnaya Zvezda, First Edition, April 21, 1992, p. 2.

118 V. Gorkov, Aviatsiya I Kosmonavtika, Moscow, February 1989, pp. 32-33.

This and the need to save money has forced most of the space tracking vessels back to port and several have been decommissioned or even sold for scrap.

#### 2.3.3.3 Cosmonaut Training Facilities

The Gagarin Cosmonaut Training Center in Star City (Zvezdny Gorodok) is the central facility for preparing cosmonauts for flight. Located 30 kilometers Northeast of Moscow, the facility includes classrooms, laboratories, a health center, flight simulators, full scale spacecraft mock-ups, centrifuges, a neutral buoyancy tank and whatever else is needed to prepare cosmonauts for space. Its neutral buoyancy tank is 23 meters in diameter and 12 meters deep allowing training on full-scale space station modules. Its large 18 meters radius centrifuge can subject pairs of cosmonauts to accelerations of up to 30 g's simultaneously in multiple directions[119]. About 4,000 people live in the town of Star City including most military cosmonauts (the civilian cosmonauts tend to live near NPO Energia's facilities in Kaliningrad). About 10 experienced and 35 rookie cosmonauts are presently active in the program. From these, five two man crews consisting of one veteran and one rookie are in training for Mir missions at any one time. Foreign cosmonauts are also trained at the Star City facilities in a course which usually takes about 18 months to complete. The former cosmonaut and first man to walk in space, Alexei Leonov, was head of training at the center until he was forced to resign following his support of the August 1991 coup attempt[120]. Most but not all training facilities for the new Russian Space Shuttle are housed in a specially designed hanger in Star City. The principal exception is the Buran flight simulator which is located at the Central Aero-Hydrodynamics Institute (TsAGI) in Zhukovsky.

## 2.4 Operations & Management Practices

Now that this review of the organization, capabilities and institutions of the former Soviet space program is nearing its end, what general principles can be distilled from the knowledge of Russian space activities presented here? Hopefully this overview provides the reader with an appreciation of the vast

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119 V. I. Labunen, Administrator of the Gagarin Cosmonaut Training Center, interviewed in Star City, October 27, 1992.

120 V. Buldakov & R. Morozov, "A. Leonov Retires", Argumenty I Fakty, No. 44, November 1991, p. 6.

reach of Russian space activities both in terms of capabilities and institutions involved. The Russian space program is not a monolithic entity but is composed of thousands of separate organizations and hundreds of thousands of individuals each with their own histories and interests. To be able to benefit from the achievements of the former Soviet space program we must learn to understand and cooperate with the institutions and individuals that comprise it. Enumerating the enterprises and capabilities of the Russian space industry does provide factual information on its organization and strengths but there is much more that can be derived from this knowledge. From examining many organizations and how they interrelate, general conclusions about the *culture* of the Russian space industry can be made. Similarly, by examining Russian hardware and space systems, general conclusions about their design practices and technological strengths can be deduced. Although thousands of organizations exist each with their own idiosyncrasies, they all are part of a greater Russian space industry and this environment plays a significant role in shaping their actions. The following discussion will build upon the information presented in the previous sections to derive several general characteristics of the former Soviet space industry that are important for consideration by potential Western partners. These characteristics are true to a greater or lesser extent depending on the specific organization examined but they exist at some level in all institutions comprising the former Soviet space industry.

Before describing these general characteristics of Russian space enterprises, a brief discussion of the conditions that created them will be given. The communist system was undoubtedly a dominant factor in forming the operating practices of the Soviet space industry. Communism relied heavily on central planning and authoritative decision making and both of these traits not surprisingly found their way into space program management. Capitalistic structures such as markets were nonexistent resulting in prices and consequently cost accounting systems that were essentially meaningless. Marketing of products was given little weight as both the marketing and financing functions were subsumed into the centrally planned allocation system. Authority was concentrated in hands of the central planners who operated the space program with little or no input from other sectors of the society. There were however other significant environmental factors besides communism that helped form the *culture* of the Russian space industry. The Cold War with the capitalistic West played a major role in developing management practices as political and technological competition with the West became the central focus of space activities. The major criteria for approving new programs in this competitive environment was whether they improved the U.S.S.R.'s image as a prosperous nation and as the world's technological leader. Besides the geopolitical factors of communism and Cold War competition, other domestic factors affected space industry practices. These included the relatively recent arrival of industrialization in Russia, the lack of democratic traditions and maybe most importantly, the legendary ability of the Russian people to persevere. The stoic Russian character, able to endure hardships that would be unthinkable in other nations and still not lose hope, played a very large role in setting many business practices. Business leaders could have grand production plans and implement them with Draconian measures with little fear of worker resistance. The simple "boot strapping" of a nation of peasants into a space faring world power in less than forty years attests to the strength of Russian perseverance and its successful utilization by industrial leaders.

*Dominance By Technical Specialists*

One of the most striking aspects of the Russian space industry, and Russian society in general, is the great influence and prestige held by scientists and engineers. It may not seem surprising that scientific people dominate such a technologically intensive field as space exploration but the extent of their control and influence beyond their technical specialty is truly remarkable. From the beginning the Soviet government put unprecedented faith in the power of science to solve societal problems, essentially designating science as the new state religion. Although the early Soviet leaders were apprehensive of giving too much power to an elite class of technically trained professionals, eventually they succumbed to the need for technical expertise in running a centrally planned economy. Scientists and engineers started as advisors to government but over time began to hold the top level leadership positions themselves. Unlike in other nations, technical training and not a legal or business education became the prerequisite for advancing to the highest levels in government or industry. For more than three decades the top Soviet leaders, including most General Secretaries, have held engineering degrees. And engineering degrees in the former Soviet Union tend to be much narrower in scope than in the West. Undergraduate degrees with such unbelievably narrow purviews as "Ball Bearing Production for Paper Mills" are not uncommon. Essentially no social sciences or humanities (except for Marxist dogma) are taught to engineering students giving them an almost exclusively technical perspective. The result is that the technocratic leaders who manage Soviet industry, and in particular the space industry, tend to pay insufficient attention to the social or environmental impacts of their activities or even to broader business ramifications. As discussed in Section 2.1, beginning in the late 1960's the technocratic leaders of industrial enterprises captured control of the space program using their specialized knowledge and influence in the bureaucracy to become the main customers as well as the producers of space products. Once this type of manager with a narrow technical outlook took control, it was inevitable that grandiose projects with exciting technical traits would be given precedence over projects that provided broader benefits to society but were less intellectually stimulating.

The great prestige enjoyed by scientists and engineers resulted in their promotion to upper levels of management but also tended to lead to conflicts in applying technology for useful purposes. Businessmen were considered inferior and the best and brightest technical experts preferred to have little to do with business activities such as financing or marketing new systems. They would produce their designs and perform their research but provide little assistance in applying the results or in customizing the design according to user needs. However, recent economic turmoil and the need to supplement earnings has greatly increased interest in business among all members of society, including scientists and engineers. This has been accompanied by a decrease in the prestige of science in general as people turn away from an institution that the Soviet government promised would provide all the answers but which has failed to do so. An indicator of the declining influence of science in Russian society is the growing public fascination with astrology and other pseudo-sciences as indicated by the booming sales of books on these subjects[121].

The results of having space enterprise managers trained solely in the scientific and engineering disciplines, instead of including those with business and legal educations as well, have been devastating to the Russian program. The industrial leadership looks to technical solutions and scientific expertise to solve all of its problems. The top management assumes that the most highly trained and experienced personnel always have the best solutions. Little effort is made

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121 N. Vorontsov, comments at the seminar Crisis in Russia: What is to be Done?, held at the Massachusetts Institute of Technology, April 29, 1992.

to obtain input from customers or any non-specialists since only those with years of training are considered competent enough to have useful ideas. The experts presumably know what is best for everyone even when those same experts are crippled by an exceedingly narrow education and isolated from broader concerns and interests by limited contact with non-specialists. Consequently the needs of the customer or user of a space system often receive little attention. The planning process for new Russian space systems is condensed so that the engineers can dive right in and begin designing even before the requirements are clear. Unlike a new start for NASA where four or five years can be spent in Phases "0", A & B determining system requirements and user needs, the Russians typically start with a technical proposal and within the project's first year are developing detailed designs[122]. They waste little time in assessing whether anyone really needs the new system, if it can be built and if it is supported by the Chief Designer, the project gets the go-ahead. After millions have been spent and the technocrats need more money, then they begin to look for uses for the new system and post facto calculate its benefits to society (these calculations themselves tend to be a monument to narrow technical perspectives). The lack of adequate up-front planning leads to many programs that due to inertia continue for years yet have no real customers beyond the benefits to the manufacturers themselves. The Russian space enterprises have brought their lack of customer orientation along with them in their attempts at international cooperation. They have little appreciation for developing close customer relationships and soliciting outside input on their product designs. Instead, they would prefer that customers simply buy their products "as is" and not waste so much of their time in the selling process. Potential partners must recognize the contempt which has developed in the former Soviet Union for "sales people" and the great prestige held by technical experts. And Russians must begin to realize that often a successful manager must be both.

*Conservative Design Approach*

Russian industry's incremental approach to developing space systems makes continued use of proven designs and technologies for decades, performing fundamental design changes only when absolutely necessary. This

122 N. Tolyarenko, "Design and Construction of Space Vehicles", lecture given at the International Space University in Toulouse, France, July 1991, Figure 2.

practice contrasts sharply with that in the U.S. were spacecraft technologies rapidly become obsolete and nearly every spacecraft has its own unique design. But it should not be concluded from this that the Russian industry does not push the leading edge in space technologies because in fact many of Russia's operational space propulsion and power systems are the most advanced in the world. However, these advanced systems tend to be integrated into old work horse designs and are utilized only when the previous approach proves to be wholly inadequate. There are several important reasons why Russian designers tend to be so conservative relative to their Western counterparts. Firstly, Russia's relatively late industrialization and its delayed participation in the scientific revolution put it in a position playing catch-up to the West in high technology. Although Russia has been fully industrialized for decades, its self image as a late starter along with the inefficiencies in its research establishment brought by communist control have perpetuated the perception that Russian technology is inferior. Although many would not admit it, most Russian designers tend to be skeptical of technologies developed at home. Therefore designers have been reluctant to utilize these technologies until they are well proven through years of testing. Another important reason for Russian conservativeness in design results from the extreme tenacity of the Russian people as previously discussed. Most space system designs in the former Soviet Union were developed through years of hard work and entailed countless failures. For example, in the study of Venus the first real success came only after seventeen failures. Following all those disappointments, a Venera spacecraft design was finally derived that successfully orbited and landed on Venus more than a dozen times. Who could blame the Russians for wanting to use the Venera design as much as possible after they had paid for it so dearly? Since many failures requiring great perseverance to overcome seem to be the rule in designing new space systems in the former U.S.S.R., it is not surprising that once they have a design that works, they stick with it. Finally, as previously discussed, engineers have a strong hold on the management of space enterprises in Russia and as we all know engineers like to be as conservative in design as possible. In the U.S. conservative engineering tendencies are countered by competitive business forces which demand ever more capable systems. In Russia where the engineers "rule the roost" and the producers dictate to the customers, the old reliable designs preferred by the engineers are utilized for decades before they are finally retired.

The impact of Russia's incremental design approach has been both positive and negative. The most obvious negative result from such a slow and methodical approach to utilizing new designs is that technology advances may be retarded. This has been the case for most Russian spacecraft which are generally much heavier and have shorter operating lives than similar Western systems. Russian spacecraft buses also tend to provide fewer services requiring the instruments they carry to provide their own power conditioning, thermal control, on-board memory and many other functions commonly provided by U.S. spacecraft. The reason for this poorer performance is that most Russian satellites are derived from basic designs from the 1950's and 1960's which have been modified little to meet changing needs over the past thirty years. For example, the Vostok spacecraft, first used in 1961 to carry Yuri Gagarin into space, continues to be used in various forms as a military photo reconnaissance satellite, the Resurs-F Earth resources satellite, the Photon microgravity processing spacecraft, and the Bion biological research spacecraft and has been flown in these different roles over 600 times. Clearly the Vostok spacecraft, designed for manned flight, cannot be optimal for performing all of these diverse missions. The Russians pay the price of reduced performance to be able to reuse designs in which they have developed high confidence. Unfortunately, such an approach allowed many promising technologies such as microelectronics to go undeveloped because the old technologies appeared good enough, at least to the conservative design engineers in charge.

Although conservative design practices have had a negative impact on spacecraft performance, they have led to Russia's development of the world's most capable launch vehicle fleet. Heavier spacecraft require larger launch vehicles so that Russia was forced to develop vehicles with great lift capability. The shorter life span of Russian spacecraft meant that more replacements were needed along with more launch vehicles to put them into space. This allowed the Russians to put both their spacecraft and launch vehicles into mass production and reap the cost benefits which come from economies of scale[123]. High annual production rates along with the longevity of launch vehicle designs makes production runs of Soviet boosters an order of magnitude greater than those in other space faring nations. The A-class booster provides the most extreme example having put Sputnik-1 in orbit in 1957, orbited Gagarin in 1961,

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123 A. Dupas, "The USSR's Prudent Space Policy", Space Policy, August 1987, p. 241.

and since then launched nearly 1,400 other spacecraft, more launches than all U.S. vehicles combined. Production of over a thousand units provides a large base over which to amortize fixed costs for development and tooling and permits many learning curve effects that result in reduced recurring costs to be fully realized. Consequently, one would expect Russian enterprises to be able to produce launch vehicles far cheaper than U.S. companies who operate with much smaller production runs. In the end the former Soviet space program probably paid more than it had to for its space capabilities because the cost of additional spacecraft likely outweighed the reduced per unit cost from mass production. But for someone examining Russian capabilities as a potential partner, the low per unit cost of its systems, especially its launch systems, can be very appealing. The result of Russia's conservative design philosophy has been to create second class satellites but world class boosters, both of which are produced in mass quantities very cheaply.

*Central Role of Chief Designers*

In a communist nation whose central ideology is equality of all workers, it is ironic that so much authority is vested in the hands of the industrial leaders, known affectionately as the Chief Designers. Part of the Chief Designers authority is derived from the high regard given to technical specialists in general as previously discussed. Chief Designers are often considered to be the leading technical expert in their organization and therefore are given great respect. However, simple respect for technical abilities cannot explain the near worship of some of the most prominent Chief Designers such as Korolyov and Glushko. From the description of enterprises in Section 2.3, the dominant role of Chief Designers in their respective organizations is apparent. They are the final authority for approving programs and budgets within their enterprise and its chief representative to the outside world through their participation in such groups as the Council of Chief Designers. Chief Designers tend to hold their position for incredibly long periods (30 or 40 years in some cases) being replaced only after a dramatic overthrow or their own death. The fact that most enterprises are named in common usage after their former or present Chief Designer (e.g. Korolyov's bureau. Yangel's bureau, Reshetnev' bureau, etc.) attests to their dominant role in these organizations. Much of the organizational structure of industrial enterprises was copied directly from the Soviet society in which they existed. Thus it is not surprising that strong individuals rose to near dictatorial power in industry just as they did in society in general. Strict hierarchy and central authority provide fertile ground for producing an autocrat. But more was at work in Russia than mere authoritative structures in forming the very personal admiration and awe in which Chief Designers (and Soviet leaders generally) were held. Unlike in the U.S. where impartiality and rule of law are the norm in the business environment, Russian business has always relied heavily upon personal contacts and trust. Much as in other sectors of Russian society, business operates on a very personal basis where loyalty to one's associates is more important than strictly following the law. In such an environment, it is not surprising that people strove to have friends in high places by honoring those in power since powerful friends were indispensable to professional advancement. The personal nature of business along with the central authority and technical prestige commanded by the Chief Designers led to a personality worship of industrial leaders that is unique to the Soviet business environment. Recognizing the esteem in which Chief Designers are held and learning to adapt to organizations managed through a personal hierarchy is a major challenge for potential Western partners.

*Close Association with the Military*

The final characteristic of the Russian space industry which needs to be mentioned is its well known close association with the military. The military is important to the industry not only because it is the major customer of space services but also because it controls most of the infrastructure that the industry relies upon for launching, tracking and recovering its spacecraft. Consequently many military concerns and perspectives are also shared by the space industry. For example, secrecy and distrust of foreigners are common throughout the space industry. As contact with international partners has grown, much of this distrust has disappeared but skepticism of foreigners' intentions remain just below the surface. Similarly, much secrecy has been done away with but a heritage of concealing information still makes it difficult for many space industry officials to be fully forthcoming. The space industry has spent decades competing with its Western counterparts and it will take some time for its people to feel comfortable with the emerging cooperative role. However, in the foreseeable future the Russian space industry will continue to play a major military role and most of its military activities will continue to be off-limits to foreigners. Thus potential Western partners must be careful to push for access to all information legitimately required for cooperative activities but also be sensitive to the fact that their partners possess military secrets that they are not able to disclose. To be effective partners, U.S. organizations need to become cognitive of the differences between American and Russian business practices. Only through a better understanding of each others' modes of operation, which could take years of hard work to completely develop, will the benefits of international joint activities in space ever be fully realized.

# Chapter 3

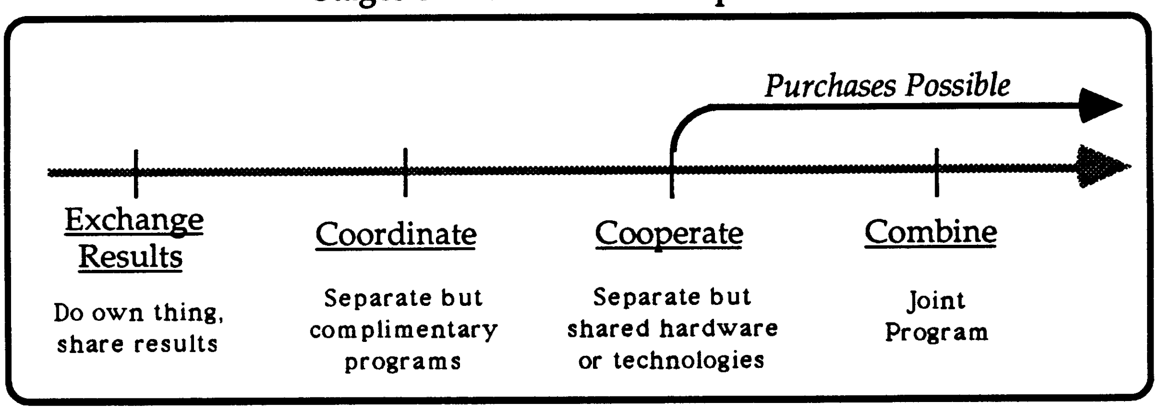
# Suggested Areas for Russian Cooperation

This chapter will identify the most promising areas for NASA to pursue joint projects with the Russian space program. It's objective is to determine, through an assessment of the benefits and costs for each category of potential projects, those areas for cooperation that offer the greatest net benefit to the U.S. as a whole. The assessment begins in Section 3.1 with a comprehensive examination of the cooperative areas that are presently being pursued by NASA, other government agencies, U.S. companies and organizations abroad. The purpose of this initial overview is to bound the analysis by enumerating all areas throughout the world where cooperative activities with Russia are being either performed or considered. Section 3.2 discusses and critiques the selection process that is currently used by the U.S. government, and NASA in particular, for determining which areas of space cooperation to pursue. It argues that shortcomings in this process have led to poor decisions concerning when Russian space cooperation is considered desirable. Recommendations for improving this process will be put forth later in Chapter 4. The focus of this chapter is to determine *what* areas should be pursued, not the process question of *how* to pursue them. To this end, Section 3.3 proceeds through each area identified in the first section, weighing the benefits against the costs to determine a list of recommended areas in which NASA should pursue cooperative projects with partners from the former Soviet Union.

Before beginning the assessment of the most promising areas in which to cooperate, it is important to first clearly define what is meant by the term cooperation. In this analysis, the term *cooperation* is used mostly in a general sense to refer to any type of activity that allows two or more nations to benefit from each other's resources or capabilities. It may include use of another nation's data, people, facilities, technologies, services, hardware, or complete space systems. There are of course many different levels at which nations may conduct cooperation. Figure 3.1 distinguishes the four main stages in a cooperative relationship. It is not necessary to progress through these stages in a linear fashion however as one moves to the right, greater commitment is required and consequently the advanced stages are usually proceeded by success in simpler cooperative activities.

Figure 3.1

**Stages of International Cooperation**




The simplest method of cooperating is for nations to conduct independent programs and to share whatever results they obtain. A somewhat more complex approach is for nations to coordinate their programs so that their results will compliment each other when they are shared. The next level of sophistication is, for lack of a better term, cooperation in the strict sense. Strictly speaking, cooperation entails separate programs that share not only results, but also the means for achieving results (e.g., facilities, technologies or hardware). Nations may chose to use foreign assets to perform a diverse range of functions all the way from adding complimentary capabilities not critical to a program's success, to providing essential elements necessary to implement the core program. Even in its strict sense, space cooperation entails a wide variety of options. The final and most advanced stage of international cooperation is the combination of separate national projects into a single multinational joint program. The administration of projects under the auspices of the European Space Agency represent the only truly joint space activities conducted in the world today. In strictly cooperative or joint projects when the inputs to space ventures may be shared, it becomes possible to cooperate by selling space assets between nations. Fundamentally cash purchases are no different than bartering a hardware contribution to obtain another nation's assistance. Cash purchases simply allow transactions in a more complicated environment such as when the barter contributions from individual partners are not exactly equal. International financial transactions in the space community are the natural result of more intimate and complex cooperative relationships. The opportunity to purchase Russian assets does not at all change the benefits of cooperating in space, only the means that can be used to achieve these benefits.

## 3.1 Areas of On-Going Joint Activities

The purpose of this section is to use the experiences of other organizations to help derive a complete list of areas in which NASA may wish to seek cooperation with the Russians. The different areas of cooperation that both public and private organizations around the world are pursuing will be examined. In addition, this investigation will provide a description of NASA's present position in Russian space activities relative to other foreign and domestic partners. Particular attention will be paid to those cooperative areas where international partners are very active yet in which NASA has few joint projects.

The overall landscape of present cooperative activities between Russia and international partners is shown in Figure 3.2. This figure is a matrix that relates the different partners of the Russian space program with the areas in which they cooperate. The determination of the level of activity of each partner in each cooperative area is somewhat subjective but is meant to convey only the gross differences in activity levels based upon extensive knowledge of on-going projects worldwide. Cooperative Russian space activities can be grouped into five main categories or areas: 1) manned systems, 2) space sciences, 3) satellite applications, 4) launch vehicles, and 5) sub system-level inputs. This classification is obtained by using the top level designations for all cooperative areas shown in Figure 3.2. Since most aerospace component purchases and service agreements are affiliated with an effort to obtain access to Russian technologies, it makes sense to combine the last three columns in the figure. This assertion is supported by the common interest of almost all partners in Russian hardware and services along with technology that is shown in Figure 3.2. The five categories given above will be used in all further analysis to assess the most promising areas for NASA to cooperate. These categories are very broad and it is assumed that they contain all on-going activities with the Russians as well as possible future cooperative projects not yet being pursued. For example, a future joint mission to Mars would not be beyond the classification system. If the mission included humans it would fall into the manned systems area and if it did not it would be part of the space sciences area.

In examining the summary of information shown in Figure 3.2, a few key points jump out immediately. First of all, cooperation between the U.S. and Russia can be divided into three main clusters where each cluster's activity is controlled by a different mix of governmental and industrial players. One cluster is in the areas of manned systems and space science. Here NASA and its aerospace contractors play the dominant role in managing and conducting activities. Manned systems and space science are two of NASA's major program areas and its Russian cooperation in these areas is conducted largely at the coordination stage. For example, NASA has for decades been coordinating its solar system exploration missions with its international partners and over the last few years this has come to include coordination with Russian planetary scientists. The next cluster is in the areas of satellite applications and launch services with users of space systems (telecommunications firms, users of remote sensing data and microgravity processing, etc.) being the main partners. These areas of cooperation entail the use of complete Russian systems or services that tend to be sold for hard currency. The final cluster is around the areas comprised of sub-product level inputs (aerospace components, technologies and engineering or testing services). All major space partners in the U.S. play a role in these basic areas. In particular, the breadth of interest in Russian space technologies shown by the substantial amount of activity with partners worldwide, demonstrates the importance of this cooperative area. Cooperation in space technology is one of the few areas were U.S. space organizations have been unambiguous in their support of increased Russian interaction.

Many U.S. organizations are pursuing Russian technologies using whatever means are available (e.g., buying, bartering or stealing). Ironically, the lead government agency in the pursuit of Russian technology has been the Strategic Defense Initiative Office (SDIO) whose primary mission is to defend against a Russian ballistic missile attack. SDIO has purchased four SPT-70 Stationary

Figure 3.2

## Map of Present Cooperative Activities with the Russian Space Program

| Partners | | | Manned Systems | Space Sciences: Planetary/ Astronomy | Satellite Applications: Earth Observing | Satellite Applications: Communi-cations | Satellite Applications: Microgravity Processing | Launch Services | Sub System-Level Inputs: Aerospace Hardware | Sub System-Level Inputs: Technology | Sub System-Level Inputs: Engineering or Testing Services |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Non-U.S. | EUROPE | ESA | ● | ● | ● | ○ | | | ● | ● | ● |
| | | France | ● | ● | ○ | | ○ | | ○ | ● | ● |
| | | Germany | ● | ● | | ○ | ● | | ○ | ● | ● |
| | | Others | ● | ○ | | | ○ | | ○ | ○ | ○ |
| | OTHERS | Japan | ● | ○ | | | | | | ● | ○ |
| | | India | | | | | | ● | ● | ● | ● |
| | | Int'l Users | | | | ○ | | ○ | ● | ○ | ○ |
| U.S. | Gov't | NASA | ● | ● | ○ | | | | ○ | ○ | ● |
| | | DoD/SDIO | | | | | | | ○ | ● | ○ |
| | | DoE/Others | | | | | | | ○ | ○ | ○ |
| | Firms | Aerospace | ○ | ○ | | | | | ○ | ● | ○ |
| | | Users | | | ○ | ○ | ● | ○ | | ○ | |

● - Much Activity ○ - Some Activity - No Activity

Plasma Thrusters, several taciturn high temperature switches, and two Topaz-2 nuclear space reactors[124] with plans to purchase an additional four reactors by the summer of 1993, all at a costs of less than $35 million. The military's clear intention to reverse engineer these products to transfer to the U.S. the technologies that are imbedded in them raises serious questions of intellectual property protection for international partners. SDIO has a detailed plan to acquire Russian technologies in some fifty different areas at an expected cost of $50 million providing an estimated savings in development costs of over $4.5 billion to U.S. taxpayers[125]. Recently, SDIO created the Defense Technology Institute whose expressed purpose is to promote U.S.-Russian collaboration in the development of defense technologies[126]. SDIO's long-term intentions in Russia are uncertain and many see them simply as carpetbaggers who are taking advantage of the desperate financial situation in Russia. The Department of Energy as well as other government agencies are also pursuing the acquisition of Russian space technologies as have many private U.S. companies. Pratt & Whitney's agreement with NPO Energomash for access to Russian large liquid rocket engine technology (in particular, RD-170 engine technology) is a typical but prominent example. Rockwell International, Boeing, McDonnell-Douglas, General Dynamics, Lockheed, Loral Space Systems and Aerojet General are all actively pursuing acquisition of space technologies in Russia. Although NASA has allowed SDIO and U.S. industry to take the lead in utilizing Russian technologies, it is now beginning to recognize the value of these assets and to take action to acquire some of them. Recently, NASA initiated limited projects to investigate Russian technologies in optics, lasers, space power, materials, propulsion systems and space batteries for their possible use on U.S. spacecraft.

When examining the clustering of cooperative activities in Figure 3.2 outside of the U.S., a very different picture emerges. In Europe, cooperation with Russia is much more broad-based with many different national and international players involved in substantially more Russian-related projects than in the United States. As in the U.S., the Europeans are strongly pursuing Russian

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124 J. Asker, "Purchase of Russian Space Hardware Signals Shift in U.S. Trade Policy", Aviation Week & Space Technology, April 6, 1992, p. 25.

125 "SDIO Plans to Acquire Russian ABM Technology, Specialists", Aviation Week & Space Technology, February 10, 1992, pp. 18-20.

126 "Cold Warriors Funding U.S.-Russian Research", Space News, January 18-25, 1993, p. 2.

technology opportunities but they are also utilizing Russian facilities, expertise and flight systems to a much greater extent than the Americans. Part of this is due to the greater needs of the European space program because of its relatively small size and part is due to the common continent-wide interests that the Russians and other Europeans share. But there are also important competitive motives at work in Europe's broad-based response to Russian space opportunities. It is clear from Ariane's dramatic penetration into the world launch services market in the 1980's that the Europeans take international competition in space products seriously. Russian assistance in manned systems, scientific missions, application satellites and possibly even launch vehicles has the potential to propel Europe into a position of prominence in the international space community. The only area where Europeans have shown an aversion to using Russian assets is in launch services and this is obviously because they wish to deter Russian entry into an international market that they already dominate.

Outside of Europe, the map of cooperative activities breaks down into two main clusters. One is in the areas of manned systems and space science with Japan as the exclusive partner and the other is in technologies, services and hardware and includes Japan as well as other partners. Japan is the only nation outside of the U.S. and Europe that can afford manned flight and scientific activities and thus it is the only one cooperating in these areas. However, as is occurring worldwide, Japan and many Third World Nations are making use of Russian space technologies. Japan's proven ability to turn externally developed technology into a competitive weapon in the international marketplace should be enough to make its activities in Russia a concern to the U.S. aerospace industry. But so far, most concern in the U.S. has focused on developing nations, in particular India, and their attempts to acquire Russian launcher and spacecraft technologies. The U.S. fears that such technology could help these nations develop missile delivery systems and thus contribute to the proliferation of high technology weaponry. Such national security concerns are of course important, but so should be industrial competitiveness concerns. Indian has also been the only international customer to date for Russian launch services having launched twice on Russian vehicles. The international telecommunications organization Inmarsat will soon join India as a Russian launch services customer having purchased a 1995 launch for its Inmarsat-3 satellite on a Proton vehicle.

Of the five main areas for cooperation, NASA is active in three: manned systems, space sciences, and sub system-level inputs. Of these, NASA is the lead

U.S. organization in the first two but has lagged behind other organizations in its pursuit of Russian technology and technical services. The June 1992 U.S.-Russian space cooperation agreement gave a great boost to NASA's manned cooperative activities. It called for an exchange of astronauts and cosmonauts on U.S. and Russian spacecraft and the docking of the U.S. Space Shuttle with the Mir space station. The agreement also provided for expanded joint life science work including the flight of U.S. experiments on Mir and Russian Bion capsules. And lastly in the manned systems area, it suggested the use of Russian hardware in the space station Freedom program, in particular the use of the Soyuz vehicle as an interim Assured Crew Return Vehicle (ACRV). The most remarkable aspect of these developments is that some of the projects entail direct funding of an international partner, apparently relaxing the "no exchange of funds" policy that has always been followed in the past[127]. Nonetheless, the majority of these projects consist of coordinating activities and they are far less ambitious than those being undertaken by the Europeans. NASA's other major cooperative area, space sciences, also received a boost from the recent agreement however there has been cooperation in this area for years, mostly consisting of data exchanges. Recent expansions in space science cooperation include the flight of U.S. instruments on Russian spacecraft (both planetary and Earth observing), the sharing of deep space tracking and communications systems (both in-space relays and surface antennae), and the initiation of joint studies and equipment testing. As in manned systems, NASA is becoming increasingly involved with the Russians in space sciences but at a slower pace than the Europeans.

NASA has almost no involvement in Russian space cooperation in the areas of satellite applications and launch services. The agency sees itself as a developer of space systems and technologies for use in the scientific exploration of space. When technologies it has helped to create find non space science applications, such as telecommunications or weather forecasting, NASA assumes little responsibility in assuring that they are put to effective use. Consequently, unlike in other nations, the practical products derived from the space program (e.g., application satellites and launch vehicles) are ignored by the space agency and their utilization is left solely in the hands of industry. NASA believes its only interest in these areas should be as a buyer of the products or services. In its

127 "Joint U.S.-Russian Statement on Cooperation in Space", White House press release, June 17, 1992.

capacity as a buyer, the agency has investigated the possibility of using Russian launch vehicles to orbit large payloads or to reduce launch costs but for political reasons these investigations have not gone far. NASA's lack of concern for assisting industry beyond the needs of its present programs also helps to explain its relatively restrained approach in pursuing Russian technologies. Because of the limited scope of its mission, NASA has focused its efforts in the manned systems and space science areas paying almost no attention to other possible cooperative projects except for those in the technology area, and only limited attention there. Why has NASA drawn the borders of its mission and consequently of its cooperative ventures so narrowly? To answer this question it is necessary to closely examine the space policy making process in the U.S. as will be done in the next section.

## 3.2 Selection Process for Cooperative Projects

This section will describe and critique the present process for selecting cooperative Russian space ventures and argue that the flaws in this process have resulted in poor policy making. The national or interagency process is described first, followed by a presentation of the specific procedures used within NASA. The final subsection concludes with a discussion of how shortcomings in the project selection process, both within NASA and at the national level, have led to inferior strategies for pursuing Russian space cooperation. Recommendations for improving the selection process to avoid future problems is left for Chapter 4, when other implementation issues will be addressed.

### 3.2.1 The National Selection Process

Space cooperation with the Russians is a national concern involving many private and public interest groups throughout American society. In addition to effects on the space program, space cooperation agreements impact foreign policy, national security and industrial competitiveness and therefore the Departments of State, Defense and Commerce all play important roles in addition to NASA. Other important players in the formation of U.S. international space policy are the intelligence community (e.g. the C.I.A.), developers of space-related technologies (e.g. the Department of Energy), users of space systems (e.g. the National Oceanographic and Atmospheric Administration) and regulators of space systems (e.g. the Department of

Transportation). Through its lobbying efforts and advise to policy making bodies, industry also plays an important role. The diverse interests of these organizations were supposed to be coordinated in the policy making stage by the National Space Council, headed by the Vice President, and in the implementation stage by an interagency review process (known as the Circular 175 process)[128]. However the recent disbanding of the Space Council, and its prior inability to deal with the avalanche of new Russian cooperative opportunities, has resulted in most policy making occurring at the interagency review level. When there is no clear direction from the executive level regarding a certain area of proposed cooperation, the decision to pursue or not pursue an opportunity in this area has in the past set U.S. policy by default.

The State Department administers the Circular 175 process and consequently it has substantial authority, some would say too much authority, in directing the outcome[129]. The Defense Department also possesses major influence due to its control of export licensing for defense-related equipment (i.e., most space hardware). The objective of interagency review is to maintain consistency and a focus on national level objectives in U.S. space policy, but in fact it has produced just the opposite effect. Each agency included in the review process takes a parochial point of view, arguing only for its own interests with the process regulating the debate until a particular viewpoint wins out. Sometimes the State Department wins and foreign policy concerns are given most weight while other times the Commerce Department wins and protection of domestic industry prevails. The result is an uncoordinated, often contradictory policy which flip-flops between the narrow interests of the competing agencies. For years, no U.S. spacecraft could be launched on Russian vehicles, then a one time exception was made for an Inmarsat launch on Proton. Once again, no U.S. satellites were allowed on Russian vehicles, and then a Lockheed agreement to market Protons in the U.S. was approved. The flip-flopping U.S. policy regarding American use of Russian launch vehicles apparently depends on the outcome of the latest interagency battle.

Not only does the present process result in inconsistent policies, but it also unfairly supports the interests of government agencies at the expense of private

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128 J. Hofgard, Chief of International Program Office, NASA Headquarters, interviewed in his Washington office, January 22, 1993.

129 A. Lawler, "State Trumps Policy Foes", Space News, January 18-25, 1993, pp. 4 & 8.

interests. For example, the Department of Energy (DoE) is allowed to purchase 40 kilograms of Plutonium-238 from the Russians[130] which undoubtedly helps to maintain their nuclear weapons production facilities, while small entrepreneurial U.S. firms are denied access to low cost Russian launch vehicles supposedly because of technology transfer concerns. Surely it is more dangerous to U.S. security to fund the production of radioactive materials than to allow low technology electronics to be flown on Russian vehicles! But the DoE has considerably more clout in the selection process than do the small space system users who are basically unrepresented. Although the inconsistencies due to governmental in-fighting makes it difficult for the various government agencies to create long-term plans for Russian cooperation, they at least have some say in the decision making process. Industry is at the complete mercy of government decisions that they have little ability to effect.

Pratt & Whitney's efforts to obtain access to Russian liquid rocket engine technology is a good example of how the present process neglects the needs of industry in determining when to support cooperation with the Russians. As has been previously mentioned, Pratt & Whitney announced a joint venture with NPO Energomash in October, 1992 for exclusive rights to utilize its large liquid rocket engine technology in the U.S.. Of most interest was the technology from the Energomash's RD-170 engine (Zenit first stage) which is the world's largest and most advanced engine. To form this joint venture and give the U.S. access to leading-edge Russian space technologies, Pratt & Whitney had to invest large amounts of its own capital[131]. This investment represents an enormous risk to the company since there is no government commitment that Russian rocket technologies will be allowed into the U.S. market even if they result in lower cost and more powerful engines[132]. Pratt & Whitney decided to take the gamble because it felt that the profit potential the Russian technologies offer if they are permitted into the market outweigh the financial risks. Even though Pratt & Whitney decided to forge ahead with its Russian joint venture, it is clear that the

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130 V. Kiernan, "U.S. Buy of Russian Plutonium for Space Mission Criticized", Space News, January 4-11, 1993, p. 7.

131 J. Roberto, Director of Business Development & Planning, Pratt & Whitney, interviewed by phone at his office in West Palm Beach, Florida, November 6, 1992.

132 J. Rymarcsuk, "Pratt & Whitney: Using Russian Liquid Fuel Rocket Engine Technology as a Competitive Weapon in the U.S. Market", Managing International Trade & Competition term project, Harvard Business School, Autumn, 1992.

financial and operational risks placed on companies by the government's lack of clear, steady direction is slowing U.S. involvement with the Russian space program. Many U.S. companies, most notably the other two liquid rocket engine manufacturers, Aerojet General and Rocketdyne, have been scared-off by the government's indecisiveness towards Russian cooperation. Given the technological superiority of many facets of Russia's space program, this governmental impediment to enhanced Russian cooperation will likely result in diminished U.S. technological competitiveness in the international market. This is particularly true since in nations such as Germany and Japan, their governments are not only creating an environment more conducive to Russian joint ventures, but they are also actively supporting private interests in the exploitation of Russian space assets.

### 3.2.2 NASA's Selection Process

Within NASA, Russian cooperation activities are coordinated by the International Relations Division at NASA Headquarters in Washington. Suggested cooperative projects come to this organization both from principal investigators within NASA who identify opportunities in Russia and from external directives to pursue certain cooperative areas. NASA then internally assesses the various possibilities for cooperating using long established guidelines. For decades, NASA's participation in joint international projects has been guided by a few basic principles[133]:

- A preference for specific project-oriented agreements rather than generalized "umbrella" agreements.
- A preference for cooperating with government agencies rather than with private foreign organizations.
- A desire for U.S. control of all elements on the critical path.
- An insistence on clean technical and managerial interfaces.
- No or minimal exchange of funds between cooperating partners.
- No or minimal technology transfer to be assured through creation of a detailed technology safeguards plan.
- Open access to all scientific results.

133 J. Schumacher, Deputy Associate Administrator, Office of Policy Coordination and International Relations, NASA Headquarters, interviewed in his Washington office, January 22, 1993.

These principles guide not only *when* NASA engages in cooperative activities but *how* it cooperates. Consequently they will be referred back to many times in both this and the following chapter. Given their importance to NASA's policy making and program implementation, it is critical to understand how these tenets were first developed and why they have been adhered to so steadfastly over the years.

NASA's approach to international cooperation, as exemplified by the above principles, was created at a time when the U.S. was clearly the dominant Western space power and international space policy generated little interest in the U.S. beyond the space agency. NASA could use its dominant position to exert tremendous control over its international partners as well as other government agencies in formulating cooperative space projects. It could dictate control of the critical path, disallow exchange of funds, limit technology transfer, and insist on working only with government agencies because its partners had little other choice put to follow NASA's rules or be left out of international space activities. Being an organization dominated by scientists and engineers, NASA put great emphasis on simple and efficient interfaces, project-oriented management, and sharing of all scientific discoveries. The space agency structured its international activities just as it did all of its domestic work, putting most effort into addressing scientific and technical concerns and little into management issues. The scientists and engineers ran the programs while professional managers, with their interests in areas such as strategic business planning and cost control mechanisms, were relegated to the role of "bean counters". Although NASA's position both in the U.S. government and in the international space community has substantially changed over the years, there has in fact been little change in its approach to cooperation. As the bureaucracy at NASA has matured, its bureaucratic structures have become calcified resulting in the agency's inability to adequately adapt to changing environmental conditions. The guidelines presented in the previous paragraph are basically the same as they were in the 1960's, as are most other management practices within NASA. The agency's resistance to change has caused many of its programs, both domestic and international, to become incredibly inefficient and mired in practices that have been out-of-date for decades. Granted, in recent years NASA has begun to interpret its cooperative guidelines more broadly, and at times even ignore them. Yet the ideals that these guidelines represent continue to exert strong influence over the space agency's thinking towards international cooperation.

The changing world environment has made anachronisms of many of NASA's principles for cooperating. The last two decades have seen the development of much greater parity in the capabilities of international space powers but NASA still demands a privileged role in all joint ventures. The globalization of the world economy has driven private industry to seek international "strategic alliances" to cooperate over an extended period of time and over a series of situations. NASA still seeks only short-term, well defined projects in which to cooperate. The onset of space commercialization and internationalization has given many private concerns and supra-national organizations important roles in the space community. NASA still insists on cooperating only with national governmental agencies. With commercialization, the international competitiveness of a nation's space industry has become more important. Optimizing economic factors such as system costs, reliability, and flexibility to meet the needs of multiple customers is now more important than maximizing technical performance. Access to technologies for improving economic performance will be a major determinant of the future competitive strength of the U.S. space industry[134]. Yet NASA still insists on minimal technology transfer in its cooperative projects through clean managerial and technical interfaces and no exchange of funds for purchasing foreign technologies. NASA continues to cling to some of its competitive feelings towards the Russians developed during the Cold War. Consequently, it tends to underestimate Russian technical capabilities and neglect technologies that were "not invented here". A clear example of this is NASA's consideration of Russian electric propulsion technology as "experimental", when thrusters using this technology have been flow on operational Russian spacecraft since the 1970's. The world has experienced substantial changes over the last thirty years yet NASA's approach to international cooperation, and many of its other management practices, have failed to keep pace with these changes.

The process for selecting cooperative space projects at NASA has of course seen some evolution since the 1960's. As previously mentioned, interpretations of NASA's basic guidelines for international cooperation have become progressively looser. In the Russian case, NASA has gone so far as to award several contracts directly to Russian enterprises. This violates both the "no

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134 J. Johnson-Freese, "Changing Patterns of International Cooperation in Space", lecture delivered at the International Space University in Toulouse, France, July, 1991.

exchange of funds" rule and the rule for cooperating only with government agencies. NASA is also funding Russian research centers to obtain access to their technologies. However in both these situations, the agency considers the present agreements only short-term remedies that are justifiable only because of the extreme circumstances in Russia. In the long-term, NASA intends to return to pursuing Russian cooperation using its old principles of engagement. Yet whether or not this will be possible remains uncertain. Once the floodgates of Russian space cooperation are opened up, it will be very difficult to close them. NASA is already beginning to experience a shift in the sources from which Russian joint projects emanate. Previously, specific areas for cooperation were determined by a high level agreement and then scientists and businessmen were encouraged to pursue projects in these designated areas. Now, since a broad framework for U.S.-Russian cooperation was agreed upon last June, the initiative for defining new areas for space cooperation has shifted from the politicians to the scientists and businessmen. The creation of new Russian cooperative ventures is no longer a "top down", but a "bottoms up" activity and since there are more people to initiate projects at the bottom, there is a potential for many more projects. Soon NASA may have so many projects that rely on its more liberal approach to cooperation that it may be unable to revert back to its old way of doing business. Although, NASA's policies toward international cooperation have experienced some recent liberalization, change has been relatively slow and there remains a real danger of reversion unless a top-level commitment is obtained for the new policy direction.

### 3.2.3 The Results of a Poor Selection Process

One of the greatest limitations of the present selection process, both at NASA and at the national level, is its lack of a long-term national perspective. This results not only in insufficient consideration of the needs of all U.S. players, but it also neglects the needs of Russian partners. A major motivation for U.S. space cooperation with the former Soviets is to help maintain their aerospace industrial base during its transition to a capitalistic structure. Without such support Russian technologies could be irretrievably lost or dispersed to other countries who may use them militarily against the U.S.. Therefore, it is in the America's best interest to pursue cooperative projects that not only benefit U.S. participants, but also Russian partners attempting to preserve peaceful sectors of their industry. Yet except for the State Department, who has only limited insight into the needs of the Russian aerospace industry, no U.S. agency even considers Russian requirements. The declining economic condition of Russian space enterprises makes international activities far more attractive if they include the possibility to earn hard currency. But NASA still pushes for projects that entail no U.S. funding for Russian contributions even though such financial support is critical to preserving Russian industry. For example, in manned spaceflight NASA has an agreement with Russia to fly a U.S. astronaut to Mir similar to the flights that were taken by German, French, English, and Japanese astronauts. The big difference is that all of these other nations, realizing the desperate economic situation of Russian space enterprises, paid the Russians hard currency for their flights while the U.S. obtained its flight gratis. Of course the U.S. provided a free flight to a cosmonaut on the Space Shuttle in exchange but the Russians have dozens of man-years in space; they hardly need a few days more on a U.S. spacecraft. What they do need is cash to maintain and transition their industry, but NASA is too cheap or short-sighted in its policies to provide support. NASA has no problem spending hundreds of millions of dollars at home to implement the astronaut-cosmonaut exchange flights[135], but it stiffs the Russians the $12 million (the amount per flight the French are paying) to save a few bucks. That amount of money, although less than NASA spends on faxes each year, if given to the Russians could fund over 25% of their annual operating budget for the entire Mir program. But since NASA considers only its own narrow interests and no one pays any regard to Russian needs, NASA saves a few dollars at the expense of Russian (and American) national interests.

To make wiser decisions concerning which projects to pursue with the Russians, it is essential that the interagency review process and NASA's internal selection process put greater emphasis on understanding the long-term effects that proposed projects will have in Russia. The present approach of addressing opportunities only from a simplistic U.S. perspective not only does great disservice to Russian hopes of a rapid transition to a market economy but also ignores many subtler U.S. interests. As discussed in Chapter 2, the organization and operation of the former Soviet space program differs substantially from that in Western nations. The entire industry is dominated by scientists and engineers

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135 "NASA Awards Contracts for Shuttle-Mir Docking Mission", Space News, September 28-October 5, 1992, p. 2.

who have little interest in marketing or financial considerations. Each enterprise is run by an autocratic Chief Designer who rules the enterprise as his own personal kingdom. And there is no established central authority for space activities so the Chief Designers are continuously struggling amongst each other for control of the space program. U.S. organizations attempt to operate in this complex, foreign and uncertain environment when they pursue Russian cooperative ventures. The natural reaction of many of these organizations, most notably NASA, is to impose their understanding of U.S. program structure on the Russians. In the U.S., companies produce space hardware while in Russia NPOs produce hardware. Therefore they conclude that NPOs must be the same as companies. But in many very important ways, NPOs are nothing like private Western corporations. Similarly they observe that Russia has a space agency (RSA) and the U.S. has a space agency (NASA) and therefore these agencies must perform similar functions. In fact they are quite different. NASA employs tens of thousands of people, has been around over thirty years and controls almost all civilian space funding. The RSA employs a few hundred, has existed less than a year and manages only a small fraction of the space program's budget. Nonetheless, NASA insists on working almost exclusively with the RSA because it sees the RSA as its Russian counterpart. And when it does consider working directly with Russian industry, NASA goes to NPO Energia as if it were the only Russian space enterprise. There are over a thousand Russian enterprises involved in space, many with far better technologies than Energia, but since it has established contacts and no better information, NASA works predominantly with Energia. Many other Russian enterprises resent Energia's apparent monopoly on NASA contacts[136]. Tying itself so closely with NPO Energia is not only unfair to the rest of the Russian industry but it also limits NASA ability to exploit the full range of capabilities that the Russian industry has to offer.

The U.S. has an unprecedented opportunity to mold the Russian space industry according to U.S. interests but it is squandering this opportunity by pursuing cooperative ventures in a haphazard manner. Russian enterprises' urgent need for new funding sources and the incredible ruble-dollar exchange rate means that even small investments could have major impacts on Russian industry. However, the lack of national coordination of U.S. investments in

136 Yu. Tsurikov, Department Head in KB Salyut, interviewed at KB Salyut headquarters in Moscow, October 26, 1992.

Russia has allowed each organization to consider only its own short-term needs in deciding where to invest which has led to funding in many disparate areas. But no matter how successful Russian enterprises are in attracting foreign funds, a consolidation of their industry is immanent now that the Russian government's demand for space products has so markedly declined. If properly managed, the U.S. could use its financial influence to support those sectors of the Russian industry that are most important to American interests (i.e. non-military, unique capabilities with U.S. applications) and let the other more threatening sectors be pruned away[137]. The present approach of the Russian government is to attempt to keep the entire industry solvent which is unlikely to succeed. But such a dispersed funding approach by the Russians could make strategic funding of particular sectors by the U.S. even more effective in molding the Russian industry into a friendly and productive U.S. partner.

## 3.3 Recommended Areas for Pursuing Cooperation

NASA's out of date criteria for selecting cooperative projects along with the highly partisan manner in which U.S. agencies interact in setting space policy has led to poor decisions concerning which cooperative areas to pursue. To obtain better results, it is necessary to take a step back from the fray and examine the broader national objectives that may be advanced through Russian space cooperation. Just such an approach will be taken in the following assessment. Building upon the discussion of the costs and benefits of international space cooperation that were presented in Chapter 1, this section will assess the net benefits of U.S.-Russian joint ventures in each of the potential cooperative areas. In particular, it will determine which of the five cooperative areas identified in Section 3.1 are appropriate for NASA to pursue with the Russians. The criteria for determining an area's suitability for cooperation will be whether it supports U.S. national objectives more than it deters from them (i.e., whether its long-term benefits outweigh its costs). Knowledge of U.S. and Russian needs along with evidence from cooperative projects with other countries and in other industries will be used to support the conclusions. However, in the real world policy formulation is driven by more than logical arguments such as the cost/benefit

137 A. Aldrin, Russian Space Researcher at Rand Corporation, interviewed by phone at his office in Santa Monica, California, November 18, 1992.

analysis presented here. It is set through a complex negotiation process involving many different interest groups and many political factors. The recommendations in this section are only the first step. They provide guidance on the ideal areas for cooperating but do not address how such ideal solutions can be reached. Chapter 4 will provide this critical next step by recommending changes in the policy making process to make it more effective in selecting and exploiting the best opportunities for cooperation.

To better structure the following analysis, the costs/benefits terminology of Chapter 1 has been modified into the "deters from" and "supports" national objectives terminology shown in Table 3.1. As was previously noted, the benefits from international cooperation support three main national objectives: improving the space program's efficiency, advancing foreign policy goals, and enhancing the competitiveness of domestic industries. The specific benefits from joint space activities are listed below in the middle column across from the particular objectives that they support. Likewise, the costs of international cooperation can be considered to deter from fully meeting these same three national objectives. The specific costs imposed by joint space projects are listed in the last column of the table below across from the particular objectives from which they deter. The benefits and costs contained in these two columns are identical to those derived in the first chapter.

Table 3.1 - Criteria to Assess a Project's Fitness for Cooperation

| Cooperation Objectives | Supports Objective | Deters from Objective |
|---|---|---|
| Improve Space Program Efficiency | • Lowers Program Costs<br>• Improves System Performance<br>• Foundation for Future Work | • Inflates Overhead Costs<br>• Increases Program Risks |
| Advance Foreign Policy Goals | • Assists Economic Transition<br>• Avoids Weapons Proliferation<br>• Stimulates Int'l Goodwill | • Sustains Potential Adversary<br>• Unwanted Tech. Transfer<br>• Harms Traditional Partners |
| Enhance Industrial Competitiveness | • Access to Unique Capabilities<br>• Provides Low Cost Sources | • Invites in New Competitors |

The five potential areas in which NASA could pursue Russian cooperation are: manned systems, space sciences, satellite applications, launch vehicles, and sub system-level inputs. To be considered a candidate for pursuit, a cooperative area must support at least one national objective more than it deters from it. Yet that is not enough since a project's net effect may be to support one objective while deterring from another. In such a case, unless the project's relative impact on the conflicting objectives differs substantially, a difficult weighing of national objectives against each other becomes necessary. Whenever possible, prioritizing of national objectives will be avoided but in the event there is no other discriminator, recent presidential and legislative direction will be used as guidance. Besides having the capability in theory to further national objectives, a potential joint space project must be implementable to actually have an impact. Consequently, although specifics of an implementation plan will be put off until the next chapter, a cooperative area's potential "implementability" will be given substantial weight in determining its suitability for pursuit.

*Manned Systems*

NASA is the sole U.S. agency involved in human spaceflight and consequently has exclusive responsibility for pursuing Russian cooperation in this area. The agency is considering joint projects with the Russians in three sub-areas of manned systems: astronaut/cosmonaut exchanges and spacecraft dockings, joint space life science research including NASA's use of Mir, and application of Russian hardware and technologies on U.S. manned systems. The astronaut/cosmonaut exchanges represent the highest profile projects and build upon experience from the Apollo-Soyuz mission in 1975. The main benefits of these exchanges are that they generate international goodwill and lay a foundation for future cooperative work. They also provide some exposure to Russian techniques for performing operations in space and therefore could assist the U.S. in improving the effectiveness of its space operations. However, the costs involved in implementing these joint programs are immense, running into the hundreds of millions of dollars. From the space program efficiency perspective, it is difficult to justify these costs on the possibility of learning improved space operations techniques. The only way that exchange projects may provide substantial gains in efficiency is by laying the foundation for future, more clearly beneficial activities. Consequently, they are worthwhile only to the extent that they lead to future more productive joint ventures. Similarly, their foreign policy benefit in stimulating international goodwill provides only short-term advantages that will quickly turn negative unless followed by real cooperation. A few initial exchange efforts to "break the ice" from the Cold War may well be warranted, but they must not be viewed as ends in themselves since they entail only short-term benefits and substantial costs. Other longer-term foreign policy benefits, such as assisting Russia's economic transition, could be realized if NASA provided some financial support to Russian enterprises in these joint projects. But the agency's insistence on minimal exchange of funds actually conflicts with foreign policy goals by diverting limited Russian resources to these largely symbolic projects and away from more substantial efforts to convert the economy to a capitalistic basis. Although the Russians are committed to these exchange programs for political reasons, they are uncertain of how they will pay for their half of the project[138].

The other two sub-areas (joint life science research and utilization of Russian manned space systems) provide projects that more clearly support U.S. national objectives. Both of these areas offer many opportunities to improve the space program's effectiveness by using Russian assets to lower program costs and improve the performance of U.S. systems. But in implementing joint projects in these areas, NASA must guard against escalating overhead costs for increased management and integration functions that could negate the system cost savings. Use of the Soyuz-TM as an Assured Crew Return Vehicle (ACRV) for space station Freedom provides a good example. The Russians could modify and build a couple of Soyuz capsules for use on Freedom for $30-$40 million, an order of magnitude less than NASA could develop and produce a similar system. But NASA's intent to use a U.S. firm as a middleman in the procurement of Soyuz capsules has some members of the Senate Appropriations Committee worrying that "this approach would eat up potential cost savings by adding another layer of management ... and costs with few discernible benefits"[139]. However, opportunities such as those provided by access to the Mir space station and use of highly developed Russian rendezvous and docking technologies could, without a doubt, be profitably applied to the U.S. space program if properly

138 S. Leskov, "America and Russia have Signed an Agreement, But They Don't Know How They Will Finance It", Izvestiya, Morning Edition, May 19, 1992, pp. 1 & 8.

139 A. Lawler, "Senate Panel Opposes Broker For Soyuz Deal", Space News, August 24-30, 1992, p. 6.

managed[140]. These opportunities could also be exploited to help enhance the international competitiveness of U.S. firms by supplying them access to leading-edge technologies. Finally, if financial assistance was given to the Russians in exchange for access to their highly developed manned systems, it could also support U.S. goals to help their economy transition. Since there are few defense applications of manned systems and no international market for manned spacecraft, there is little downside to pursuing cooperation in this area. It is therefore recommended that NASA continue and expand cooperation in the manned systems area since, if properly managed, it supports the effectiveness of U.S. space activities far more than it detracts from it. However, NASA should shift its emphasis from crew exchanges and the short-term political benefits that they provide to the more long-term and clearly beneficial opportunities in joint life science research and use of Russian human spaceflight capabilities.

*Space Sciences*

Space sciences is another area in which NASA plays the leading U.S. role in cooperating with the Russians. Although cooperative projects in this area tend to be divided up into categories according to the scientific specialty they support (i.e. astronomy, planetary sciences, solar terrestrial physics, and Earth sciences), the reasons for cooperating in any of these specialties are basically the same. Space science cooperation is pursued predominantly for the increases in program efficiency that it can provide, although secondary foreign policy benefits can also be important. The potential to reduce costs and improve program effectiveness by sharing scientific results, coordinating activities or sharing hardware and flight opportunities are enormous. In pursuing scientific discoveries in space, the U.S. and Russia have many similar non-political objectives that can be simultaneously realized in the most cost-effective manner by working together.

For example, both nations have a strong interest in better understanding the cause of Ozone depletion in the upper atmosphere and in monitoring the extent of the damage. Since each nation can afford to launch only a relatively small number of remote sensing satellites, it is not possible for either to obtain complete data on this scientific phenomenon. But by combining efforts through sharing data, coordinating satellites to obtain maximal coverage of areas of

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140 W. Broad, "Russians Offer Use of Mir Space Station as a Prelude to Mars", New York Times, February 23, 1992, p. 26.

interest, and flying each other's instruments when domestic launches are not available, our nations can together more fully understand the problem. However, as in the manned systems area, complicating factors may negate this synergy unless care is taken. Continuing with the Ozone depletion example, in 1987 NASA reached agreements with the Russians to fly a Total Ozone Mapping Spectrometer (TOMS) on a Russian Meteor-3 satellite. A major justification for the joint project was the cost savings it promised the U.S. for not having to build and launch a dedicated satellite to carry the TOMS. But technical differences in U.S. and Russian design practices required that an Interface Adapter Module (IAM) be constructed so that the TOMS could be integrated into the Russian spacecraft. In the end, the IAM cost more to produce than the instrument itself[141] and when combined with additional expenses for the technology safeguards that are required to export space hardware to Russia, little net cost savings was realized. Although the TOMS project provided few cost savings, it was still invaluable since it laid a foundation for future work and to this day continues to provide essential data on the Ozone depletion problem.

Besides the difficulty in actually realizing costs savings from joint projects, relying on a foreign partner can substantially increase a project's risk. The U.S. has conducted only limited cooperative activities with Russia resulting in only minor increases in risk, but it's activities with Europe have been far more extensive. Fortunately, a U.S. project has yet to suffer a major impact due to a lack of support from its European partners, but unfortunately the reverse is not true. The Ulysses project provides a particularly poignant example of how a partner's poor performance can destroy the benefits of international cooperation. Begun in 1978 as the International Solar Polar Mission (ISPM), it originally consisted of two spacecraft (one European and one U.S.) to be launched in the early 1980's by the Shuttle using a 3-stage Inertial Upper Stage (IUS). In 1980, NASA decided not to develop the 3-stage IUS complicating the project's launch plan. In 1981, NASA withdrew its offer to build one of the spacecraft. Slips in the Shuttle manifests and the 1986 Challenger accident led to further launch delays. Eventually in 1990, a single European-built spacecraft started on its journey to the sun, a mere shadow of the program intended at its inception thirteen years earlier. The costs imposed on the Europeans by NASA's failure to

141 P. Backlund, Earth Sciences Project Manager, NASA Headquarters, interviewed at his office in Washington, D.C., January 19, 1993.

keep its commitments were enormous teaching them a hard lesson on the risks incurred by taking part in international joint ventures.

Space science cooperation, like cooperation in manned systems, can also support foreign policy goals by increasing international goodwill and helping to transition the Russian economy through financial assistance. Until recently, nearly all space science cooperation was conducted without any exchange of funds but Russia's desperate financial state has now caused this to change. To keep Russia's Mars '94 & '96 projects from falling apart, first the Europeans[142] and then the U.S.[143] agreed to provide direct financial support. This type of assistance can play an important role in sustaining the Russian aerospace industry during the present turmoil so that it will be around in the future to be a potential partner. The possibility that sensitive defense technologies may be unknowingly transferred as a result of joint ventures in this area represents a substantial threat to U.S. security and commercial interests. Consequently, sophisticated and costly technology transfer countermeasures, as mentioned in the TOMS example above, are often necessary. These precautions reduce costs savings but are necessary to avoid negative impacts on U.S. foreign interests. The many opportunities for improving the effectiveness of U.S. space activities along with secondary foreign policy benefits make space science a promising area for pursuing Russian cooperation. However, the potentially high costs and risks involved in implementing projects in this area necessitates that great care be taken in structuring joint activities to minimize these negative effects so that the overall net effect is beneficial.

*Satellite Applications*

Included in this area are satellites for the following applications (in order of decreasing level of commercialization): telecommunications, Earth observation, microgravity processing, navigation, and search & rescue. Unlike the previous two areas discussed, NASA is only one of several U.S. players active in this area. As a government agency supported by tax dollars, NASA believes that it has a duty to buy American products if at all possible. It tends to purchases whatever satellites it requires from U.S. industry, developing new capabilities only when

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142 M. Dornheim, "France and Germany will Help Fund Russian Mars 1994 Space Mission", Aviation Week & Space Technology, May 25, 1992, pp. 79-80.

143 "NASA Antes Up Money For Russian Mars Mission", Space News, Dec. 7-13, 1992, p. 22.

they are demanded by its own needs. Although it is a major developer of satellite technologies (along with the DoD and private companies), NASA prefers to let industry take the lead in finding external applications for the technologies it develops. The agency puts little effort into assuring that space capabilities with broader applications beyond its own requirements are created, since it does not see such work as central to its mission. Therefore, believing it has no responsibility to support the broad interests of the space industry and barring itself from directly purchasing Russian satellites through its "buy American" philosophy, NASA has shunned Russian overtures to cooperate in this area. It should be noted that of the five potential areas for cooperation that are being discussed, Russian technical capabilities in this area are by far the least impressive. Because of their relatively low performance, Russian application satellites offer fewer opportunities to potential U.S. partners but they still offer some important advantages. NASA's complete reluctance to cooperate in this area is more a result of how it views its mission relative to U.S. industry than a result of Russian technological shortcomings in this field.

From a national perspective, cooperating in satellite applications could help to improve industry competitiveness and to further foreign policy goals. Although Russian application satellites do not have all the sophistication of their Western counterparts, they are much cheaper to make. Access to low cost Russian space services could allow many small entrepreneurial firms in the U.S. and abroad to utilize space for the first time for communication, navigation and microgravity processing purposes. Use of lower cost inputs would permit these firms to produce more competitive products and similar benefits could also help to make NASA's program more cost-efficient. This is particularly true for microgravity experiments, where flights on Photon capsules or the Mir station are substantially less expensive than on the Shuttle. On the negative side, allowing Russian satellite manufacturers entry into the U.S. market could hurt domestic producers of similar services by stiffening competition. But in fact, since Russian satellites are so much cheaper and lower performing than U.S. satellites, they serve a completely different market. General Electric and Hughes could continue to sell their sophisticated satellites to companies such as AT&T, while the Russians could provide their services to small start-up firms such as Rimsat and Sokol America who could never afford to buy from U.S.

manufacturers[144]. In addition to supplying lower cost options, Russian satellites also provide some unique capabilities not available in the United States. Of particular note are their long-duration microgravity processing capabilities on Mir and on free-flying capsules that have allowed small U.S. firms, such as Payload Systems Inc., to exploit the market for in-space manufacturing. No comparable capability exists in the U.S. so without Russian cooperation, domestic firms would be unable to compete in this potentially lucrative market.

The major foreign policy benefit of cooperating in this area is the support it provides the Russian industry by purchasing of its products and services. As previously mentioned, any financial support that assists Russian industry in retaining its personnel and in transitioning to a greater reliance on market mechanisms is in America's best interest. But there are also important foreign policy risks that must be managed. As in any cooperative area where high technology pieces of hardware are exchanged between two countries, the risk of undesired technology transfer becomes a concern. To help prevent the transfer of defense-related technologies to the Soviet Union during the Cold War, a Coordinating Committee on Export Controls (COCOM) was set up by the Western powers[145]. This committee established rigid controls on exports to the U.S.S.R. with the intent of blocking the transfer of any equipment or technology with military applications, including most space hardware. For over three decades, COCOM regulations made cooperative projects that required the exchange of space equipment or technologies impossible. However, since the break-up of the Soviet Union, Western nations have begun a thorough review of their export control procedures which has already resulted in over 70% of the space-related items on the COCOM control list being removed[146]. As the process continues, the objective is to develop a system that creates a free enough environment so as not to hamper cooperative efforts, but possesses sufficient discipline to stop any unwarranted technology transfers that could jeopardize foreign policy goals.

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144 D. Marcus, "Firms Stretch Dollars in Russia", Space News, November 23-30, 1992, p. 4.

145 B. Forman, "The Impact of International Export Controls on International Cooperative Space Programs", lectured delivered at the International Space University, Toulouse, France, July, 1991.

146 J. Boright, Deputy Assistant Secretary of State for Science and Technology Affairs, remarks at the National Space Outlook Conference, Washington, D.C., June 24, 1992.

With proper management of the technology transfer concerns, the net effect of cooperation in this area will likely be to improve industrial competitiveness, further foreign policy goals and possibly even make NASA's space activities more cost-efficient. But smaller U.S. firms, and not NASA or the large established aerospace companies, undeniably have the most to benefit from access to low cost Russian satellites. It is difficult to justify NASA's cooperation in this area based solely on its own limited opportunities for directly using Russian satellites. But if NASA has a broader mission to help promote the commercialization of space activities, as it should according to the Commercial Space Act of 1984[147], then it has a responsibility to assist U.S. entrepreneurs in finding commercial uses for low cost Russian systems. Since NASA has taken a very parochial perspective, focusing on its own narrow interests, it has chosen to play only a minor role in pursuing cooperation in this area. If it considered its broader mission to support the U.S. space industry and to promote foreign policy goals, NASA would aid those attempting to commercialize space in their attempts to utilize Russian systems. NASA's pursuit of cooperation in this area would require a change not only in the agency's international space policy but also in its relationship with domestic industry. However, since for years NASA has had legislative direction to promote space commercialization, it is not a change in policy for it to begin supporting domestic industry, only the long overdue implementation of existing policy. Once it is agreed that NASA has a responsibility to assist companies in commercializing space, the clear benefits to industry of having access to Russian satellites makes NASA's support of cooperation in this area highly desirable.

*Launch Vehicles*

The debate on whether Russia should be allowed to enter the international launch services market has been one of the most hotly contested issues surrounding Russian cooperation. This issue has caused such a fervor because of the major impact that Russian entry would have on a whole host of players in the U.S. space community, particularly ob its more commercial elements. There are numerous reasons why Western organizations may want to utilize Russian launch vehicles but the most important is the potential cost savings that they offer. The Russians use mass production techniques to produce launch vehicles

147 A. Dula, "Private Sector Activities in Outer Space", International Lawyer, Win. '85, p. 181.

on assembly lines much as companies in the U.S. produce automobiles, and at a correspondingly low cost. The result is that Russian boosters can place payloads into Low Earth Orbit for a cost of between $300-$700 per pound compared to a cost of over $3,000 per pound for U.S. vehicles. As was concluded in a recent study by Rockwell International, Russian "economic capabilities in the field of Earth-to-Low-Earth-Orbit transportation exceeds our most hopeful dreams. The United States cannot match the Soviet transportation system in terms of reliability, dependability, lifting capability, low cost, or proven track record"[148]. The impressive capability of Russian launchers, including the ability to place over 100 tons in orbit on a single launch, could help NASA, other government agencies and industry to reach space more cost-effectively. Furthermore, employing Russia's unique heavy lift capability would make many new missions possible such as orbiting of a space station or Mars vehicle on a single launch. Unfortunately, as a result of NASA's Byzantine accounting system there is little incentive for the agency's managers to seek the cheapest or most efficient launch option that the Russians can provide. Launch costs are often not allocated to specific programs and when they are they tend to be dramatically underestimated. Consequently, program managers focus all their efforts on minimizing payload costs and almost none on reducing the costs for launch services since they are beyond their control. Empowering program managers with a budget to purchase the most cost-effective launch vehicle instead of giving them a "free" Shuttle ride, would allow fairer consideration of other launch systems, including Russian systems, and could dramatically reduce the agency's overall expenditures for launch services.

The sale of Russian launchers in the West would provide significant financial support to the Russian space industry. A launch vehicle, even at the low Russian price, is a big ticket item so that a single Western sale of a large vehicle such as the Proton could provide enough hard currency to fund its manufacturer for an entire year. Purchasing launch vehicles from Russian manufacturers allows them to keep their rocket specialists gainfully employed so that they are not tempted to sell their services in the Third World and it also provides capital for restructuring their business away from military production. Both these results support important U.S. foreign policy goals.

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148 E. Keith, Low-Cost Space Transportation: The Search for the Lowest Cost, AAS 91-169, Rockwell International's Space Systems Division, Downey, California, 1991, p. 19.

Although the benefits from utilizing Russian launchers are formidable, so are the potential costs. The fear that Russian competitors would decimate the domestic launch industry has been the greatest deterrent to allowing them into the U.S. market. An important national objective of cooperating in space is to enhance the competitiveness of the domestic industry and if a cooperative project strongly deters from this objective it should not be pursued. U.S. launch vehicle manufacturers would almost certainly be negatively impacted by the entry of Russian competition, at least in the short-run. But the space industry consists of more than just the vehicle manufacturers, it also includes the spacecraft manufacturers and others who purchase launch services. These players would benefit by access to low cost vehicles that would allow them to more competitively price their end products whose price is strongly driven by transportation costs. Consequently, the competitiveness of some sectors of the U.S. industry would be harmed while the competitiveness of other sectors would be enhanced by access to Russian launchers. Yet the direct nature of the impact on the launch vehicle manufacturers as well as their strategic importance to national security tends to make their protection evoke the greatest concern. The threat to the launch industry is exacerbated by the potential of U.S. and Russian retired missiles being converted for use as space boosters. Hundreds of Russian SS-18's, SS-19's, SS-24's and U.S. Minuteman II's, being decommissioned to meet the terms of the Strategic Arms Reduction Treaty of 1991, could soon be flooding the small launch vehicle market unless steps are taken to protect existing producers[149]. Small launch vehicles are produced predominantly by entrepreneurial firms that were formed over the last decade as a result of government calls for increased commercialization of space activities. To first encourage the creation of these firms and then destroy them by allowing low priced products to be dumped into their market would set a terrible precedence and deter other entrepreneurs from entering the space business. Clearly some protection of the burgeoning commercial space launch industry is required. To this end, the U.S. is now conducting trade talks with the Russians (and the Chinese) to set internationally approved practices for competing in the launch services market. The goal of these talks is to allow the Russians into the international launch market so that the benefits enumerated above may be

149 A. Lawler, "Missiles Tapped for Post-Cold War Launchers", Space News, November 30-December 6, 1992, pp. 3 & 27.

realized and at the same time to provide adequate protection against unfair competition for U.S. manufacturers.

Some in the U.S. defense establishment argue that the Russian launch industry should continue to be isolated from world markets so that their ability to produce missiles (a close cousin of launch vehicles) that can threaten the U.S. militarily is decreased. However, in attempting to extinguish Russian missile production capabilities through financial privation, the U.S. may inadvertently promote the dispersion of these capabilities to other nations. The Russian missile threat is a known quantity that the U.S. has learned to manage over the last three decades. Although it is unpleasant, it is far preferable to dispersing missile capabilities to adversaries that the U.S. has little experience with and little knowledge of how to control. Therefore risking such proliferation in an attempt to drive the Russian space industry out of existence is an unwise strategy.

Because of its considerable potential to lower launch costs for the U.S. government and industry as well as its support of foreign policy goals, it is recommended that U.S. organizations be allowed to utilize Russian launch services on a limited basis. However, the potentially catastrophic impact on U.S. launch vehicle manufacturers as a result of Russian entry into the launch services market requires that restraint be applied in cooperating in this area. The U.S. launch industry should not be sacrificed for foreign policy reasons or to lower the short-term costs of a few programs. Nonetheless, Russia's presence in the international space marketplace cannot be ignored. NASA should seize the opportunity to use Russian launchers when they offer unique capabilities that do not directly compete with American products. The prime example of this is the Energia launch vehicle that provides unique heavy lift capabilities that are not available in the United States. For the near-term however, to support the U.S. industry during a difficult transition period, NASA should restrict its use of Russian vehicles to those providing unique capabilities. As a government agency with responsibilities for assisting industrial development, it is wholly appropriate for NASA to "buy America" when the industry is in trouble. But in the long-run U.S. industry must adapt and reduce costs to be able to compete internationally to avoid becoming parasites on sympathetic government agencies. NASA's goal should be to nurture the launch industry while it improves its competitiveness, not protect it so that it may remain uncompetitive. Private launch service users on the other hand, should be allowed to utilize Russian launchers as soon as the on-going launch pricing negotiations are completed since it is unfair to punish them for the launch industry's lack of cost control. Eventually NASA will also want to include the possibility of flying spacecraft on smaller Russian vehicles, particularly as a Russian "contribution in kind" to an international joint venture. However for the immediate future, in accordance with America's national emphasis on improving the domestic economy, the needs of the U.S. launch industry should outweigh the needs of the Russians in NASA's decision making on launch services.

*Sub System-Level Inputs*

The use of Russian technologies, components and engineering or testing services provide some of the clearest benefits to U.S. partners with minimal risks. In contrast to the cooperative activities involving complete systems that were discussed in the previous sections, utilization of Russian space technologies and services is of broad interest to organizations both inside and outside of the space community. The reason for this broad appeal is that Russian technical capabilities offer many opportunities to lower costs and to improve the performance of industrial products and processes. The Soviet Union's long-standing commitment and extensive allocation of resources to developing superior technologies for space systems has made it a world leader in such broadly applicable technologies as advanced materials, low-cost manufacturing techniques and power conversion systems[150]. Technologies can readily be transferred to products or manufacturing processes beyond those for which they were developed allowing their benefits to be leveraged into completely new areas. And unlike procuring complete Russian systems, accessing technologies and services entails far less upfront financial commitment and therefore is less risky. Beyond the confines of the space community, many U.S. companies from medical equipment manufacturers to construction firms are now making use of Russian technologies and services. For example, the Cummins Engine Company, America's leading manufacturer of heavy-duty diesel engines, is conducting several joint ventures in the former Soviet Union that entail sharing of design techniques, production technologies and may soon include the joint production

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150 R. Perry, Comparisons of Soviet and U.S. Technology, Rand Corporation, Santa Monica, California, June 1973, p. 5.

of a U.S.-Russian engine[151]. Similar types of cooperative programs could be created in the space community as well. From a space program perspective, joint projects in technologies and services are highly desirable because they offer substantial cost savings and performance enhancements with minimal implementation risks and expense. From a space industry perspective, similar technical benefits and ease of implementation also make joint ventures in this area worth pursuing. Since most Russian technologies or services being considered for cooperative ventures are unique or complimentary to U.S. capabilities, they offer only minor competition to U.S. domestic systems.

From a foreign policy perspective, cooperation in this area receives somewhat mixed reviews depending on the particular approach taken. Direct purchases of Russian technology, such as those being undertaken by SDIO, provide some immediate financial support to the Russian industry but in the long-run these transactions strip the Russians of their competitive technologies leaving them with little in return. For the long-term health of the Russian industry, it would be better to create cooperative projects in which the Russians provide value-added services that entitled them to substantial compensation instead of forcing them to sell off their existing assets to the highest bidder. Unfortunately, many U.S. players are considering only their own short-term gains and not the long-term effects on the Russia economy and U.S. foreign policy interests. The U.S. could learn much from the Europeans who have taken a longer-term outlook in their dealings with the Russian space community. The Europeans are now providing substantial funding to scientists and engineers in Russia to work directly on European space programs. They are also utilizing Russian facilities to test their space hardware including a project to test a Hermes mock-up in a supersonic wind tunnel at TsNIIMASh[152]. These activities give Russian the critical financial support that is needed to sustain its space industry while at the same time they supply Europe with low cost access to world-class technologies and services. The success of some organizations in the Russian aerospace community in selling their technologies and services abroad demonstrates the appeal of these capabilities. One of the most remarkable

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151 D. Yoffie, "The Cummins Engine Company in the Soviet Union", International Trade and Competition, McGraw-Hill, 1990, p. 328.

152 P. Orlov, "Foreign Interests in Soviet Space Systems", from the Vremya newscast, Moscow television, 1700 GMT, September 27, 1990.

success stories is that of the Central Aerohydrodynamics Institute (TsAGI) who at present relies on Russian government funding for only 29% of its budget, obtaining the rest from private sources at home and abroad[153]. This institute has used its U.S. division, TsAGI International, a Washington state based joint venture to assist it in marketing and raising capital in the U.S. and in other Western nations. TsAGI's remarkable success in selling its services in aviation testing and design provides a concrete example of how Russian technical services can be put to use internationally.

NASA has been slow to utilize Russian technologies and services mainly because it is used to relying exclusively on U.S. domestic capabilities. However, the political changes in Russia as well as the economic changes in the world space industry make America's continued technological self-sufficiency in space a difficult and costly policy to pursue. For the benefits that Russian capabilities can provide to its own systems as well as to U.S. systems in general, NASA should begin to more aggressively seek cooperation in the technology and services area. The low risks and low costs for accessing Russian technologies and services, when combined with their potentially huge payoffs in reduced program costs and increased performance, make this the most promising (and presently the most popular) area for U.S.-Russian cooperation. Yet NASA has allowed other government agencies and U.S. firms to take the lead in pursuing Russian technologies. Recent NASA contracts to TsAGI for spaceplane technology, to TsIAM for scramjet flight testing, and to the Ukrainian Paton Institute for manufacturing technologies[154], demonstrates that the agency is beginning to take cooperation in this area more seriously. It is recommend that such activities be continued and expanded and that NASA look for other fields in which technological cooperation may be beneficial. To best promote foreign policy interests, NASA should pay Russian enterprises for their technological contributions but not using SDIO's "cash & carry" approach, instead working to develop long-term relationships with the Russians to obtain value-added products and services that are mutually beneficial to both partners.

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153 D. Mussington, researcher in Russian technology policy, Kennedy School of Government, Harvard University, interviewed in Cambridge, Massachusetts, October 1, 1992.

154 J. Hofgard, "U.S.-Russian Programs: Contracts and Grants", NASA Headquarters presentation, January 19, 1993.

## Conclusions

NASA has an important role to play in pursuing all areas of Russian cooperation. At present, its emphasis on cooperating only in the manned systems and space sciences areas is too confining and should be expanded. The manned systems area does offers many promising opportunities for improving NASA's program and supporting foreign policy goals that should be pursued. But the agency's present focus on crew exchanges and their short-term political benefits neglects the longer-term payoffs of more tangible joint manned projects.

Cooperation in space sciences is also very promising and activities in this area should be expanded. However, NASA must not fall into the trap of pursuing international activities as an end in themselves. Joint projects are conducted to obtain specific technical and political benefits and if escalating costs and risks jeopardize these benefits, joint activities should not be pursued.

NASA has avoided cooperation in satellite applications and launch vehicles because it restricts itself to purchasing domestic systems and believes that it has no responsibility to assist U.S. firms in accessing Russian capabilities. Unique or low cost Russian satellites may not offer much directly to NASA's programs, but to entrepreneurial U.S. firms Russian satellites are very appealing. NASA should use its space expertise and experience with the Russians to assist U.S. companies in improving their effectiveness by utilizing Russian satellite capabilities.

Potential Russian penetration of the U.S. launch services market poses a real threat to the future well-being of the U.S. launch industry and consequently cooperation in this area must be handled gingerly. For the present, NASA should continue to purchase most of its launch services exclusively from U.S. sources to help preserve the domestic industry. However, NASA should vigorously pursue the substantial cost savings and increased performance that Russian launchers offer in areas such as heavy lift boosters, where Russian capabilities are unique and face no domestic competition.

Russian technologies, services and components offer the most promising opportunities for cooperating in the space field with their high payoffs and minimal costs and risks. NASA has only begun to scratch the surface of the possibilities in this area. The agency should become more aggressive in utilizing Russian technologies and services for its own purposes as well as in helping companies, both aerospace and otherwise, to exploit Russian capabilities to improve their international competitiveness.

# *Chapter 4*

# Implementing Cooperative Activities

This chapter will describe how the U.S. government, and NASA in particular, could better pursue cooperative space activities with the former Soviet states. Its objective is to recommend specific strategies for improving the implementation of cooperative ventures in the areas identified in the previous chapter. The analysis will address a broad range of implementation issues including the selection, coordination, and management of joint space projects. Section 4.1 begins with an evaluation of the current national policy making process for international space activities. This process has been pieced together over time as cooperative activities have evolved and become more complex. Recommendations for improving its efficiency and responsiveness to U.S. national objectives is presented along with suggestions for their implementation. Section 4.2 builds upon these recommendations by discussing their impact on NASA's role in Russian cooperation. NASA's present outdated approach to joint space activities is critiqued and a new strategy is proposed that is more compatible with global developments and more supportive of national policy goals. Finally, Section 4.3 discusses issues of concern in implementing individual projects with Russian enterprises. Whereas the second section provides high level strategic recommendations for improving NASA's overall implementation process, the final section provides specific project level advice for making Russian joint projects more productive. This advice is derived from a thorough understanding of the needs and business practices of the Russian space industry and their impact on the suitability of particular cooperative approaches.

The most important reason why a new approach to implementing cooperative projects is required is because of the dramatic changes that have occurred throughout the global space community. The break-up of the Soviet Union and its impact on world space activities has already been discussed at length but this event has *not* been the only perturbation to an otherwise unchanging international landscape in the space field. International space activities have been continuously evolving for decades. The days when the U.S. dominated the entire world space community (outside of secretive Russian activities) are gone. Now there are many nations, with more nearly equal capabilities, involved in the exploration and utilization of outer space. The nations of Europe and Asia no longer have to rely upon U.S. or Soviet systems to obtain access to space, they have their own independent capabilities. In the past, U.S. motivations for conducting international space projects were predominantly scientific or political in nature. Its partners cooperated to obtain access to leading-edge American space systems and technologies. Cooperative activities were conducted on a project-by-project basis, with no exchange of funds and included the open sharing of all results[155]. As the capabilities of international partners have grown, they have assumed larger roles in cooperative projects with the U.S. and other areas besides space science have been included in international activities. The U.S. has lost its ability to completely dominate space projects in which it is involved. Since the Spacelab project with ESA in the early 1980's, the U.S. has begun to increasingly rely upon international partners for major hardware contributions to its space systems.

With the changing international balance in space capabilities, motivations for cooperating in space have also changed with economic considerations becoming an important factor in justifying new space projects. To obtain political support, the Space Shuttle promised to be a low cost "truck" to space. Although this claim proved to be completely fictitious, the fact that such a claim was necessary to obtain legislative approval demonstrates that a new era in space activities was emerging. Cost-effectiveness and commercialization were the new rallying cries in the space industry. Economic motivations joined political and scientific benefits as reasons for pursuing international cooperation. With the emphasis on economic performance and the increasing capabilities of foreign

155 J. Johnson-Freese, "Changing Patterns of International Cooperation in Space", lecture delivered at the International Space University, Toulouse, France, August, 1991.

players, it was inevitable that commercial competition would arise as a force in the international space arena. As in other industries from automobiles to computers, this led to a challenge to America's economic leadership in aerospace products. The entry of Russian systems and technologies into the international market has exacerbated the competition and threatens to destabilize what little balance existed. America's position in the global space industry is less secure than ever prompting many government agencies besides NASA, the traditional focal point for all space issues, to become involved in international space matters. Space cooperation is being used by interest groups both inside and outside of the U.S. government to advance their own agendas. The demands on cooperative programs have increased while at the same time NASA has lost its role as exclusive manager of space activities. These developments, along with the growing power of other spacefaring nations, are creating an ever more complex environment in which NASA must mange its international space activities.

Structuring cooperative activities in this new international environment offers many novel challenges. When NASA was concerned primarily with scientific and political pay-offs and its partners were mainly interested in utilizing American technologies, it was easy to arrange mutually beneficial projects. But as space capabilities and the motivations for cooperating began to converge, creating single projects that met the needs of multiple partners became more difficult. When both partners have similar goals such as improving their industrial competitiveness and they offer similar technical capabilities, the benefits to cooperating tend to be incremental and only accumulate to a significant degree over a long time period. Private companies have recognized this for years, leading them to form strategic international alliances that provide for cooperation over a period of time and a range of situations. These arrangements allow a company to obtain assistance in a particular area and at a particular time while providing assistance to its partner on a different project and possibly at another time. The net result is that both partners benefit but the benefits are not equally distributed across all projects. In fact, it is possible that a particular project may not benefit one partner at all, but by cooperating in this area he may receive support in another that outweighs his immediate losses. This type of approach is completely contrary to NASA's present project-oriented philosophy that demands that each project stand on its own isolated merit.

However, other agencies in the U.S. government are not nearly so rigid and NASA could learn from their example. In particular, the Defense Department either directly or through its industrial contractors, selectively allows the transfer of technology and funds to international partners in support of joint research and development efforts. These are not individual projects with specific beginning and ending dates but long-term, open-ended commitments to cooperate in certain areas. The DoD has also promoted transnational firm-to-firm cooperation in defense technologies since it believes that "cross-border defense industrial cooperation can spread the costs of development and provide economies of scale in production, often allowing industry to provide better value to participating governments"[156]. NASA's project-oriented approach is long-established and has been largely successful in the past in organizing its international space activities and thus it will be difficult to change. But the changing environment of the world space community demands a more long-term and strategic approach to fully realize the benefits of international cooperation and remain competitive in the global marketplace. Consequently, in the following discussion cooperative relationships will be defined not as a collection of disparate individual projects as in the past, but as a long-term commitment to combine efforts in a specific area. Cooperation should be driven by a broad commitment which then leads to individual projects to implement this commitment. It should not emphasize the creation of individually justifiable projects that somehow in the aggregate are expected to promote strategic national goals. This analysis will focus on how to implement cooperation in specific areas and the aggregate benefits that will result and not on how to implement particular projects with short-term benefits.

In the new global environment that emphasizes economic competitiveness (which is closely related to technological competitiveness) and other complex national goals, the old rules for cooperating no longer apply. NASA must learn to balance its programs to include the needs of other U.S. interests and foreign partners to maintain the agency's long-term health. It must also learn to mange its interaction with these new players in a more effective manner. The agency is no longer in a position to dictate space policy in either the U.S. or abroad. New motivations for pursuing joint space activities, most notably improved industrial competitiveness, must be considered in formulating NASA's strategies for cooperating. It is imperative that these new drivers of space policy and the more

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156 Atlantic Partnership Steering Committee, The Atlantic Partnership: An Industrial Perspective On Transatlantic Defense Cooperation, Center for Strategic and International Studies, Washington, D.C., 1991, pp. ix-x.

complex environment be considered in structuring future cooperative activities. This chapter will discuss in detail how the agency should modify its implementation strategies to meet the demands of the new environment in the long-term. It will include recommendations for improving both NASA's interaction with external organizations and its internal management approach. The end result will be an action plan for making NASA's space activities with Russia more compatible with the demands of global economic competition and the needs of the many players impacted by its international space activities.

## 4.1 Restructuring the Coordination/Selection Process

The shortcomings of the process for coordinating and selecting international space ventures in the U.S. were described at some length in the previous chapter. In that discussion it was argued that the Space Council's inability to keep up with the rapidly changing global space environment had by default led to most U.S. policy being set in the interagency review process. The inherently parochial nature of the interagency debate has resulted in policies toward Russian cooperation that are inconsistent, ineffective and neglect long-term national objectives. This section will identify several reforms that should be made to the top level policy making process to make it more effective and more responsive to national needs. Of course, NASA as an agency within the U.S. government is not free to modify the highest level policy structure at will, however it is able to work within the system as an advocate for change. NASA should promote structural changes in the national policy making process to achieve the ends specified in the following paragraphs.

### 4.1.1 Focus on National Objectives

As applied in the previous chapter, the three national objectives in pursuing space cooperation: advancing foreign policy goals, enhancing industrial competitiveness, and improving space program efficiency, should provide the criteria for determining whether cooperation should be pursued in a particular area. Yet in the present adversarial interagency review process these broad objectives play little role. To better focus cooperative activities on these objectives as well as to provide more consistency in U.S. policy, it is essential that a high level body with national perspective be formed to coordinate international space cooperation, particularly Russian cooperation. The National Space Council has been unable to perform this task and it is uncertain whether President Clinton's new Science, Technology and Space Council will be able to do any better. The problem is that international cooperation in space entails so many complex and divergent issues that it is difficult for a council imbedded in the space program to make effective policy. There are important foreign policy concerns and industrial policy issues that are much larger than the space program per se. Consequently, to arrive at a policy that meets the needs of all those concerned, it is necessary to take a broader perspective. Relying on the interagency review process to thrash out all of the complicated issues is a wholly inadequate approach. A special council at the executive level (possibly a subcommittee of the newly formed White House Science , Technology and Space Council) is needed to assure that U.S. space policy towards the Russians meets broadly defined U.S. objectives and is not arrived at piecemeal. The council would set policy to promote national objectives and it would assure that all relevant U.S. laws and regulations (e.g. export control laws) supported the stated policy. Its position would be sufficiently high to allow it to include the needs of NASA, other government agencies, U.S. industry and international partners in establishing policy. Under the proposed scheme, the interagency review process would be relied upon only to assure that national policy towards the Russians was properly implemented. To better understand the benefits of such a council, the following paragraphs describe why it is needed to effectively support national objectives in each of the three areas identified above.

### Advance Foreign Policy Goals

Several governmental agencies consider the advancement of foreign policy goals part of their mandate. Unfortunately, the various international agendas of these organizations are often in conflict with each other or with other national objectives. Therefore an international space coordination council has a critical role to play in assuring that U.S. foreign policy goals are promoted in a consistent and effective manner. A coordination council could provide guidance to individual agencies concerning the appropriate cooperative areas to pursue as well as the preferred implementation approaches to be utilized. Such guidance is necessary because the approach used to implement a joint project makes a big difference in how well it supports foreign policy goals. Russian cooperation that provides no financial support or does not involve those who work on weapons technologies will not help assuage the risk of proliferation. Joint activities that make use of only government-to-government contacts will not teach Russians about Western business practices and therefore will do little to help their transition to capitalism. And cooperative projects that allow for no exchange of funds will be of little interest to a financially strapped Russian industry and will not help them in the costly conversion to nonmilitary production. It is not only important for foreign policy reasons to pursue Russian cooperation in particular areas, but to pursue it using the right approach.

Without an executive council to manage cooperative space projects, the Department of State (DoS) has assumed most of the responsibility for coordinating international activities at the national level. However, the DoS considers exclusively the impacts on foreign affairs in determining its position and therefore is in no better position than any other agency to create well balanced policy. Its high profile actions in support of Russian economic stabilization has prompted many in the United States to label the DoS as the leading advocate for increased cooperation with the Russian space industry. It is ironic that the Russians see the State Department as playing just the opposite role. Since the DoS is responsible for administering export control regulations for military (and consequently most space) hardware, every time an export to Russia is blocked, the Russians believe that their efforts to cooperate in space have been foiled by the U.S. State Department[157]. In fact, in most cases the DoS supported the action but was overruled by military or commercial concerns, leading to a denial of the export over State's objections.

As previously discussed, the DoS supports cooperation because it can help the Russian aerospace industry transition to free market capitalism, convert its production away from military hardware, and stem the proliferation of advanced weapon technologies to Third World nations. U.S. businessmen believe that Russian industry in general, and their aerospace industry in particular, is suffering from several "systemic" gaps that make it impossible for it to fully enter the community of Western industrialized nations. Two of the most important of these are its marketing gap and its management gap. Products in the former Soviet Union are distributed, not marketed and the concept of customer-orientation is almost completely unknown. Similarly, in all of Eastern Europe "there is a serious absence of leadership ability and advanced business

157 M. Smith, Specialist in Science and Technology Policy, Congressional Research Service, interviewed in the "Newsmaker Forum" of Space News, November 23-29, 1992, p. 22.

know-how among managers ... and even more limited use of modern management methods and techniques"[158]. The result is that the Russians are in dire need of assistance if they are to stand any chance of successfully transitioning to a capitalistic economy.

Policy makers in Washington have recognized this need and the importance of a stable Russian economy to U.S. interests abroad. Washington's response to this need has been to provide billions of dollars in direct assistance to Russia to help it during this difficult transition period. But simply giving Russia money is a one dimensional approach that supports only foreign policy goals and degrades the Russians in the process[159]. Instead, by purchasing Russian assets in fields such as aerospace where they have much to offer, other national objectives can be simultaneously supported and a long-term and mutually beneficial relationship can be established. Yet coordinating purchases to meet the needs of diverse U.S. interests is far more difficult then just sending a check, so for ease of implementation the U.S. has tended to use the latter approach. However, with the top level coordination of an executive council, purchases of Russian space assets could be managed to simultaneously benefit the space program (i.e. meet NASA's needs), support Russia's economic transition (i.e. meet DoS's needs), have no negative security ramifications (i.e. meet DOD's needs), and provide the U.S. low cost products and services (i.e. meet industry's needs). The U.S. must not pass up realizing so many concurrent benefits just because of difficulties in coordinating activities. Even if one does not accept that Russian space cooperation provides many mutual benefits, it still makes sense to coordinate all economic "aid" to Russia, including support to the space industry. This can be accomplished most effectively by a central body for managing all Russian space interactions that is responsible for creating projects consistent with the broader U.S. program to assist Russia's economic transition.

As stated by U.S. Representative John Dingell of Michigan, "this is our moment - our chance to help transform the new republics of the former Soviet Union into political and economic allies, so that our nation might never again have to divert so much of our precious domestic resources toward preparation

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158 P. Kraljic, "The Economic Gap Separating East and West", The McKinsey Quarterly, Spring 1990, pp. 66 & 69.

159 B. Lambeth, Senior Defense Analyst at Rand, "Foster Russian Democracy, Don't Hinder It", Viewpoint, Aviation Week & Space Technology, March 23, 1992, p. 9.

for war"[160]. It is particularly critical that the U.S. focus on transforming the Russian space industry because of the many military applications of space systems. The Russian's desperate need for financial and business assistance means that joint activities with Western partners can have tremendous impacts on the viability of particular enterprises and consequently the overall industry structure. The Russian space industry is presently undergoing a substantial consolidation due to declining domestic spending on space activities. Through a coordinated U.S. effort in support of certain sectors of the Russian space industry, the U.S. could mold the industry along the lines of its national interests. The incredible leverage of foreign currency in Russia makes it possible to implement such a strategy at a relatively low cost to the U.S.. For example when converted at present exchange rates, the total Russian space budget is less than $25 million. So by strategically placing purchases on the order of $10-$20 million, the U.S. could greatly influence which sectors of the Russian industry survive and which are pruned away in the shake-out. Obviously, it is in America's interest to see threatening military capabilities pruned away and capabilities of direct commercial value to the U.S. supported. Implementing such a national level strategic investment approach in Russia requires the type of top level coordination and direction that only an executive level council can provide. Thus, realizing the important foreign policy goal of transforming the Russian space industry into a friendly and supportive partner requires that cooperative activities with Russia be coordinated by a central policy making body.

The final foreign policy objective that would be better managed by a national coordination council is control of technology transfer, both for defense and commercial reasons. The international COCOM system, formed in the Cold War era, is hopelessly out of date and needs a thorough review[161]. This has already begun to some extent but further reforms in both domestic and international technology control regimes are necessary. Separating the control of military technology in the State Department and of commercial technology in the Commerce Department is becoming increasingly untenable. There are too many dual-use technologies in the space field to make such a distinction meaningful. A

160 J. Dingell, "Russians Need Our Capitalist Expertise and Our Money", Congressional Record, Vol. 138, No. 23, Washington, D.C., Tuesday, February 25, 1992, p. E-409.

161 W. Wirin, U.S. Laws and Policies Restricting Soviet Space Opportunities in the United States, Space Commerce Corporation Memorandum, March 16, 1990, p. 1.

better approach would be to have a single agency responsible for all export licensing from the United States. But short of this unlikely development, central coordination would provide more consistent technology controls. Only an executive council with broad national interests in mind can possibly weigh-off the manifold commercial and security technology transfer concerns against the possible benefits to the nation. Therefore, to assure that cooperative projects are implemented in an appropriate manner supportive of foreign policy goals, to allow for simultaneous pursuit of several national objectives, to manage the strategic restructuring of the Russian space industry, and to support a uniform approach to controlling technology transfer, it is necessary to have national level coordination of Russian space policy. Without such coordination through an executive level council, the complex foreign policy benefits of cooperating with the Russian space industry will have little chance of being fully realized.

### Enhance Industrial Competitiveness

A national coordination council would also play an important role in balancing competing domestic viewpoints on the use of Russian assets for stimulating U.S. industrial competitiveness. As discussed in the previous chapter, some Russian systems and technologies represent little threat to domestic producers and therefore their use enjoys wide support in the U.S.. Other Russian products however, pose significant competitive threats to some American firms and therefore allowing their entry into the market has both supporters and detractors in U.S. industry. A top level coordination council is needed in the former case only to make sure that all government policies are clearly defined and widely understood. However, when some sector of the domestic industry is threatened by allowing in Russian competition, top level coordination becomes critical for guaranteeing that policy decisions are consistent with broad national interests. Assuring appropriate use of Russian products in the former category is relatively easy. As the head of the Russian Space Agency has stated, "it is not help we need from the West, but simply that they recognize us as equal commercial partners"[162]. With clear policies on export regulations and governmental rules for utilizing foreign assets, individual organizations can be set free to exploit whatever Russian capabilities they feel

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162 Y. Koptev, "A Roof In Space for the Common European Home -- Now We Can Build It Together", Izvestiya, Union Edition, October 8, 1991, p. 2.

would improve their competitiveness. The government could also play a more proactive role in facilitating contact with Russian space enterprises to assure that U.S. industry makes full use of Russian assets. Such governmental support would be consistent with U.S. policy to assist strategic sectors of the economy in maintaining their international competitiveness. How NASA might perform such a role will be discussed in the next section. But the really important need for a national coordination council arises when Russian entry into the U.S. market could assist competitiveness in some sectors of the domestic industry and harm it in others.

The debate over Russian participation in the international launch services market is a case in point. The question is whether allowing Russian launch vehicles into the market would benefit or injure the U.S. space industry as a whole. U.S. launch vehicle manufacturers would be harmed so their supporters in the administration insist that the Russians must be banned from the market to protect American interests[163]. U.S. firms have taken even a harder line against permitting Russian launch services competition than the Europeans who stand to lose much more since their Ariane vehicle already dominates the market[164]. On the other hand, satellite manufacturers and other launch service users argue that access to low cost Russian transportation systems would produce lower in-orbit costs for U.S. satellites making them more competitive in the world market. Since no top level council exists for weighing the validity of these competing claims, the U.S. policy has been erratic, approving some Russian launch requests while denying others. There is no consistency in U.S. policy making companies apprehensive to invest in projects that involve use of Russian vehicles, possibly foregoing substantial opportunities to improve their competitiveness.

U.S. launch vehicle manufacturers argue that Russian enterprises present "unfair" competition because they receive state subsidies that allow them to sell launch services for less than U.S. manufacturers. This "fairness" argument appeals to many in the administration who still believe that international competition occurs in a free market. In fact all countries subsidize their space system manufacturers in one way or another and due to limited resources, the

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163 J. Rockefeller, U.S. Senator, "U.S. Firms Must Be Shielded", Space News, November 2-9, 1992, pp. 19 & 20.

164 P. de Selding, "ESA Ministers Go Easy on Proton Marketing", Space News, November 16-22, 1992, p. 24.

Russian government tends to do less subsidizing than most. These types of "fairness" arguments have led the U.S. government to initiate trade talks with Russia to establish guidelines for "fair" pricing of launch vehicles. Presumably, if these talks determined that the Russians really could produce launch vehicles for only one fifth the cost of U.S. manufacturers, they would be allowed to charge only one fifth the price. But that will certainly not happen. What will most likely result is an international fixing of launch prices that forces the Russians to charge higher amounts than needed so that Western firms can retain most of the market. Such a solution sacrifices potential cost savings to launch service users in the name of "fairness" without weighing the overall effect on U.S. competitiveness. A far better approach would be to recognize that "fairness" has nothing to do with the debate. The U.S. has a national objective to support the competitiveness of its domestic industry and Russian entry into the market should be allowed only if its net effect is to support this as well as other U.S. national goals. Only an executive level council that can weigh the effects on different national objectives is in a position to make an informed decision on which policy should be pursued.

### Improve Space Program Efficiency

The objective to improve space program efficiency is relatively straight forward and its pursuit rests almost entirely within NASA's institutional purview. Consequently, there is little role that a high level executive council need play in this area. It is in NASA's best interest (and in the best interest of other space system users) to insure that they obtain access to the best space technologies and systems at the lowest possible cost. Certainly NASA does not always perform its programs for the lowest cost, but this is more a result of operational rather than strategic problems. The agency fully recognizes the value of lowering expenses yet its poor cost control mechanisms often allow expenses to get out of control on individual programs. There are only a few organizations capable of improving the space program's efficiency and it is in their own best interest to pursue this objective. As a result. narrow agency and national goals converge in this area and there is little need for executive level coordination.

In conclusion it is essential that an executive level council be formed to create and maintain a national perspective in Russian space cooperation, particularly in supporting foreign policy and industrial competitiveness goals. This council could also coordinate space cooperation with nations besides Russia but its authority should be confined to the space area due to its specialized needs and issues. Without such a body, obtaining consistent and well coordinated policy over time is impossible. Besides coordinating policy between agencies and overseeing the interagency review process, the council would also provide direction to individual agencies on how to implement activities with the Russian space industry to be more responsive to national needs. Thus, in the case of NASA, the council could specify the need to infuse capital into Russian and to support particular Russian organizations to achieve foreign policy and competitiveness goals.

### 4.1.2 Broaden NASA's Mission Statement

In the past, NASA like most other government agencies has taken a very narrow view of its organizational mission. The space agency is responsible for exploring and utilizing space in the most effective manner but has considered any foreign or industrial policy ramifications of its work to be of only secondary importance. To meet the ever more global and commercial challenges of space operations, it is essential that NASA abandon this limited view of its mission and accept responsibility for utilizing space to advance broader national goals. A broader agency perspective is required to make NASA's programs consistent with the demands that will be placed on them by the newly formed executive council. NASA's extensive involvement in a diverse range of space activities makes it uniquely qualified to take a national perspective in managing space ventures. The highest level policy decisions that trade-off foreign policy, commercial and space program concerns against each other would of course be decided by the national council discussed in the previous section. But this council alone is incapable of assuring that the implementation of space activities is consistent with national objectives. As the one who carries out most space projects, NASA must also recognize the importance of promoting multiple objectives and restructure its organization to be responsive to these needs. The national council can provide NASA guidance on which objectives are most important in particular areas but it should not be expected to micro-manage NASA to assure that proper weighting of these objectives is obtained in its programs. For example, the council may conclude that transitioning the Russian industry to a capitalistic and nonmilitary basis is more important than obtaining short-term technology benefits for the U.S.. Consequently, it may direct NASA to make sure that its efforts weigh these objectives accordingly. NASA must then decide whether by working with the RSA they are supporting the status quo and consequently stifling the incentives to transition the Russian industry. Although interfacing through the RSA may be the best approach for obtaining access to Russian space technologies, it could also be adversely affecting the industry's transition. NASA must understand the inter-related effects of its cooperative space activities on both national objectives and the Russian industry well enough so that it can make informed decisions on how best to implement its programs. The agency must also possess a grasp of national objectives so that it can use its intimate knowledge of the space industry to effectively advise and support the national policy making council.

To instill broader national perspectives throughout NASA, it is necessary that the agency improve its interface with external government organizations and better diffuse national goals down to its program managers. International cooperation and its inherently inter-related effects can not be effectively dealt with without top level support from the NASA administrator and other NASA executives. Specific recommendations for improving NASA's administrative and policy making structure for Russian cooperation will be discussed in Section 4.2. The agency must also begin to take longer-term perspectives in joint projects. This is difficult with the annual budget cycle to which all government agencies are subjected, but when dealing with international partners, year-to-year commitments are simply too short-sighted to be effective. Finally, NASA must recognize its emerging role to help the U.S. space industry remain competitive. "Industrial policy" was for many years a dirty word in Washington, but successful application of this concept in Japan and Europe have changed the minds of many Americans. The new administration recognizes an important role for government in helping to support industrial competitiveness. The space industry will certainly be affected by this development. Consequently, as the lead agency in the space field, NASA must be ready to take on a much greater role in promoting the commercialization of space and in supporting the future competitiveness of the domestic industry.

### 4.1.3 Streamline the Policy Making Process

In addition to the reforms for improving the effectiveness of the policy making process that were discussed above, there are also steps which can be taken to improve the efficiency of the process. The complexity of the project approval cycle in the U.S. has led to relatively slow progress in initiating new cooperative programs, thus greatly frustrating the Russians. The result has been that Russian enterprises are turning more and more to Europe as their partner of choice in joint space activities. The Russians feel that Americans "are all talk and no action. Hundreds of Americans have visited Russia and drunk a lot of Vodka but there have been few agreements"[165]. America's slow response to Russian proposals to cooperate is mainly a result of the its convoluted policy making process that simply cannot react quickly to changing situations. All potential projects are treated as if they're unique requiring approval by dozens of government agencies and months to process. Large multi-million dollar projects that dramatically affect foreign affairs are treated in the same manner as projects of a few thousand dollars with no political or commercial impacts. It does not matter if a nearly identical project was approved before, the entire review process is triggered for each new project regardless of past actions. The executive oversight and interagency review processes were established when international ventures (particularly with the Russians) were unusual and they have changed little over the intervening years. To improve their efficiency in the new environment of more routine international cooperation, it is recommended that cooperative projects be broken down into at least two levels for approval purposes. For example, expensive, unprecedented, or highly political projects could be reviewed by the coordination council discussed above to determine a policy on utilizing Russian assets in a particular area. However, for more routine projects similar to those undertaken in the past that entail smaller dollar values and fewer political ramifications, the interagency review process could be put to use to provide a streamlined review. There could even be multiple levels of interagency review so that the most routine projects are only examined by a few key agencies allowing them to be rapidly processed. If Russian cooperation in space is ever to become more than an oddity, it is imperative that procedures be established for approving new projects in a timely manner without requiring the concurrence of dozens of bureaucrats on every single venture.

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165 M. Sinelshikov, Department Chief, Russian Space Agency, interviewed in his Moscow office, October 18, 1992.

## 4.2 NASA's Implementation Approach

The importance of NASA taking the broad policy perspective outlined in Section 4.1.2 is driven by the diverse demands now placed on international space projects. In determining the best approach for implementing its cooperative space activities, NASA should focus on the same three objectives that drive the national policy making process. The first objective of improving space program effectiveness has of course always been pursued by NASA. However the importance of the latter two objectives, concerning foreign and industrial relations, has been recognized only recently and therefore their application in guiding the agency's planning is much less well established. For NASA to create international space projects that are responsive to broad national needs, this situation must change. Foreign and industrial concerns should take their place alongside of the space program's technical needs in deciding how to pursue international cooperation. NASA must avoid falling into the trap of pursuing cooperation as an end in itself just because it seems like the right thing to do. The agency should focus on specific, well defined objectives in structuring all of its cooperative activities and two of its most important objectives should be to further foreign policy goals and to support the domestic industry.

This section will discuss how NASA's present strategy for implementing cooperative activities could be modified to become more responsive to national objectives. First a point-by-point critique of the space agency's current guidelines for structuring cooperative projects is presented along with recommendations for improving these rules of engagement. Included in this critique is a discussion of the present trends in the world space community and what they may mean for NASA. The section concludes by recommending a new implementation strategy that makes greater use of private companies as the interface between international space programs. By utilizing this new strategy, it is argued that broader national objectives will be achieved in a more efficient and sustainable manner. As discussed previously, NASA has not been completely blind to the changing role of space cooperation in the international environment. Realizing the increasing importance of cooperation with the Russians and the need to consider broader national interests, NASA designated a special Associate Administrator position for Russian Affairs in 1992 and placed Samuel Keller in this post. The purpose of this reorganization was to elevate coordination for Russian policy out of the bowels of the External Relations Division and into direct contact with the NASA Administrator. Unfortunately, another reorganization only a few months later removed such high level oversight of Russian policy relegating it again to its old position three steps removed from top NASA management. Although at least some in NASA management recognize the need to change their approach toward international cooperation, sustaining any long-term improvements has been difficult.

### 4.2.1 Reevaluating NASA's Guidelines for Cooperation

Several of NASA's guidelines for conducting international space projects that were presented in Section 3.2 require some degree of modification. The emerging demands on cooperative space activities have resulted in these old rules of engagement simply becoming out of date. The following assessment will address the five guidelines requiring the most alterations, recommending ways in which they may be improved. The focus of this discussion will be on the implementation effects of these guidelines as opposed to their project selection effects that were discussed in the previous chapter. The five principles to be evaluated are: no exchange of funds, clean interfaces, control of the critical path, project-oriented agreements, and government led cooperation.

**No or Minimal Exchange of Funds**

Traditionally, NASA has expected each party to a cooperative agreement to fully fund its own portion of the project. The rationale for this requirement was very simple. A major justification for pursuing joint space activities was to reduce costs, and in the first order analysis one could hardly expect to save money by sending it overseas. Later as protecting U.S. jobs became more of an issue to the space program, it was also argued that financial transfers would lead to domestic jobs being shipped overseas. Because of these two reasons, NASA has long followed a "no exchange of funds" policy in its international projects. In conducting its Spacelab work with ESA, its Shuttle manipulator arm project with Canada and its Space Station Freedom program with several other nations including Japan, all partners have provided their contributions to the joint activities free of charge. However, as with any general rule there have been exceptions. For example, NASA did purchase additional Spacelab modules and Shuttle manipulator arms from foreign suppliers following the cost free supply of the first unit of these components. These follow-on purchases were seen as a low cost means to obtain additional hardware and were only secondary to the central cooperative arrangement. Of course the greatest exceptions to the "no exchange of funds" rule have been made with the Russians. NASA currently has several contracts providing millions of dollars in funding to some half a dozen Russian organizations. These projects are intended as a temporary stop-gap to help maintain the Russian industry during a time of turmoil. Although NASA has allowed its "no exchange of funds" policy to bend, it has not yet abandoned it and intends to return to this mode of operation as soon as possible[166].

Unfortunately, NASA's desire to return to the good old days when all international partners made their contributions free of charge is myopic and neglects the irreversible changes that have occurred in the world space community. NASA should not be planning to revert back to its former practices but should be expanding its use of new tools such as financial support of foreign partners. As previously discussed, any meaningful Russian cooperation is impossible without the exchange of funds because of the desperate financial conditions in the former Soviet Union. And why would one want to avoid providing financial support to the Russians when such assistance is exactly what is required to attain many important foreign policy goals? The ability to exchange funds allows NASA much greater flexibility in structuring its cooperative programs permitting it to make full use of its partner's comparative advantages. The agency should no longer be constrained, as in a barter economy, to only cooperative exchanges in which each partner must supply equal contributions. It should exploit the substantial cost savings that can be realized by procuring products at their lowest prices worldwide. For Russian cooperation in particular and for international cooperation in general, NASA should seize the opportunity to leave behind the unnecessary constraints of its old "no exchange of funds" rule.

There are two main reasons why NASA is reluctant to cast away its "no exchange of funds" constraint. The first is that since the agency is funded by U.S. tax dollars, it feels that it has a responsibility to feed those dollars back into the American economy. As a government agency, NASA does have important national responsibilities but they cannot be effectively met using a simplistic rule of thumb such as "avoid giving money to foreigners". The agency's responsibility

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166 D. Jacobs, International Relations Division, NASA Headquarters, interviewed in his Washington office, January 19, 1993.

is to promote the three national objectives enumerated above and if supporting these objectives requires funding overseas partners, it should be done. The other reason why NASA continues to avoid overseas purchases is because of their potential negative impact on U.S. industry. When products are bought from an overseas instead of a domestic supplier, the immediate effect is a loss in U.S. jobs. Accordingly, some restraint in utilizing foreign sources may be necessary, especially considering America's present emphasis on improving its economic performance. But in the long-run, the ability to purchase low cost foreign assets can help to improve America's international competitiveness and consequently to create American jobs. As stated by Senator Barbara Mikulski, "the goal of any joint venture in space exploration or space science with members of the former Soviet Union should be the generation of additional U.S. jobs"[167]. NASA must not unilaterally rule out continued purchases of Russian assets but should direct its purchases toward those areas where its needs as well as those of the U.S. industry and worker can simultaneously be met.

### Clean Interfaces and Minimal Technology Transfer

Related to the "no exchange of funds" rule is NASA's traditional requirement for clean technical and managerial interfaces. Each party to a cooperative agreement is expected to possess or develop all of the technologies that are necessary to implement its share of the project. As far as possible, interfaces are to be kept simple and well-defined to minimize managerial complexity and technological contact between foreign partners. Under this approach, the joint design or development of space systems is essentially prohibited. This principle for cooperating was established years ago to limit the transfer of advanced technologies to Eastern Bloc nations and to protect America's technological lead. The first of these justifications has vanished along with the Eastern Bloc and the second has faded with America's decline as the undisputed leader in space technologies. NASA has begun to recognize the limitations of its requirement for clean interfaces and has "for the first time ever, officially entered into technology-related collaboration with Russia"[168]. But its

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167 E. Pianin, "Russians Offer to Sell, Lease Spacecraft", Washington Post, February 22, 1992, p. A-6.

168 S. Leskov, "America and Russia Have Signed an Agreement, But They Don't Know How They Will Finance It", Izvestiya, Morning Edition, May 19, 1992, pp. 1 & 8.

guiding principle of minimizing technology transfer and striving for clean interfaces wherever possible remains in force. There is a benefit in keeping international management interfaces as simple as possible but the costs of rigidly clinging to this principle can often exceed the benefits.

In the ever more integrated global economy, multinational corporations who regularly do business across national borders are becoming commonplace. This situation is particularly evident in high technology industries, including the aerospace industry[169]. Through internal movements within these global firms, many of the antiquated barriers to technology transfer from the Cold War era have been circumvented. A global economy facilitates the international movement of technology making the requirement to use exclusively domestic capabilities overly restrictive. Instead of attempting to ban technology transfer, an impossible task in the world's inter-related economy, NASA should try to manage technology flows to the benefit of U.S. interests[170]. Cooperative projects should be strategically planned to allow U.S. firms and organizations access to foreign technologies that can improve their effectiveness and competitiveness in the international market. If more complex interfaces are required to obtain access to these technologies of critical competitive importance, then so be it. The Russians with their highly advanced space technologies are one of the most promising potential partners in this area. The state of technology continuously advances with contributions coming from nations all over the globe. The U.S. is no longer the world's sole source of advanced space technologies. NASA must cast aside its fears of compromising U.S. technological leadership through openness to foreign technologies, since the benefits to such openness far exceed the possible costs. The real threat to U.S. leadership is that our country may chose to isolate itself from external technological developments preferring instead to rely exclusively upon our own means. Such a short-sighted and nationalistic approach would certainly seal our fate as a non-competitor in the emerging global marketplace for space products and services.

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169 J. Logsdon & M. Laub, The Globalization of Technology: Implications for the Future in Space, Space Policy Institute, George Washington University, March 1992.

170 K. Pendersen, "Thoughts on International Space Cooperation and Interests in the Post Cold War World", Space Policy, August 1992, p. 236.

### U.S. Control of the Critical Path

The need to demonstrate American leadership has always been of utmost importance in all joint space ventures involving the U.S.. Typically, the U.S. will plan an international space project, taking the central position for itself and offering ancillary positions to its international partners. When the U.S. completely dominated the world space community such an approach may have been appropriate but its time has passed. In the future, to truly reap the economic benefits that are possible with international cooperation, NASA will be forced to cede some control of critical path elements to its foreign partners. There simply are not that many projects that can be structured with one party holding a completely dominate position while still providing mutually beneficial contributions to all those involved. The managerial and economic realities are catching up with NASA in its cooperative activities and it will soon have to face the fact that demanding a privileged position in all projects is untenable. A new definition of leadership is needed based upon the concept of a leader among equals, not the present paternalistic model. It is pure arrogance to expect other nations, possessing advanced technologies and a desire to support their own industrial competitiveness, to always accept inferior roles in joint activities. To accomplish the ambitious projects planned for the future, NASA will have to learn to treat its international partners more like peers and less like lackeys.

There are of course some very good reasons why NASA prefers to control the critical path in its cooperative projects. By producing the critical elements itself, NASA can assure that a project will continue even if all its international partners unexpectantly withdraw. The U.S. is not required to put much trust in its allies since their contributions provide only secondary functions. For example on the Space Station Freedom program, if either the Japanese or Europeans decided not to provide their modules it would lessen the capabilities of the station but the program could still go on. The trust demanded in such a relationship is therefore quite small. But maintaining control of the critical path does not come cheaply. NASA is forced to assume responsibility for producing all infrastructural elements which often includes duplicating capabilities produced by its partners. The net result is that NASA's risk is reduced but at the expense of increasing the overall project cost. In the future, as more equal projects are formed with international partners, the costs of maintaining control of all critical elements will eventually exceed the benefits from reduced risks.

Instead of rigidly requiring U.S. control of the critical path at all costs, a better approach would be to use risk management to reduce uncertainties in the most cost effective manner. Multiple sourcing of hardware or establishing levels of success could be used to manage risk instead of trying to remove it. Keeping NASA's international space activities as low risk as possible is a worthy goal but there are also other important goals, such as minimizing costs, that should not be overlooked. With large projects including many international partners, paying for all critical elements is infeasible. NASA must learn to accept and manage the additional risk that are unavoidable when one fully exploits the advantages that space cooperation can afford. To better control risks NASA should strive to develop long-term relationships with its international partners built upon trust and mutual respect. Only through managed interdependence will the full benefits of international cooperation be garnered without unduly aggravating the risks to any nation.

### Short-Term Project-Oriented Agreements

Unlike the three guidelines discussed above that have experienced many recent exceptions, NASA's mandate that its international cooperative activities consist of specific, clearly defined projects remains in full force to this day. The entire agency is managed as a group of projects so it is not surprising that its international activities are run in a similar fashion. By creating projects that are supportive of the agency's general mission, NASA is able to distribute its work among many different project managers for planning and implementation purposes. NASA sees project-oriented management as the most efficient approach for partitioning its work and in controlling its diverse space activities. This type of management approach is widely used in technical organizations where objectives can be well defined by top management and flowed down to individual project managers for implementation. It was developed to an art form during the Apollo moon missions whose success was due in large part to NASA's creation of the world's most sophisticated management control system. Although project-oriented management was the perfect approach for getting men to the moon, it has serious disadvantages for promoting the internationalization of space activities.

The short-term and narrow perspectives of individual project managers make them unaware of the many broader possibilities from space cooperation. As discussed at the beginning of this chapter, by focusing only on the needs of particular projects, higher level national objectives can be sacrificed. For example, due to a project manager's desire to minimize his own project's cost and complexity, he may avoid utilizing foreign systems that are only of marginal benefit to him but in the aggregate could provide great benefits to the nation. To overcome such limitations, industry has long recognized the need to form strategic alliances with international partners to make full use of foreign comparative strengths. Unlike project-oriented agreements, strategic alliances entail long-term cooperation in broad areas and do not require that all possible benefits be identified upfront. They allow for one partner to "trade" its comparative strengths in one area for a partner's assistance in another area. These "package deals" can help participates to take full advantage of their partner's capabilities without the undo restriction of balancing each individual project. ESA's internal relationship provides a good example of how a strategic alliance in international space activities can be successful[171]. NASA on the other hand insists on cooperating only on a project-by-project basis even in such clearly long-term activities as the joint development of Space Station Freedom. To obtain more effective cooperation in the future, NASA should follow the lead of industry and the Europeans in creating long-term strategic alliances. These arrangements provide the only way to fully realize the pay-off from joint space activities. The diverse and often national level benefits from international cooperation are simply beyond the view of individual project managers. NASA must recognize this and begin to take a longer-term and more flexible outlook in structuring its international space activities.

### Government Led Cooperation

The final NASA guideline for cooperating that needs to be reevaluated is the agency's traditional insistence on directly working only with government organizations. As a government agency, NASA is more comfortable dealing with other governmental bodies because it believes that they operate in a similar fashion and under similar political constraints. However as previously mentioned, assuming too many similarities between foreign space agencies and NASA can be misleading. This is particularly true for the Russian Space Agency

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171 J. Logsdon & J. Fabian, International Cooperation in Space: New Opportunities, New Approaches, Space Policy Institute, George Washington University and the Association of Space Explorers, April, 1992, p. 10.

and the centrally controlled space industry that it directs. Nonetheless, governments are uniquely capable of providing national commitment and they have the extensive resources necessary to undertake the type of long-term and expensive projects that have been the mainstay of international cooperation. For these reasons, NASA has always sought government-to-government agreements and rarely involved the private sector (except for the scientific community) in its cooperative activities. Yet the growing worldwide emphasis on economic competition and the commercialization of space is forcing NASA to reevaluate its position. Space is no longer the exclusive domain of governments, supporting commercial space interests and their international competitiveness has now become very important. Accordingly NASA, as well as other government agencies, should begin to consider the economic and trade implications of their proposed joint activities, taking care to consult industrial leaders to assure their needs are met. They should also consider cooperating with other potential international partners besides government organizations (i.e. private companies) since these enterprises possess the value-adding capabilities and their prosperity is critical to expanding the commercial utilization of space.

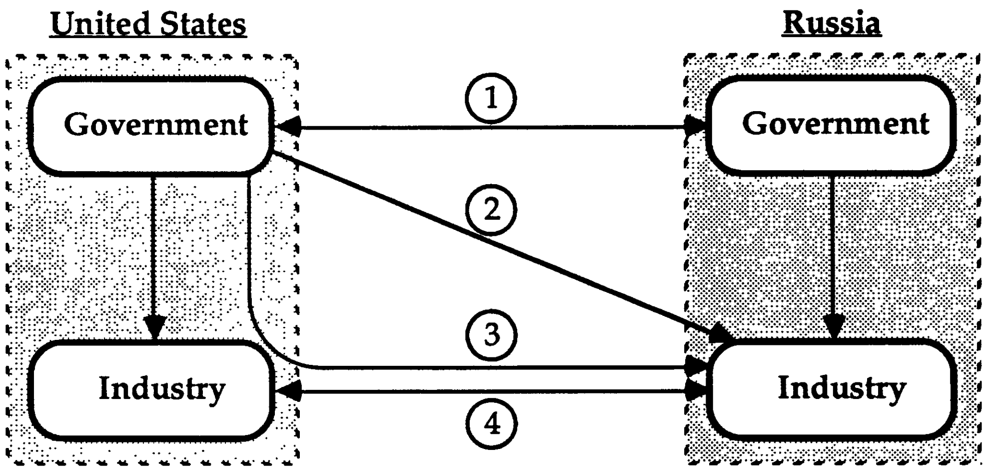
The private sector will play an increasingly important role in the space community in the coming years and NASA should not cut itself off from this valuable resource by insisting on cooperating only with government agencies. The growing importance of economic considerations in space activities will mean that industrial players will play an ever more significant role both at home and abroad. At home, NASA's programs will be increasingly judged on how well they protect and promote the competitiveness of the commercial sector. As a result, consultations with industry to obtain their advice and support will be a critical factoring in securing Congressional budget approvals. Abroad, the growing strength of foreign industrial enterprises will allow them to enter into extensive, long-term agreements without direct government supervision. Such a development can already be witnessed by observing the independent activities of the large Russian enterprise Energia, or the large German firm Kayser-Threde. Putting the domestic and international trends together, one would expect direct industry-to-industry contacts to play a greater future role in initiating and structuring international space activities. Many American business leaders already have a more internationalist outlook than most government officials as evidenced by the boom in private international joint ventures. The full ramifications of this development for the space industry will be discussed in the next section. However, outside of the fully commercialized telecommunications sector, government will continue to play the lead role for a long time. NASA should take advantage of private initiatives as much as possible but it should also realize that in most cooperative areas it retains leadership responsibility. The agency's goal should be to create an environment in which private international space ventures can prosper. It must not limit itself to working only with other government agencies but should look for ways to work with foreign companies so that its interests and those of the domestic industry can be simultaneously met. In the future, NASA should aim to become industry's partner in managing international cooperation, not cling to its present role as industry's customer recognizing only other government agencies as its peers.

### 4.2.2 The Need for a New Strategy

To overcome NASA's shortcomings in cooperating with the Russians, it is necessary not only to modify some of the existing guidelines for cooperation, but to develop an integrated strategy for conducting international activities. The criticisms and recommendations provided in the previous section represent separate observations that must be brought together into a coherent strategy if they are to be effectively implemented. It is fine to say that project-oriented management and government led cooperation should be de-emphasized, but what is to take their place? This section will analyze the global trends occurring in the space community and recommend a revised strategy for NASA that is more compatible with the new international milieu and more responsiveness to America's national interests.

The most common strategy to date for conducting international cooperation in space has been to structure joint activities using government-to-government agreements. Using this approach, commitments are made between government agencies in participating countries who then provide all interfacing functions with their national industries to develop the necessary hardware. However, as shown in Figure 4.1, this is not the only possible way in which to structure international joint ventures. The traditional approach is shown as Strategy 1 in the figure below but there are additional possibilities identified as Strategies 2-4 that should also be considered. For example, instead of obtaining access to foreign space capabilities using another nation's government as an intermediary, NASA could contract directly with foreign industrial enterprises to purchase their products. Alternatively, NASA could use U.S. companies as the interface with overseas firms either through government or private initiation. These latter cooperative approaches are becoming increasingly popular with greater emphasis in the space community on commercial considerations. The implications of this trend on NASA's strategy for cooperating with the Russians will be analyzed in the following paragraphs. By assessing the pros and cons of each of these possible strategies, insights into how NASA may improve its interchange with the Russians will be derived.

Figure 4.1
**Strategies for Accessing Russian Space Assets**




The conventional strategy for conducting international space activities (Strategy 1) has been very effective for scientific and exploration projects but its potential utility in more demanding areas such as technology sharing is limited. To truly have the symmetric organizational structure shown in Figure 4.1, it is necessary that the government-industry relationship be the same in each participating country. As is well known, this is not the case between the U.S. and Russia. The government and industry in America are distinctly separate entities while their functions remain intertwined in Russia. Consequently, it is not completely accurate to consider enterprises such as NPO Energia exclusively as part of "industry" because they possess many quasi-governmental functions. The danger with this strategy is that U.S. government agencies have the tendency to simply assume that their Russian counterparts occupy similar positions in the hierarchy to their own. This has been particularly problematic for NASA in its relationship with the Russian Space Agency (RSA). Unlike in the U.S., all civilian space power in Russia is not concentrated in a single agency. The RSA is far less influential and well established in its space program than is NASA in the U.S. program. But to utilize conventional government-to-government agreements, NASA requires a foreign space agency similar to itself so it has either deluded itself in overestimating the authority of the RSA or used its influence to try to form the RSA in its own image. Both of these actions are the result of an attempt to force-fit a strategy where it really does not apply. The fundamental institutional mismatch between NASA and the RSA cannot be overlooked. The RSA does not have complete control over all Russian space assets. NASA must recognize this and broaden its contacts in Russia to assure that it is dealing with those organizations that truly control the capabilities of interest and not with those governmental agencies who are only theoretically in charge.

Through years of cooperation with the Europeans, Japanese and others on such programs as the Shuttle and Space Station Freedom, NASA has developed a detailed approach for conducting international projects. This long-established procedure is now being used to implement most cooperative activities with the Russians[172]. Government organizations play the central role in this approach by creating Intergovernmental Agreements (IGAs) that establish national commitment and Memoranda of Understanding (MOUs) that specify the responsibilities of each nation's space agency in joint activities. Not surprisingly, NASA would like to continue to use its well developed and largely successful procedures for conducting international projects. However, these procedures were developed for coordinating scientific and exploratory space projects and their applicability in broader cooperative areas and in the changing global environment is highly questionable. Governments are no longer the only players in the space arena and they are no longer in sole control of their nation's space capabilities, particularly in the former Soviet states. In the future, NASA must not lock itself into cooperating only with government partners simply because of bureaucratic inertia. The agency should consider more direct contacts with Russian industry as is being done by other agencies and companies both inside and outside of the space community.

172 Implementing Agreement between the National Aeronautics and Space Administration of the United States of America and the Russian Space Agency of the Russian Federation on Human Space Flight Cooperation, signed by D. Goldin & Y. Koptev, October 5, 1992.

The most straight-forward strategy for accessing former Soviet space assets is to go right to their source in Russian industry (Strategy 2). This avoids the complexity of dealing with the government as an intermediary as well as the uncertainty of whether the government is truly in control of a particular area. It also assures that financial support gets into the hands of the people who need it most and is not siphoned off as it goes through the bureaucratic channels. Because of these reasons, the Europeans are directly funding several Russian institutes and enterprises to conduct work for them without using the RSA as an intermediary[173]. NASA has also begun to provide direct funding to Russian institutes and enterprises, in particular to NPO Energia and Lavochkin's Babakin Research Center. There are however several reasons why such a direct approach is not very desirable. First of all, it requires that NASA establish working relationships with many organizations in the former Soviet Union instead of just a single central space agency. This can be very difficult considering the communication barriers, diverse business practices, and the general ignorance of each others' organizations that exist between the U.S. and Russia. Consequently, there is a tendency to latch-on to lower level organizations and use them as surrogates for a top level coordinating agency. Just such a situation has occurred between NASA and NPO Energia. To minimize the need for contacts all over Russia, NASA tries to utilize NPO Energia as an interface to the rest of the Russian industry. But lacking any responsibility to the industry as a whole, Energia uses its privileged position to monopolize NASA contracts for its own people leaving other enterprises with little Western support. This situation is neither fair to the rest of the industry nor in NASA's best interests.

A second important downside of the direct approach is that top level governmental commitment is not given to joint ventures. Only the individual enterprises involved in a particular project are responsible for its completion, not the entire Russian government, hence there is a much greater risk of default. There is also the added uncertainty of the legal foundation for agreements between NASA and non-governmental entities in the former U.S.S.R.. Are Russian enterprises able to enter into legally binding contracts with foreign governments and if so, who is responsible for their enforcement? The lack of clearly defined rules in this area makes NASA understandably apprehensive in pursuing the direct strategy. Finally, the idea of "giving away tax dollars" to

173 "Russia Gets ESA Contracts", International Space Report, Spaceflight, June 1992, p. 182.

individual Russians strikes many in the U.S. as inappropriate and politically questionable. NASA would far prefer to fund the Russian government (or possibly U.S. firms) for particular tasks and have them obtain whatever assets are necessary from the Russian industry. Such approaches are more consistent with NASA's normal modes of operation and therefore are subject to less internal resistance within the agency.

A more politically acceptable strategy in the long-run for obtaining direct access to Russian space assets is for NASA to use U.S. industry as the intermediary (Strategy 3). This strategy has several important advantages over direct government procurement from Russian enterprises. First of all, it allows NASA to work primarily with its domestic contractors with whom it has a long and well-developed relationship. This greatly simplifies the government's interface role placing most of the burden for establishing effective working relationships with the Russians on private firms. Industry, with its fewer bureaucratic constraints and more internationalist perspective, is in a much better position than NASA to make the dramatic organizational changes needed to accommodate the Russians. Secondly, a major objective of cooperation is to expose the Russians to Western business practices and this can only be done by having them work with U.S. firms and not with government agencies. Thirdly, another important objective is to transfer Russian technologies to U.S. firms to improve their international competitiveness. Technology transfer to U.S. firms will be greatest if they have direct contact with Russian enterprises and do not have to go through a government middleman. For all of theses reasons, government use of private industry as an interface to the Russian space industry has become quite common. For example, NASA is using Rockwell International to procure the Androgynous Peripheral Docking Assembly from NPO Energia that is needed to make the Space Shuttle compatible with the Mir docking system[174]. NASA could have purchased this hardware itself but it believes that the technical interchange that will result from having Rockwell as the procuring agent will help to make the project more successful. Similarly, SDIO has used Rocketdyne (a division of Rockwell International) and Space Power, Inc. as purchasing agents for the Topaz 2 reactors that it has bought from the

174 A. Lawler, "Rockwell, NPO Energia To Build Docking Device for Shuttle, Mir", Space News, September 14-21, 1992, p. 12.

Russians[175]. Both these examples demonstrate the growing trend away from government-to-government interaction toward industry-to-industry interaction. Of course there are some negative impacts from utilizing private companies as an interface with the Russians. One of the most important of these is the additional costs that are added to a project because of the presence of a private middleman. If the private company adds no value beyond simply acting as a contracting agent, the additional costs of utilizing it are generally not worthwhile. However, if the company has particular technical expertise or is in fact the final destination for the technology being procured, it will often be worth the additional costs to obtain more efficient technology transfer or a better final product.

The most progressive strategy for accessing Russian space assets is to allow private companies in the U.S. to establish joint ventures with Russian enterprises to supply the technologies and products needed by the American space program (Strategy 4). These joint ventures would be formed as a result of private initiatives to increase the competitiveness of individual firms. The government would be responsible only for creating an environment in which firms are willing to take the risks of utilizing Russian systems to improve their product lines. Enhanced American space services that make use of Russian technologies, components or complete systems would then be available for government purchase similar to any other products made by the domestic industry. This differs from the previous strategy by relying on commercial instead of government leadership in forming and implementing cooperative projects. For it to be effective, government would have to set consistent policies for the use of Russian systems so that industry could determine which areas of cooperation offer the best opportunities for profit. Without consistent government policy, industry would face the unnecessary political risk of losing its investment in a joint venture due to changes in policy that post facto disallowed use of particular Russian capabilities. To avoid such misunderstandings, U.S. government and industry must work together as a team in establishing which areas of cooperation are most supportive of national objectives and also offer reasonable possibilities for successful implementation. By taking this approach, NASA will be able to manage the top level direction of cooperative activities with the Russians while still exploiting the advantages that company led cooperation offers.

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175 B. Henderson, "Russian Partners to Aid U.S. Firms in Developing Space Reactors", Aviation Week & Space Technology, June 22, 1992, p. 35.

There are many reasons for preferring commercial leadership in cooperating with the Russians. These include most of the benefits that Strategy 3 offers, such as simplifying the demands on the government bureaucracy, providing greater business exposure to Russian enterprises, and directly supporting U.S. commercial needs, as well as a few others. International business relationships are relatively common and their reliance on private capital makes them strive for the maximum possible efficiency. To the contrary, government-to-government agreements are fewer in number, operate in a politically charged environment, and often suffer from bureaucratic inefficiencies and excessive implementation costs. Using private incentives to improve the efficiency of economic interactions is the heart of a capitalistic economy. The Russians are well aware of what can result from too much reliance on government leadership in economically important spheres. The U.S. space community must be careful not to fall into a similar trap. The greater efficiency, flexibility and creativity, as well as the established international channels and contractual procedures that U.S. business possesses should be exploited to improve cooperation with the Russians. Only in this way, can crucial government limitations such as an inability to commit funding beyond a year at a time or to manage strategic alliances instead of short-term projects be overcome.

The usefulness of direct corporate contact with Russian enterprises has led to the worldwide formation of many private joint ventures. However, the lack of a clearly articulated policy on what type of joint U.S.-Russian products the government will be willing to purchase has stifled some initiatives. Nonetheless, dozens of U.S. aerospace companies have initiated joint ventures with Russian enterprises to help them improve their domestic products. International Space Technology Inc., a joint venture of Loral Space Systems, a major U.S. satellite manufacturer, and KB Fakel, the leading Russian producer of electric thrusters, intends to modify Russian thrusters for use on American satellites and is a typical example[176]. Russian enterprises are also initiating contacts with U.S. firms to make use of their expertise and financial resources for such projects as the joint development of an advanced telecommunications system in the former Soviet states[177]. And beyond U.S. borders, direct corporate contact with Russian

176 "Russian-U.S. Firm to Sell Novel Satellite Thrusters", Space News, December 6, 1992, p. 6.

177 B. Davis, "Soviets Aim to Find Western Investors for World-Wide Satellite TV Venture", Wall Street Journal, Friday, March 29, 1991, p. A-12.

space enterprises is booming. The recent announcement by Aerospatiale, the European builder of the Ariane launch vehicle, that it has signed 10-20 contracts with Russian enterprises with a combined value of several million French francs demonstrates the growing importance of this cooperative approach abroad[178]. There is a clear trend away from governmental leadership in all Russian space cooperation towards a larger role for industry. In the more traditional areas of space science and manned exploration, direct government control may continue to be necessary. But in the newly developing technology and commercial product areas where competitiveness and foreign policy considerations dominate, private leadership of cooperative efforts are much more suitable. NASA must recognize the benefits of utilizing industry as an interface to Russian enterprises and begin to form partnerships with U.S. firms to more effectively exploit their abilities. Only through a teaming of efforts between U.S. government and industry can all of the diverse objectives of Russian space cooperation be realized in an efficient and productive manner.

## 4.3 Project Level Implementation Issues

The higher level implementation issues addressed in the two proceeding sections were driven by developments in the international community as well as internally imposed limits by America's space policy making apparatus. Although Russian needs and peculiarities played some role in deriving the previous recommendations for change, they were not the dominant factor. Both the NASA and interagency system for conducting international space cooperation should be restructured to more effectively pursue joint activities with other nations, regardless of whether Russian participation is involved. The Russian element adds some additional demands to the need for reform but it is not the fundamental driver. The situation is quite the opposite for project level implementation issues. When it comes to the actual planning and implementation of specific projects with Russian partners, understanding their unique technical and management structures is of critical importance. The technical capabilities, political environment, and the entire economic and industrial system in the former Soviet Union are unlike any with which NASA is used to working. Consequently, new modes of operating are required if projects

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178 "Aerospatiale, Russian Outfits Sign Contracts", Space News, February 8-15, 1993, p. 2.

are to be implemented in an effective manner. This section will first enumerate the various approaches that could be used to implement joint projects with the Russians, discussing their potential strengths and weaknesses. Then an assessment of the impacts of Russian management practices on the expected usefulness of each of these approaches will be given. Distinctive Russian needs and characteristics will be shown to be the dominant factor in determining the most suitable approach for implementing individual projects. The analysis in the following paragraphs is concerned primarily with NASA's implementation needs but since NASA's projects may be conducted through a company interface, issues of interest to private industrial partners are also addressed.

### 4.3.1 Approaches to Implementing Cooperative Projects

The types of cooperative projects that could be conducted with the Russians are quite numerous but they can generally be divided into two main categories: Research & Development (R&D) and Production projects. The options for implementing projects in these two categories are very different. Table 4.1 lists in ascending order of complexity the types of projects that could be undertaken in each cooperative category. In the R&D category, the lowest level cooperative projects entail funding Russian enterprises to use existing expertise and personnel to assess U.S. space systems designs and to suggest how they may be improved by utilizing Russian capabilities. Low level R&D cooperation could also include testing of U.S. equipment or models at one of the many capable Russian experimental facilities. Either one of these approaches would utilize existing Russian assets for limited purposes over a fixes period of time. Examples of this type of cooperation are quite common and include most of NASA's contracts with NPO Energia as well as many initiatives that U.S. companies are pursuing. The Boeing Company is using this approach extensively to improve the technology in both its aeronautical and space systems[179]. The next level of sophistication in R&D cooperation consists of licensing existing Russian technology for use in the United States. These project are more long-term than funding studies or experiments since they may lead to follow-on production activities. However, they still rely exclusively on existing Russian capabilities and do not require extensive interaction between U.S. and

179 L. Tucci, "Boeing, Russian Firm Team on Life Support", Space News, Feb. 1-7, 1993, p. 6.

Russian researchers. Examples of this type of cooperation are less numerous since they demand greater commitment and greater understanding of Russian capabilities. Pratt & Whitney's joint venture with NPO Energomash for access to RD-170 rocket engine technology is one of the most prominent instances of such cooperation to date[180]. The most advanced stage of R&D cooperation involves the joint conduct of research and development work. Such activities require integrating the vastly different R&D systems of U.S. and Russian partners. These projects benefit from the longest-term perspective but also suffer from being the most complicated and highest risk. Because of these drawbacks, there have been very few projects of this type, particularly under U.S. government sponsorship. One notable exception is the Boeing company's recent founding of a technical research center near Moscow that will employ both Russians and Americans to jointly develop technologies for commercial aircraft applications[181].

Table 4.1 - Approaches to Implementing Cooperative Space Projects

| Research & Development Projects | Production Projects |
|---|---|
| • Sponsored Design Reviews/Testing | • Hardware Purchases or Sales |
| • Technology Licensing Agreements | • Import/Export to New Markets |
| • Joint Research & Development | • Joint Production Activities |

In the production category, the lowest level approach to cooperating is simply to purchase from, or sell to, the Russians existing space hardware. This could include anything from individual components such as solar arrays or batteries up to complete space systems such as launch vehicles or satellites. Direct sales offer a rapid means for obtaining access to foreign assets with minimal need to develop elaborate interfaces or to risk long-term investments. Because of its strong benefits and minor risks, the purchase of Russian hardware has received great interest in Western nations. For example in the U.S., several entrepreneurial firms, such as Rimsat Incorporated, are considering the purchase of Russian telecommunications satellites to provide commercial services in

180 J. Lenorovitz, "Pratt Signs Accord With NPO Energomash", Aviation Week & Space Technology, November 2, 1992, p. 25.

181 "Russian Technology Draws Boeing to Open Research Center Near Moscow", Aviation Week & Space Technology, August 17, 1992, p. 31.

underdeveloped world markets[182]. The next possible level of production cooperation is for a U.S. organization to act as a marketing agent for Russian products in the West. The American partner is asked not only to utilize Russian capabilities itself but to help the Russians expand their sales to third parties. This approach can leverage American marketing and business knowledge along with high performing and low cost Russian systems to create highly competitive products in the international market. A reciprocal arrangement where U.S. products obtain access to the Russian market through a joint venture is also possible but of limited value due to the poor financial condition of potential Russian customers. The use of a Western partner as an import/export agent has been very popular in the sale of Russian products abroad. For example, the German firm Kayser-Threde now has a joint venture with NPO Energia to market Russian remote sensing data in the West to compete with Spot Image and Landsat images[183]. Without such Western assistance, the Russians lack the business and marketing expertise necessary to penetrate new markets. The most advanced stage of production cooperation is the joint manufacturing of space hardware, be it components or complete space systems. This type of cooperation requires the greatest degree of interaction, the largest financial commitments and the highest risks. Substantial differences between Eastern and Western business practices result in many practical implementation barriers that must be overcome when using this approach. Because of these difficulties, there has yet to be any joint production of space hardware by Russian and U.S. partners. However, as familiarity and confidence grows between the two leading space powers, it is only natural to expect that one day this will change. But for such a change to be possible, it is necessary that U.S. organizations learn to understand Russian practices and capabilities better so that they can become better partners.

### 4.3.2 Impact of the Russian Business Environment

Possessing a full understanding of the operations and management practices in the former Soviet Union is critical to implementing efficient and productive joint space projects. The most important Russian business practices of concern to potential Western partners were identified in Section 2.4. From the

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182 L. Tucci, "Rimsat to Use Gorizont for Pacific Coverage", Space News, Jan. 25, 1993, p. 6.

183 "Selling Mir Images", Aviation Week & Space Technology, September 28, 1992, p. 13.

discussions in that chapter, several fundamental *cultural* differences between the space industry in Russia and those in the rest of the world were highlighted. The following paragraphs will discuss the impact of these *cultural* difference on the implementation approach that should be used for joint projects. Russian industry's complete dominance by technical specialists and its prior operation in a centrally planned economy has led to little development of business skills, particularly marketing skills, by top Russian managers. As a result, Russian enterprises tend to put all their effort into optimizing a product's technical characteristics without considering the needs of potential customers or the economic requirements for making the product salable. Consequently, when forming joint ventures with Russian industry, U.S. partners must be prepared to bear most of the burden for assuring that the project is adequately marketed and financed. This is particularly true for highly integrated projects involving joint R&D and production where the success of both parties depends on a well managed overall program. U.S. partners should take responsibility for assessing a product's potential market, determining the most important product attributes for the customer, establishing customer relations and arranging for project financing. In the process of working with Western partners, Russian enterprises will learn how to more effectively perform these functions but in the early stages of cooperation, Russian business naiveté should not be underestimated.

The dominance of engineering professionals in the Russian space industry has led to conservative product designs that rely on old proven approaches instead of developing newer and more progressive ones. On the negative side, this results in Russian systems that are generally bulkier, heavier and make use of lower technology constituents than their Western counterparts. Consequently, integrating Russian components into U.S. systems can be difficult because they are designed using a different philosophy and often do not use the latest technologies. On the positive side, Russian conservatism has led to their development of remarkably robust and reliable space systems. U.S. engineers who have witnessed the Russian's heavy reliance on product testing, in-flight health monitoring, and their extensive quality assurance efforts have been highly impressed[184]. The Russians are not confident enough to fly a piece of space hardware until it has been tested to a far greater extent than is customary in the

184 J. Reardon, President of Energo, Incorporated, U.S. representative of NPO Energomash, interviewed at his office in Revere, Massachusetts, November 12, 1992.

West. The emphasis on robust designs has allowed Russian enterprises to mass produce many of their space products without negative impacts on reliability. Scale economies from mass production along with the long-standing Russian priority on producing easily operable space systems (for application in potentially hostile military environments) has resulted in low production and operation costs for most Russian space systems. Therefore, whether forming a joint venture to access technologies or manufactured hardware, one of the greatest benefits that Russian cooperation can provide is the transfer of low cost space capabilities to the West. U.S. partners must recognize this great potential benefit and structure joint projects to make use of the cost savings inherent in utilizing Russian manufacturing and technology development capabilities.

Another important cultural difference is the highly personal nature of business relationships in Russia. Unlike in the U.S., personal contacts and friendships are used to establish business agreements, not "open competitions" and legally binding contracts. This situation is exemplified by the dominant role of the Chief Designers within the space industry. Inside of a given enterprise, the Chief Designer autocratically rules (usually for life) leaving employees few avenues for advancement beyond his control. Consequently, personal fawning over one's Chief Designers is not uncommon. An enterprise's external relations are likewise at the complete discretion of its Chief Designer so that establishing a personal rapport with this individual is essential for conducting business. Potential U.S. partners must recognize these Russian practices in attempting to create joint ventures with space enterprises in the former Soviet states. The importance of personal contacts, especially with the Chief Designer, to a project's potential for success cannot be over-emphasized. When simply purchasing Russian products or funding a short-term study, establishing extensive contacts may not be necessary but for any longer-term or more integrated effort, developing a reliable relationship is essential. Russian business is built more upon personal trust and respect than upon clearly defined legal procedures. Although the hope is that greater contact with Western companies will introduce more democratic and impersonal decision making into Russian business, for now subjective factors such as friendships remain of utmost importance.

Due to their close association with the military, most Russian space enterprises have a fairly secretive manner that tends to inhibit the full disclosure of their capabilities and needs. Through continued Western exposure one would expect the Russian industry to progressively open up as it develops confidence in the intent and benefits offered by Western firms. But for now, potential U.S. partners must recognize the barriers that secrecy creates and structure their programs to either accommodate or overcome these barriers. For example, many Russian enterprises continue to produce substantial military hardware along side of their civilian space products. It is not possible for such enterprises to cooperate in a completely integrated fashion without exposing sensitive technologies to U.S. partners. Accordingly, cooperative projects with these enterprises must either be kept at the simpler stages that do not require extensive interaction, or their military and civilian work must be separated to allow for highly integrated joint space activities. A U.S. partner would only have control over the former decision so that if a Russian enterprise decided not to separate its military and civilian work, its partners only alternative would be to limit itself to relatively simple forms of cooperation with the enterprise.

Beyond the *cultural* characteristics that have developed over many years of Soviet rule, other more recently promulgated conditions must also be considered when planning a joint venture with a Russian space enterprise. One of the most important of these is the desperate financial condition of most space enterprises in the former Soviet Union. Their shortage of funding for such basic needs as paying workers, purchasing materials or maintaining facilities makes their direct investment in international joint ventures out of the question under most circumstances. Consequently, U.S. partners should expect to provide the lion's share of the funding that will be required in a cooperative project with a Russian enterprise. The political and economic uncertainties in the Commonwealth of Independent States must likewise be considered in structuring joint ventures. Politically, as the former Soviet states are divided into ever smaller autonomous units, the union-wide supply network for space system components will continue to deteriorate. The separation of Ukraine from the Russian Republic proved a great shock to many Russian space enterprises who were no longer able to obtain critical parts and materials from their Ukrainian affiliates. Political instabilities make investment in Russian ventures more risky since no one can be certain that government support for international joint ventures will be maintained if the government changes. Economically, the worsening condition and the potential for drastic changes in the structure of the economy add additional risks. Space enterprises may irretrievably lose many valuable people, technologies and facilities due to economic hardships, drastically reducing their ability to contribute to a joint project. And with the impending privatization of industry, it is unclear who has the authority to commit enterprises to long-term agreements or to sell specific assets. The political and economic environment requires that great care be taken to effectively management risks in cooperative projects. The uncertainties make any joint venture relatively high risk requiring that risk reduction approaches, such as developing relations with multiple suppliers or obtaining top level government commitments, be used to the greatest extent possible. In the end, many of the risks involved in working with the Russians cannot be avoided, but they can and should be managed.

The lack of established legal procedures in the former Soviet Union also complicates business transactions and adds uncertainty to joint ventures. There is no contract law or well-developed mechanisms for enforcing domestic, let alone international, business agreements in Russia. Consequently, U.S. partners must either be content with the personal commitments often used in internal Russian transactions or impose contractual agreements on Russian partners that in reality cannot be enforced. The latter approach is generally taken since it makes agreements with Russian enterprises similar to agreements with any other partners. But it must be recognized that these agreements are not backed up by Russian law and therefore are far riskier than similar agreements with Western partners. Finally, the general lack of business experience throughout Russian industry puts some unique demands on potential partners. One of the greatest demands is to bring Russian managerial practices up to international standards before fruitful cooperation can be conducted. For example, in implementing its joint venture with NPO Energomash, Pratt & Whitney found that it first needed to teach the Russians some basic managerial control and marketing principles before its joint activities could begin in earnest[185]. In particular, Energomash possessed no adequate cost accounting system for determining how expensive it was to perform particular tasks. Upon forming the joint venture, Pratt & Whitney immediately went to work to install a cost accounting system at Energomash that would keep track of the reimbursable expenses incurred by the Russians in support of the joint activities. Without such a system, there is no way to set a price on a particular service that is commensurate with the costs incurred. Lack of accurate cost information has often forced the Russians to price their products in a relatively arbitrary manner that has been greatly criticized by

185 J. Roberto, Director of Business Development & Planning, Pratt & Whitney's Government Engines and Space Propulsion Division, interviewed by phone, November 6, 1992.

international competitors[186]. U.S. organizations considering joint ventures in Russia must recognize that they will be required to be teachers as well as partners to their Russian colleagues if their cooperative projects are to be successful. Some U.S. organizations, SDIO being the most notable, have taken advantage of Russian business naiveté to procure their technologies and products at unreasonably low prices. The Russians recognize their vulnerability to such exploitation[187] and obviously taking advantage of them in their time of need is not the way to develop a long-term and mutually beneficial relationship.

In conclusion, Russian space enterprises have many technical capabilities but little financial support to provide to joint space ventures. They are long on technical expertise but short on business experience. Consequently, American partners should look to utilize Russian systems and technologies for their technical as well as cost advantages, but should expect to provide the Russians financial and business management support in joint space activities. Old rules of engagement, developed for international partners who operate in a similar manner to U.S. organizations, should not be force-fit to Russian cooperation. U.S. organizations should recognize the differences in Russian business practices and work with their Russian partners to develop internationally compatible alternatives to their present modes of operation. Particular emphasis should be placed on teaching Russian enterprises the importance of business control systems, marketing and financial planning. By taking these steps, some of the most important economic, political and managerial barriers to cooperating with Russian enterprises can be overcome so that the substantial technical benefits that they have to offer can be utilized by American partners.

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186 P. de Selding, "Cheap Russian Launch Bid Confirms Competitor's Fears", Space News, August 10-16, 1992, pp. 1 & 20.

187 I. Spirina & Y. Alekseyev, "Commentary on U.S. Russian Test of Topaz Reactor", on the Tinko program, Moscow television, 1400 GMT, May 13, 1992.

# Chapter 5

# Recommendations & Conclusions

The Russian space program offers numerous technologies, products and services that could be profitably employed to lower costs and improve the performance of American space systems. This study identified dozens of these cooperative opportunities and there are undoubtedly many more that have yet to be recognized. There is little argument over the applicability of Russia's impressive space capabilities in the West. The difficulty arises not in trying to identify worthwhile areas for cooperation, but in attempting to implement programs to realize the potential benefits. Too often in the past, short-term and narrow organizational objectives have been pursued at the expense of more strategic national goals. To overcome this problem, this study has focused on three national goals as the criteria for judging the value of cooperative space projects. These national goals are to: improve the space program's efficiency, support U.S. foreign policy, and enhance international competitiveness of the domestic industry. Focusing on these national goals provides guidance not only in *what* areas are useful for cooperation, but also in *how* cooperation should be pursued. The above criteria can be effectively applied only by forming an executive level coordination council for international space activities that is capable of taking a national perspective in setting space policy. The specifics of how such a council would create more consistent long-term strategies for utilizing Russian space assets are presented in Section 5.1. NASA's strategy for cooperating with the Russians would also benefit from greater emphasis on national needs and on longer-term objectives. Specific recommendations for restructuring the agency's management of joint Russian activities to improve their efficiency and their responsiveness to the above goals are enumerated in Section 5.2. Finally, Section 5.3 provides recommendations for better implementing individual joint projects with Russian partners. National concerns play an important role in assessing implementation strategies even at the project level, but other factors such as the unusual characteristics of Russian enterprises are also important. Making the changes recommended in the following sections at the national, agency and project levels will allow NASA, as well as the domestic industry, to fully utilize Russian space assets in a manner consistent with the long-term national interests of the United States.

## 5.1 Form Executive Level Coordination Council

National policy making in the U.S. for international space activities is in disarray. Decisions on whether to cooperate on particular projects are being made on a case-by-case basis with little attention to long-term national objectives. With President Clinton's disbanding of the National Space Council, the U.S. government has lost what little ability it had to coordinate the international space projects of its many agencies. The interagency review process, which has proven in the past to be inefficient and short-sighted, has now by default been given even greater responsibility. But the inherently parochial interagency process is incapable of taking a national perspective in its decision making. The relatively low level officials who conduct the interagency reviews are more suitable for assuring that established policy is implemented, not for developing new policy. When they are forced into such a role, they retreat into their institutional biases and argue for projects considering only their agency's limited needs. The results are inconsistent and reactive policies that lack a long-term U.S. level perspective. To break the cycle and produce more proactive policies that exploit the burgeoning opportunities for international cooperation in space, particularly with the former Soviet states, international space policy making must be elevated to a higher level. NASA alone cannot change the top level space policy making structure in the U.S. but it can promote such changes and make its organization compatible with them. There is a critical need to improve space policy making at both the national and agency level. NASA should pursue a strategy that directly improves its own conduct of international projects as well as stimulates the restructuring of policy making at the national level.

Under the Bush administration, there were two separate White House councils that in theory coordinated all high technology activities of the U.S. government. These were the Federal Coordinating Council for Science, Engineering and Technology, chaired by the President's science advisor and the National Space Council, chaired by the Vice President. The councils themselves were composed of the top administrators from over a dozen government agencies, but most of their actual work was performed by executive staffs and lower level working groups. With the transition to the Clinton administration, a single Office of Science, Technology and Space, led by the President's science advisor, John Gibbons, was formed. According to George Stephanopoulos, the President's communications director, "[the] Science, Technology and Space [office] is a combination of the science and technology and the space councils"[188]. Richard DalBello, a close associate of John Gibbons, has been put in charge of space matters in the new office. There is no longer a dedicated White House organization to provide national coordination for space activities. Although the Space Council's ineffective track record made its demise under the new administration inevitable, the need to coordinate space policy, particularly international policy, is greater than ever. Consequently, it is imperative that a new executive level council, devoted specifically to managing international space activities be created. Only through executive level coordination can policies remain focused on the broad objectives that can be achieved by international cooperation. It is recommended that an International Space Activities Coordination Council (ISACC) be established as one of the operating arms of Office of Science, Technology and Space under the President. This new council would be responsible for many of the dedicated space activities that were formerly the purview of the National Space Council. It would establish top level policy from a national viewpoint leaving the interagency review process responsible only for assuring that policy was properly implemented. And most importantly, it would create a national forum for assessing international opportunities and for responding to them in a proactive manner.

The relationship that the International Space Activities Coordination Council would have to other government bodies, industrial concerns and foreign partners is shown in Figure 5.1. The ISACC members would be lower level

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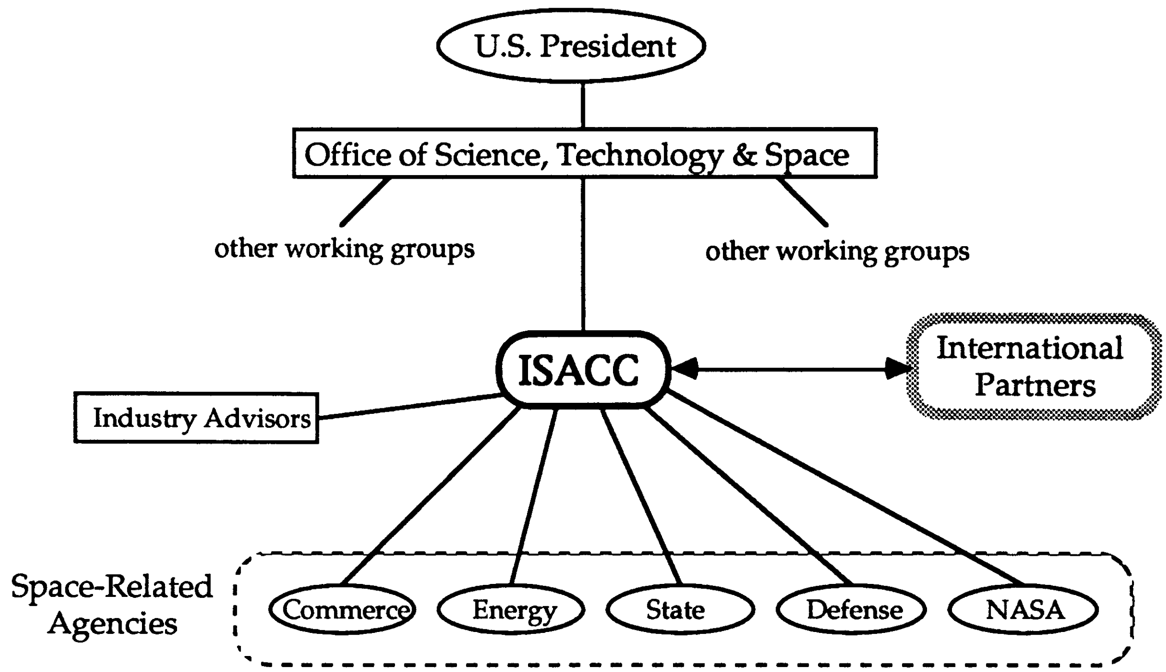
188 A. Lawler, "Single Council to Handle U.S. Space, Science and Technology", Space News, February 15-22, 1993, pp. 4 & 21.

Figure 5.1

**Function of the International Space Activities Coordination Council**




executives (e.g. the manager of international space affairs) from each space-related agency and not the chief executives who formed the former Space Council. The agencies' chief executives could still meet approximately on an annual basis in the President's Science, Technology and Space Council to debate the highest level policy issues but they would have the support of the ISACC for all international matters. The ISACC members would meet more regularly, possibly on a monthly basis, to coordinate international activities and to perform many of the tasks formerly done by working groups under the Space Council.

Although not agency administrators, the ISACC members must be of a high enough level to understand the manifold impacts of international cooperation. It is also important that they be open to the opinions of their colleagues from other agencies to avoid the barriers to constructive policy making that plaque the present interagency process. To obtain the necessary independence of thought, it is suggested that a team spirit be promoted on the ISACC so that its members have loyalties not only to their home agency but also to the coordinating council itself. This can be achieved by establishing relatively long, fixed-term appointments for council members and by allowing performance reviews from their ISACC work to be used in promotion decisions. However, the ISACC members must also maintain contacts and influence back at their home agencies to be effective. To assure that they do not become out of touch, council members should periodically consult with top administrators at their respective agencies and new members should regularly be rotated into the coordination council. The council's independence from narrow agency agendas could also be promoted by appointing its chairman from the staff of the Office of Science, Technology and Space. Taken together, these measures should instill in the council sufficient independence yet keep it well grounded in the individual agency needs, allowing it to make decisions in the overall best interests of the nation.

The ISACC would utilize input from all space-related government agencies in formulating America's international space policy. Of course the President and his staff at the Office of Science, Technology and Space would have final authority in approving U.S. policy, but their support of ISACC decisions would be presumed except in the most extenuating of circumstances. The ISACC would have the legal power to authorize or prohibit particular joint projects and the political clout to enact a long-term cooperative strategy. The council would need its own administrative budget, approved directly by the President's Science Advisor, and an operating staff of around a dozen people. To do its job effectively, it is important that the ISACC maintain close relationships with those on Capitol Hill who are responsible for funding international space projects. Once policy is established, the interagency review process would continue to be used among the organizations shown within the dashed box in Figure 5.1 to assure effective policy implementation. With the ISACC, policy could be established proactively before specific projects are suggested unlike the present reactive process whose agenda is fixed by the proposals in the system.

The ISACC should make much greater use of advice from businessmen in forming international space policy than has been done in the past. To make international space activities more supportive of commercial interests it is essential that the private sector get involved at the policy formulation as well as at the project implementation stage. Without the assistance of business concerns, policy will tend to promote purely governmental goals without due regard to the needs of commercial industry. A special industrial advisory board, composed of top executives from space-related companies, should be formed to provide a commercial perspective to the council. The widely recognized need to support U.S. industrial competitiveness and to transfer business expertise to Russia, makes the participation of businessmen in the policy making process even more important. Establishing formal channels to obtain private sector inputs to the ISACC is necessary if the present inefficient system of constant congressional lobbying by individual companies is to be improved upon. Finally, to assure that all joint space activities meet the needs of foreign partners and are consistent with established policy, the ISACC should act as the principal liaison to international organizations. It could provide a single interface to the U.S. space program for foreign partners allowing long-term relationships to be more easily established. Such central coordination of U.S. international activities is particularly useful for interfacing with multinational space coordinating bodies, such as the Inter-Agency Consultative Group (IACG)[189], who are becoming increasingly important in the management of international projects. Under the proposed system, individual agencies could still pursue direct contacts with foreign enterprises but any agreements that committed the U.S. government or entailed the transfer of funds would require ISACC approval and oversight.

The major benefit of the ISACC is its elevation of international space policy making out of the interagency process and into a White House level council. Such higher level consideration of issues allows longer-term national objectives to be pursued in a more consistent manner. It also allows the interagency process to focus on implementation issues, as it was intended, so that it can improve its own efficiency. But unlike the former Space Council, the ISACC would be an established institution that demanded a substantial commitment of time and loyalty from its members. By separating the policy creation from the implementation process, the ISACC will be able to proactively develop strategies for meeting the ever more stringent foreign policy and industrial competitiveness demands placed on international space ventures. With the change in administration, stimulating a restructuring of White House policy making bodies, and the opening up of Russian space assets to the West, there now exists an unprecedented opportunity to remake America's approach to international cooperation in space. NASA should seize this opportunity and promote the establishment of an organization such as ISACC to focus international joint

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189 The Inter-Agency Consultative Group (IACG) for Space Science was formed in 1981 by representatives from the U.S., Europe, Japan and the U.S.S.R. to coordinate activities to explore Comet Halley. Its widely acclaimed success led to its permanent establishment as a mechanism for managing international space science projects. For a complete description of the IACG and its role in international cooperation see J. Johnson-Freese, "From Halley's Comet to Solar Terrestrial Science: The Evolution of the Inter-Agency Consultative Group", Space Policy, August 1992, pp. 245-255.

ventures on national needs and thereby improve the image of the space program in general. To miss this opportunity would be detrimental to our nation as a whole and truly catastrophic for the long-term health of NASA and the U.S. space industry.

## 5.2 Restructure NASA's Cooperative Activities

Without clear direction from the national policy making apparatus, NASA has been slow to respond to the changes in the international space community. Yet whether or not real reform is attained at the executive level of government, it is essential that NASA restructure its own organization to better exploit cooperation opportunities in the future. The agency cannot blame all of its problems on a lack of executive level support, there exist many internal shortcomings in NASA's present approach and management structures for pursuing joint space activities. Developed during the 1960's and 1970's, NASA's cooperative strategy is based on assumptions about the international space community and the role of the space program in American society that no longer hold. NASA must recognize the advances in other nation's space capabilities and the broader interests in the U.S. that the space program now serves. Space cooperation has become an important foreign policy tool for managing the stable development of a market economy in Russia and for creating stronger technological and cultural bridges to other nations around the world. Effective cooperation has also become central to maintaining the competitiveness of U.S. companies in the ever more global marketplace for space products and services. These new goals cannot be effectively achieved using NASA's old strategy for cooperation that was developed in a completely different era to manage projects with completely different purposes.

NASA now has a broader mission not only to explore outer space and advance space science as efficiently as possible, but also to utilize space activities, particularly international activities, to further a broad range of foreign and industrial policy objectives. Along with continuing to conduct its traditional scientific and exploratory projects, NASA has begun more routine activities such as the operation of the Space Shuttle and the Earth Observing System (EOS). As space utilization continues to expand, operational space activities will become increasingly vital and NASA may well need to solicit assistance from industrial partners to effectively operate the burgeoning space-based infrastructure. In addition to supporting NASA work, private companies are striking out on their own to commercialize space in such areas as telecommunications and remote sensing. It is becoming widely accepted that NASA has a responsibility to help U.S. firms to be internationally competitiveness in these areas. The agency must re-evaluate its relationship with the domestic industry, no longer looking at private companies simply as "contractors" but instead as "partners" in the exploitation and utilization of outer space. Commercial interests are also an important ally because of the broad-based political support that they can bring to space activities during these uncertain budgetary times. Both to perform its broader mission and to exploit recent developments in the international space community (particularly in the former Soviet Union), it is essential that NASA restructure its approach to space cooperation to make greater use of domestic industrial partners. The following sections lists specific recommendations for improving NASA's agency level strategy for pursuing international cooperation. Although Russian cooperation is the focus of this study, several of the recommended changes would benefit NASA's cooperative projects with other foreign nations as well making their enactment even more obligatory.

### 5.2.1 Expand NASA's Cooperation with Russia

Although NASA has been slower than other U.S. agencies, companies and foreign organizations in making use of Russian space assets, it is now conducting substantial cooperation in the manned exploration and space science areas. These activities should continue to be supported and expanded with only limited modifications. In manned exploration, the present crew exchanges and docking projects are laudable first steps but provide only limited and near-term political benefits. These initial projects should lead to more broadly beneficial joint ventures in the future that fully utilize Russia's vast assets in human spaceflight. Russian spacecraft and technologies offer many opportunities to enhance U.S. manned systems and lower their operational costs, yet these assets have been only minimally exploited to date. Similarly, in space sciences, many data exchanges and coordinated projects are now being conducted but there are few truly joint activities that make full use of Russian capabilities. NASA's long-range goal should be to move beyond these early stages of cooperation to more advanced, and more broadly beneficial, cooperative approaches in both the manned exploration and scientific areas.

Outside of these two areas, NASA is conducting very few cooperative projects with Russia and this must change. No longer is NASA's mission defined as the conduct of space science and exploration for their own sake. Space activities must now support national goals such as advancing U.S. foreign policy or the competitiveness of the domestic industry if they are to obtain political backing. Unless the agency steps up to these new roles and modifies its international cooperative activities accordingly, it is in danger of losing its public support. As stated recently by U.S. Representative Alan Mollohan, "NASA is not connecting with the American people, and the agency is losing its relevance in Congress". NASA must begin to "serve broader national needs" such as supporting the technological competitiveness of the private sector or else it will become "a Cold War anachronism"[190]. Two commercial areas where NASA has provided little support to industry in accessing Russian capabilities are in satellite and launch services. The agency should expand its activities in these areas considering the use of Russian hardware for its own use (possibly in cooperation with a domestic partner) as well as assisting U.S. industry to utilize such hardware. U.S. industry should be broadly defined to include small entrepreneurial enterprises, who stand to benefit the most by using Russian systems, along with the large established aerospace firms. Special effort should be made to develop cooperative projects that introduce new capabilities into the U.S. that enhance industrial performance while not creating unfair competitive forces on individual private firms. Striking a reasonable balance is particularly important in the launch services sector where Russian competition could threaten domestic firms. NASA should also take a more aggressive role in transferring competitive space technologies from Russia into the U.S., both to support industrial competitiveness and to improve its own programs. Russia's impressive technological achievements in space make joint ventures involving technology transfer one of the most promising areas for cooperation which also are relatively low risk to implement. By expanding Russian cooperation in its traditional fields as well as into these new areas, NASA will be able to meet the broader objectives now demanded of space projects and thus assure greater support for its activities from the U.S. public and legislative leaders.

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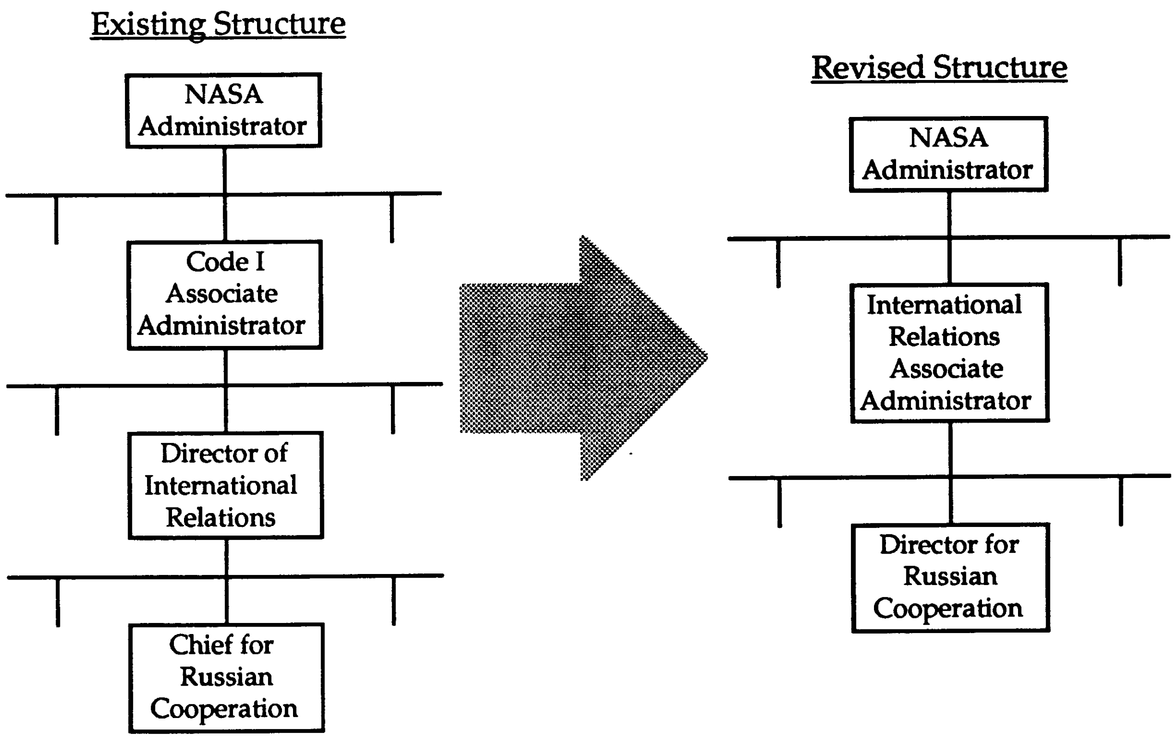
190 A. Lawler, "Image Change Needed for NASA to Gain Support", Space News, March 15-21, 1993, p. 5.

## 5.2.2 Elevate International Relations Function at NASA

Similar to the need to elevate the coordination of international space activities at the national level is NASA's need to elevate its International Relations division internally. International activities have become too numerous and too important to be effectively managed by the lower level officials that have been assigned this job in the past. Amazingly, NASA's top person responsible exclusively for Russian space activities is three levels removed from the Administrator! How can such a highly inter-related issue as Russian space cooperation, which impacts over a dozen other agencies and foreign partners, possibly be managed at such a low level? The answer is that it cannot. Since officially international relations have been relegated to such a low position in NASA's organizational structure, many informal channels of control for Russian cooperative policy have developed. Several Associate Administrators and Directors who formally have nothing to do with international activities often play a substantial role in setting policy. In addition, many important international policy making functions have been absorbed into program offices that are conducting joint activities or diffused to field centers who have close contacts with Russian organizations. NASA's informal and dispersed control of Russian space activities makes their coordination with other agencies very difficult. The lack of central control also tends to result in greater emphasis being placed on lower level needs instead of broader national objectives. To overcome these shortcomings and provide a focal point for interfacing with the ISACC, it is necessary to elevate international relations to its just place near the top of NASA's management hierarchy.

The recommended changes in NASA's organizational structure to elevate international affairs is shown in Figure 5.2. At present there is an Associate Administrator for such comparable functions as Public Affairs and Legislative Affairs while International Relations is consigned to a division director within the External Affairs office (Code I). Also included in Code I are Defense Affairs, a Policy Coordination division and several other miscellaneous management support functions. It is recommended that International Relations be elevated to its own office headed by an Associate Administrator with a Director under him responsible for Russian cooperation. This new Associate Administrator could act as the representative to the ISACC and would have direct contact with the NASA Administrator to assure that international affairs receive the necessary top level

Figure 5.2
**Recommended Elevation of International Relations at NASA**




management oversight. To make room for a new Associate Administrator, the Public Affairs and possibly the Legislative Affairs offices could be combined along with the remaining divisions of External Affairs into one office for Domestic Affairs. It is also recommended that the Commercial Programs office be expanded and given greater authority (possibly changing its name to the Industrial Relations office) so that it can better perform NASA's emerging role as a partner with industry in promoting U.S. commercial competitiveness. The International Relations office would need to work closely with the Industrial Relations office to assure that its joint ventures met the needs of U.S. industry. By making these organizational changes, NASA will be able to bring together in one office, at a sufficiently high level, control for all of its diverse Russian space activities. This new office, along with support from specialists in industrial relations, would then be able to conduct Russian cooperation in a coordinated manner that is more responsive to the needs of NASA and the U.S. industry.

### 5.2.3 Revise Guidelines for Conducting Cooperative Projects

NASA's guidelines for conducting joint space activities were developed many years ago when the U.S.-Russian relationship was quite different and the demands on international projects were less complicated. Due to bureaucratic inertia, the agency has been slow to change its cooperative approach to keep up with the times. To fully exploit the numerous opportunities to cooperate with the Russian space program in a manner consistent with U.S. national interests, it is essential that NASA's reluctance to change be overcome. Its policies for managing joint activities are presently too short-sighted and too focused on narrow agency interests to achieve the broad objectives that now drive space cooperation. To overcome these handicaps, five changes in NASA's guidelines for conducting cooperative activities are recommended.

Firstly, NASA should no longer insist on "no exchange of funds" in its international projects. Such a requirement unnecessarily constrains the agency and limits its ability to support competitiveness and foreign policy goals, particularly when dealing with the Russians. NASA's objectives to lower its overall costs and assist domestic industry are not best served by the simplistic rule to send no money overseas. Often space projects can be conducted for a lower net cost by purchasing foreign hardware and the introduction of international technology or components into the U.S. can help to improve the competitiveness of domestic products. NASA should work with domestic industry to develop a strategy for bringing into the United States the most widely applicable foreign space capabilities through purchase or exchange agreements. In the Russian case, infusing funds into the former Soviet space sector is a key requirement to meet the important foreign policy goal of stabilizing their industry. Yet a "no exchange of funds" rule restricts NASA from making any real contribution in this area. NASA should no longer limit itself to barter transactions in international activities but should instead take advantage of the enhanced flexibility and opportunities offered by financial exchanges.

A second related guideline that also should be amended is NASA's insistence on clean interfaces and limited technology transfer. The globalization of the space industry is making artificial national barriers to the movement of technology counterproductive. The U.S. should not attempt to outlaw technology transfer but should instead manage it to its own competitive advantage. Although some measures for protecting critical defense technologies must continue to be maintained, completely barring Russian technological interaction with the West is no longer necessary for security reasons. NASA should use its cooperative projects to access the substantial technological achievements of the Russian space program, not prohibit such interaction by rigidly requiring "clean interfaces". The developing global competition in space products and services will be driven by technological innovation and NASA must not cut itself off from international advances by insisting on no technology transfer in its joint projects. Obtaining access to foreign technologies is one of the best reasons for cooperating in space. For ease of management, simple international interfaces are beneficial but they should not be blindly pursued neglecting the technological incentives of more integrated cooperation.

A third NASA guideline requiring modification is the U.S. desire to control all elements on the critical path. Retaining control of all critical elements in a joint project is a costly and impractical approach for reducing risk. To fully realize the financial benefits of space cooperation it is necessary to allow foreign partners to produce and finance substantial contributions to joint projects. NASA must recognize that it is no longer able to afford the luxury of controlling all essential production so that it must find new ways to manage risks and to establish leadership in space activities. The increasing level of international cooperation and the growing capabilities of foreign partners makes U.S. critical path control an unrealistic objective for most space projects. NASA should instead accept the risks inherent in international cooperation and attempt to more effectively manage them by developing long-term relationships with its international partners built upon trust and respect.

The fourth change required is for NASA to take a longer-term perspective in its international activities. The agency's pursuit of cooperation on a strictly project-by-project basis neglects the synergy that a long-term relationship can provide and puts insufficient emphasis on higher level national objectives. Project managers have too narrow a perspective to see the implications of their actions on national interests and the pressure to justify their project on its own merits, isolated from concurrent benefits to related activities, cause non optimal approaches to be taken. To overcome these shortcomings, industry has long recognized the important role that strategic alliances can play in improving the net productivity of international ventures. It is widely believed that the "strategic alliances now common in the aviation and automobile industries" will soon begin to dominate the space industry as well[191]. The agency must acknowledge this trend and modify its cooperative guidelines to be consistent with the new business environment. NASA should learn from private industry's example and begin to utilize long-term strategic alliances instead of strictly short-term narrowly focused projects in conducting its own cooperative activities.

The fifth and final change that should be made to NASA's cooperative approach is to de-emphasize government-to-government contacts in cooperative activities. The expanding number of international projects along with the increasing power of private companies in the space industry make the demand for government leadership of all space cooperation unrealistic. Government interfaces are too bureaucratic and develop too slowly to meet the rapidly expanding needs of complex joint space ventures, particularly those involving Russian partners. "Many feel that industry will, and should, lead the way in bringing Russian technology into the U.S. space program"[192]. NASA must recognize the increasing importance of commercial players in the space community and its own limited ability to manage the more elaborate international relationships that are emerging. The agency should no longer insist on dealing exclusively with foreign governments but should instead form a partnership with U.S. industry to access foreign space capabilities together. The details of this recommendation will be discussed more fully in the next section. By making use of the efficiency and experience of private companies in implementing projects, NASA will be able to focus its efforts on assuring that its overall cooperative program is supportive of broadly defined national goals.

### 5.2.4 Create NASA-Industry Partnership to Exploit Opportunities

The most important step that NASA could take to enhance its cooperative activities with Russia, making them more efficient and more responsive to national needs, would be to enlist the participation of U.S. industry in implementing joint projects. The agency's reliance solely on its own internal capabilities for managing the rapidly growing field of international space

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191 J. Manbers, Vice President of NPO Energia USA, "Secret to 21st Century Success", editorial, Space News, March 15-22, 1993, p. 15.

192 M. Smith, Specialist in Science and Technology Policy, Congressional Research Service, "Buying Russian Technology - Pros and Cons for the U.S. Program", Space Policy, November, 1992, p. 365.

cooperation, particularly Russian cooperation, limits its potential for success. Utilizing industry as the principal interface to the Russian space community would provide several important advantages. Firstly, NASA would be able to continue to interact primarily with domestic firms with whom it has cultivated long-standing and productive relationships. This would allow the space agency to avoid developing many of the complex and costly interfaces that are necessary to do business directly with the Russians. The burden of developing contacts at the various relevant Russian organizations would rest with industry who, due to its experience in forming strategic alliances and its less bureaucratic structure, is more suited to such a task. Secondly, important foreign policy goals would be advanced by using companies as an interface. Direct contact between U.S. companies and Russian enterprises would provide the best means for teaching Russian managers Western business practices and how to compete in a free market. And through business-to-business contacts, the financial support that is necessary to stabilize the Russian industry could be more easily provided since companies, unlike NASA, are not politically adverse to funding foreign partners.

Thirdly, important industrial competitiveness goals would be supported by utilizing private commercial contacts. Since the final destination of most technology transferred to the U.S. is within industry, greater efficiency can be achieved by having companies directly access Russian technology instead of using NASA as a middleman. And stimulating companies to form Russian contacts to meet NASA's needs can foster relationships that can be beneficially exploited to improve the companies' competitiveness in other areas. Finally, and maybe most importantly, making use of U.S. companies to interface with Russian partners would increase the overall efficiency of joint activities. Commercial management techniques are simply more innovative, flexible and cost-effective than the more rigid approaches used in the government. Private companies are driven by the profit motive to adopt the lowest cost approach whenever possible. Unfortunately, in government agencies no comparable incentive exists. Joseph Pelton, the former Director of Strategic Planning at INTELSAT, has argued that privatized space activities are inherently more productive and easier to control than government run programs. In his view, this has resulted in a "historical evolution" whereby there is "a progressive shift in the organization of major space activities away from the original space agency model towards more commercial management principles"[193]. NASA should accept this trend and utilize the greater efficiency that private initiative offers to improve the implementation of its joint space activities with Russia.

To create an environment more conducive to an active role for private companies in conducting Russian cooperation, NASA must undertake three main tasks. Firstly, the agency must establish a clear and consistent policy on the types of Russian assets that it will consider using in its programs. Obviously this policy will have to be coordinated with the ISACC to assure that NASA's international activities supports national objectives. Without such unambiguous direction, private companies will be hesitant to initiate joint ventures with Russian partners because of the fear that all their efforts may be for naught if the space agency latter decides not to utilize Russian technology or products in a particular area. Secondly, NASA should use its central position in the space program and its experience in dealing with the Russians to assist industry in making contacts in the former Soviet Union. This catalyst role is particularly important to small U.S. firms who may lack the resources needed to overcome the initial barriers involved in forming a joint venture in Russia. Thirdly, the agency must work with the "trail blazing" firms who take the initiative and pursue Russian cooperation in completely new areas. This support may include purchase guarantees of initial production runs, indirect financial support or simply providing access to the government experience base. Whatever the teaming arrangement, NASA must demand that its industrial partner provide real added value to the joint project and not just add an unnecessary (and costly) layer of management. By taking these steps, NASA will help to create an environment in which U.S. companies, both small and large, are motivated to commercially exploit Russian space assets to benefit themselves, the space program and broader U.S. national interests.

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193 J. Pelton, "Organizing Large Space Activities, Why the Private Sector Model Usually Wins", Space Policy, August 1992, pp. 233-244.

## 5.3 Improve Effectiveness of Cooperative Projects

Due to a dearth of experience, the approaches presently being used to conduct joint projects with Russian enterprises tend to have many shortcomings. Simply shifting the burden for managing project level implementation away from the government to the private sector will help but will not solve all of these problems. The approaches used by both industry and government in structuring joint activities need to be fundamentally changed. The short-term and narrow objectives that are now being pursued must be replaced by more strategic approaches to Russian cooperation. Ignorance of Russian business practices and needs must be overcome if the benefits of joint U.S.-Russian ventures are ever to be fully realized. In the following paragraphs, several specific recommendations are presented for improving the effectiveness of cooperative projects with Russia. The recommendations were derived not only by considering U.S. requirements, but also by paying particular regard to Russian needs and capabilities. Too often the unusual predicament of Russian space enterprises is given little weight in structuring joint activities, resulting in projects that are only marginally beneficial to the Russians and consequently of limited long-term value.

First of all, the utilization of Russian technical resources to lower costs and improve the performance of U.S. domestic systems should be the top priority of any joint venture. The extensive investment made by the former Soviet Union to develop leading-edge space technologies and products should be exploited by U.S. partners for immediate application in their own systems. Joint ventures with other motivations such as obtaining access to the large Russian market for space-related goods and services may be pursued, but should not be emphasized. The unstable economic conditions and the limited financial resources of Russian organizations give such ventures limited appeal, especially in the short-term. Russian technological achievements offer opportunities for cooperation in a wide range of areas. The simplest and most easily implemented projects make use of Russia's vast Research & Development and testing facilities. Potential projects include U.S. sponsored studies at Russian institutes to analyze or redesign American space systems or to test American hardware. Low Russian labor rates, their extensive experience in the design of space systems and their possession of unique testing facilities make such joint projects highly desirable. U.S. partners could also make use of Russia's in-space assets to lower the cost of performing some of their space testing. For example, the Mir space station or one of the many Russian expendable microgravity capsules could be hired to perform U.S. experiments in space biology or materials processing. Purchasing these services from the Russians would be far less expensive than developing similar domestic capabilities. Another slightly more complicated type of cooperative project involves the direct transfer of Russian space technologies to the U.S.. This can be achieved by exchanging technicians to learn new techniques, by transferring written technical specifications or by importing pieces of Russian hardware that contain the technologies of interest. Russian technological leadership in liquid rocket engines, life support systems and space nuclear reactors, make these some of the more promising areas for pursuing technology cooperation.

Instead of transferring Russian technologies to U.S. products for domestic manufacturing, American partners could directly purchase advanced components in Russia. This would take advantage not only of superior Russian technologies but also the lower production costs that most Russian enterprises enjoy. Components of particular appeal for purchase by U.S. partners are electric thrusters, rendezvous and docking mechanisms and space batteries. The most extensive use of Russian technical assets is obtained by purchasing complete Russian systems. The former U.S.S.R.'s major investment in space infrastructure allows it to manufacture and operate launch systems and satellites much more cheaply than in the U.S.. Particularly in launch services, where the Russians possess unique capabilities, there are significant opportunities for U.S. partners to benefit by utilizing Russian systems. And Russia's extensive experience in building and operating space stations could certainly be put to immediate productive use in the United States. The recent initiation of yet another redesign effort on space station Freedom makes Russian space station capabilities especially interesting to NASA at this time. By utilizing Russian knowledge and hardware developed for the Mir, NASA could substantially reduce costs and improve the political support for the Freedom program. It is even possible that the Mir and Freedom programs, the centerpieces of the Russian and American space programs, could be combined creating the world's first truly international space station. This would definitely provide a jump-start to U.S.-Russian space cooperation. Scientists and engineers have no problem identifying literally hundreds of areas where Russian assets could be used to improve U.S. systems. American partners should pursue these technological opportunities and structure their joint projects to exploit them for their cost saving and performance enhancing benefits.

Secondly, U.S. partners must recognize that the most desirable resource that they have to offer Russian enterprises is hard currency. The desperate financial conditions in the former Soviet Union along with the incredible ruble-dollar exchange rate makes direct funding of Russian partners a necessary and relatively low cost approach. Other potential U.S. contributions to a joint project such as technology, business expertise and access to the U.S. market can be important, but the critical allure from the Russian perspective is foreign funding. The immediate need to pay personnel and buy materials to keep their enterprises solvent outweigh any longer-term benefits that U.S. technological or business contributions could make. In the near-term, U.S. partners should accept their role as principal financier for joint activities conducted both in the U.S. and in Russia. As the economic situation becomes more stable in the former Soviet Union, the requirement that most financing comes from the U.S. may be progressively relaxed. But for now, U.S. organizations should use their relative financial strength as the best means of exchange for obtaining access to the impressive technological capabilities of the former Soviet Union.

Thirdly, to fully realize the benefits that Russian technical assets offer, U.S. partners must bridge the gap between American and Russian business practices. Although the promise of financial support may be alluring to former Soviet enterprises, productive projects will not be possible until some of the more significant managerial barriers are overcome. These barriers exist both on the U.S. and Russian sides. On the Russian side, the failings in their approach to Western space cooperation are well documented. Jeffrey Manbers, the U.S. Representative for NPO Energia, has identified four factors that are responsible for this situation: "the greed factor -- an attempt by every side to make a lot of profit for nothing; the Hollywood factor -- the false idea that all Westerners are incredibly wealthy; the conspiracy theory factor -- a belief that all negotiators have more authority than they really have; and the status quo factor -- the conservative mindset that makes commercial space projects difficult to implement with the Soviets"[194]. To this list the eminent Russian scientist Mikhail Marov adds "the illiteracy factor -- the rather primitive ideas of people in the East on how to conduct business with the West"[195]. To overcome these weaknesses and misunderstandings in the Russian space industry, U.S. partners must act as a

194 J. Manbers, "Negotiating With the New Russia", Space News, January 13-26, 1992, p. 1.

195 M. Marov, "The New Challenge for Space in Russia", Space Policy, August 1992, p. 276.

kind of "business teacher" to their new Russian partners. Contrary to what was taught for decades in the former Soviet Union, capitalism is not built upon pure, unadulterated greed. Western companies do pursue their own interests, but not without due regard for the long-term implications of their actions. Unfortunately, many Russian managers believe that the more greedy and short-term they act, the more they are true capitalist. It is essential that during the initial phases of a joint venture, U.S. partners instruct their Russian counterparts on Western business practices and their potential application in former Soviet industry. Russian enterprises need particular assistance in understanding the role of marketing, strategic planning and the use of management control systems. U.S. aid may need to go beyond simple instructional efforts to include assisting the Russians in actually performing some of their marketing functions or in installing more effective management control systems. Although performing these functions places additional demands on U.S. partners, their acceptance of this more complex role will greatly increase the overall potential for success.

On the U.S. side, companies must learn to understand the idiosyncrasies of the Russian space industry so that they can interact with its enterprises more effectively. In particular, the complete dominance of the Russian industry by technocrats, with their disinterest in purely business functions such as marketing and finance, must be recognized. The Russians will put all their effort into designing a technically elegant solution that may completely disregard the needs of many potential users. In a joint venture, the U.S. partner should demand control of the business functions that have historically been neglected by the Russians (e.g., strategic planning and customer relations) to assure that needs in these areas are adequately addressed. U.S. companies must also learn to adapt to the more personal nature of business relationships in the former Soviet Union. It is often obligatory to first develop a personal rapport with the managers of an enterprise before any substantial joint activities can commence. It is particularly important to obtain the trust and respect of an organization's Chief Designer due to this individual's direct personal authority over all business and technical matters. U.S. managers should be careful not to insult their Russian colleagues by insisting on too much strict formality in business dealings. The Russians are far more comfortable with a relationship built upon trust and mutual respect than one built upon binding contracts and legal commitments. Russian business practices may seem very naive to U.S. managers but they should not be summarily written off. Although inappropriate practices such as neglecting the marketing and cost accounting functions must be made to conform more with Western norms, their more culturally based differences, such as their personal approach to business, need not necessarily be changed. U.S. companies should learn to accept these differences and work with the Russians to make the diversity between our two nations a strength and not a weakness. Finally, U.S. partners must realize that most Russian space enterprises still receive a significant portion of their income from military production. Consequently, complete openness to U.S. partners is impossible and some degree of secrecy should be expected. As better relations develop the need for secrecy will decrease, but for now the lack of complete disclosure should be accepted as simply part of doing business with the Russian space industry.

The fourth and final recommendation for improving project level effectiveness is for U.S. organizations to utilize risk management techniques when conducting joint ventures in Russia. There is no denying it, the risks involved in pursuing joint activities with a Russian partner are formidable. The political and economic situation in all former Soviet states is highly uncertain. There is no established legal framework by which to structure or enforce contractual agreements with U.S. partners. And evaporation of public support, and consequently funding, for many Russian space projects has led to critical financial situations in some space enterprises and the overall deterioration of the space industry. The difficulties created by all of these uncertainties are compounded by poor communications and the general lack of cultural understanding between the U.S. and Russia. However, having just enumerated all the potential pitfalls, it must also be stated that none of the above difficulties are as bad as some would have us believe. Although it is true that Russia is going through a traumatic economic upheaval that has wrecked havoc throughout the space industry, through all of this turmoil the Mir station has been continuously manned and the cosmodromes have continued to launch over 50 space missions a year. For all our political stability, the U.S. cannot match these achievements. Russian society is run by an enormous bureaucracy and although cosmetic changes may occur rapidly, there is great inertia to maintain ongoing projects at their present levels. Unlike the U.S. who is constantly threatening to pull the plug on its international partners in the Space Station Freedom program, Russia puts top priority on its international projects. International space activities would be the last in line to be effected by any domestic difficulties. This is particularly true for international projects that bring in foreign currency since due to the weak ruble, even small foreign payments can maintain large segments of the Russian program for years. Consequently, although the former Soviet Union is a very uncertain place, the top priority that the Russians place on international space projects, the importance of attracting hard currency and the slowness of change in such a large bureaucracy drastically reduce the potential for Russian default in a major joint space project. Although the risks are not as high as some may suggest, they remain substantial and thus a risk management strategy is important for any joint venture. Therefore, U.S. partners should make full use of contingency planning, multiple sourcing, fall-back positions and other risk mitigation approaches in forming Russian joint ventures. By recognizing the risks and managing them in a proactive manner, U.S. firms can effectively control them and reap the benefits of Russian cooperation with minimal uncertainty.

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