TECHNOLOGY TRANSFER, EXPORT CONTROL, AND ECONOMIC RESTRUCTURING IN THE SOVIET UNION

THE CASE OF SOVIET COMPUTERS

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SUMMARY

Technology transfer is a topic that has received wide attention in recent years, especially with regard to Soviet attempts to obtain technologies from the West that are considered to be sensitive in terms of western security. The effects such transfers have, however, are not always those that would be expected and in many cases have not resulted in the ends that the Soviets hoped to achieve. This paper seeks to examine the true nature and effect of technology transfers between the West and the Soviet Union in the area of computers, especially duing the period from 1985 to the present. It is argued that while such transfers have not been effective in the past, changes in the Soviet Union's approach to the acquisition and integration of foreign technology, under the program of economic reform now taking place, will increase the effectiveness of these efforts in the future. Based on the results of this case study, it is concluded that the current western approach to export control needs to be re-evaluated in light of these new circumstances, if the policy of restricting such transfers is to remain viable.

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Daniel L. Burghart

A NOTE TO THE READER

Doing a study of this type has been an enlightening experience, not only in terms of the subject matter, but that being a native American working at a British University several differences of interpretation have been noted in what would normally be considered the common usage of various terms. To assist the reader, a few of these are outlined below.

The term 'West' or 'western' is considered to include Japan, both because of its level of development and the fact that it is a member of CoCom, the export control regime that is designed to monitor the transfer of western technology to the Soviet Union.

The term 'Soviets' is used as an adjectival noun referring to the Soviet people, similar to the use of the term 'Americans', as opposed to its more restrictive meaning as an elected council.

The term 'data', while denoting a plural state, is treated grammatically as a singular, an 'Americanism' grudgingly forgiven by The Oxford Dictionary of Current English.

Spellings used throughout reflect the American, as opposed to the British, tradition.

I would like to thank both the patience of those who have helped in reviewing the text as well as the reader for allowing me these idiosyncrasies, brought about, in the words of George Bernard Shaw, "by two peoples divided by a common language."

dlb

" (The Capitalists) will supply us with the materials and the technology which ... we need for our future victorious attacks upon our suppliers." [1]

V. I. Lenin

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Introduction

The issue of technology transfer has come to the forefront of debate in the last several years, in government circles, the press and the general public. The United States and its allies traditionally have relied on technological superiority to offset the quantitative military superiority of the Soviet Union during the years of the cold war. To maintain this technological advantage, the governments of the West imposed a regime of export controls to prohibit the transfer of high technology items; failure to maintain this superiority, it was felt, represented a severe threat to the security of the West. With the end of the cold war and the changes that have occurred in the East, however, many in both political and economic circles in the West are now calling for a lessening of these controls and increased trade with the Soviet Union, not only as a means of lessening tensions between East and West, but in response to the demands of the market system that is the basis of the West's economic strength. [2] This presents a dilemma for decision makers whose job it is to determine policy in this area, for while the world has applauded the events that have taken place in the USSR and Eastern Europe to date, there are no guarantees that these changes are permanent, or that events may not take yet another unexpected turn. What would happen in the case of such a turn of events? What happens should the West once again be required to maintain a technological edge to insure its security? And what happens when the current export controls no longer prove to be effective?

Within the broad realm of items that are covered in the general category of advanced technology and affected by export controls, computers form a significant and fascinating subset. Perhaps no other technology better represents the technological revolution that the world has undergone than the microprocessor. There are few areas of modern society that are not affected in some way by computers; the significance of computers in defense issues alone needs hardly be amplified. In the past, the importance of computers led the Soviet Union to engage in a major effort at obtaining western technology in this area, an effort that directly challenged western efforts to limit the transfer of technology, but whose success to date appears to be limited at best. Now, however, in light of the current attempts at economic restructuring ongoing in the Soviet Union and the policies that accompany these attempts, this situation may be changing. Using computers as a case study, it should be possible to evaluate whether current western export controls are still effective in restricting the transfer of technology in this vital area, or whether the new Soviet initiatives require the West to reexamine its export control policies.

The purpose of this study, is to help clarify the debate on technology transfer by examining the significance of western technology to the Soviet Union in the area of computers. Throughout, technology will be treated simply as "knowledge relevant to industrial capability," [3] and technological skill defined as "the mastery of the applications of advances in science to manufacturing techniques." [4] Technology transfer, for the purposes of this study, is the transfer of technology from one group or country to another, such that it increases the technological skill of those receiving the technology. Further, technology transfer can be considered as being comprised of two key elements or components. The first is the transfer of the ability to use a new technology or skill; the second is the ability to duplicate or improve on the transferred technology, so that eventually an independent capability in this area is achieved. To be considered a successful transfer of technology, both of these conditions must be satisfied.

The goal of this paper is to outline the ways in which western technology is transferred to and incorporated in the Soviet economic system. Using the Soviet computer industry as one example of this phenomenon, the case study will examine the effectiveness of western efforts to limit the flow of computer related technology from West to East. The results of this examination, in turn, will be used to determine the general effectiveness of western efforts to limit such transfers of technology, and whether current export control policies need to be revised. The key questions here, are whether the Soviet Union can effectively use the material it obtains to close the existing technological gap between East and West, and whether this represents a threat to western security. If the answers to these questions are yes, then as former U.S. Commerce Secretary Lawrence Brady has said, modifying a statement attributed to Lenin, "We may be selling (the Russians) the rope with which we will eventually be hung." [5] If not, then there is no need to modify the current procedures, and in fact there may be little reason to continue any policies on controlling technology transfers, especially if such policies are detrimental to the West's economic interests, while having little of the intended effect upon others.

The Gorbachev Initiatives

It would be something more than an understatement to say that major changes have taken place in the Soviet Union under Mikhail Gorbachev and his efforts at economic restructuring. Before Gorbachev, Soviet attempts at increasing their industrial capabilities through inputs of western technologies, both in the computer field and in general, had met limited success. [6] One of the reasons for this was that Soviet efforts at gaining technology tended to focus on the acquisition of hardware, which then had to be reverse engineered before it could be reproduced or otherwise integrated into the Soviet system. Not only was this process slow, but such transfers by their very nature are inefficient. [7] Transfers of hardware are also among the easiest to monitor in terms of export controls, thus western efforts have been deemed reasonably effective in limiting those transfers of materials that were felt to be of special concern. Even when hardware was transferred and exploited, problems with Soviet technological skills relating to manufacturing, as well as information dissemination, limited the impact of such transfers. Thus, the overall loss of technology appeared minimal at best, and represented little threat to continued western dominance in this area.

All this is changing under Gorbachev. One of the first goals that he set for the Soviet Union was raising the country's technological level, especially in the area of computers. [8] Part of this campaign included a change in attitude toward relations with the West, along with new emphasis on policies that openly encouraged seeking out western assistance in computers and other areas. Joint production ventures were proposed, where both production capability and manufacturing know-how could be gained. [9] Freer access to western personnel and materials relating to various technologies are being sought; where five years earlier Soviet scientists had been denied access to their western colleagues, now they are encouraged to establish and exploit such relationships, as well as the information that can be obtained through such contacts. Domestically, liberalization of the restrictions on internal dissemination of information has increased the value of such information for raising the overall level of Soviet development. Simply stated, the Gorbachev initiatives have brought with them a whole new series of means for obtaining and exploiting western technology, means that until recently were either discounted or completely ignored by the West in terms of export control.

Soviet attempts at obtaining western technology, in order to make up for the deficiencies of the Soviet economy, are nothing new. What is new, or at least refreshingly different, is the willingness of the Soviet leadership to admit that it seeks western aid in this task, and to actively pursue better relations with the West in order to obtain that which it needs. In this regard, the remarks of the Kremlin's chief ideologist Vadim Medvedev on 5 October 1988, stating that there was nothing wrong in borrowing from the West, were revolutionary in that for the first time the Soviets admitted both their need of help from the West and their willingness to alter many of their previously held policies and beliefs in order to gain that assistance. [10]

While many in the West remain wary of this new Soviet attempt at friendship, there are more then enough people and countries that are ready and willing to let bygones be bygones and to give the Soviets whatever they desire, as long as a profit is involved. [11]

The Significance for Export Controls

The programs set out by General Secretary Gorbachev under his call for 'perestroika' have been many and varied, however one of the recurring themes has been the need to borrow and obtain technological information from the West. [12] This in itself is not unique, as the Soviets have long sought western technology as a means of making up for their own deficiencies in this area. What is unique, and bears closer examination, are the ways in which the Soviets are attempting to secure this information. In the past, the Soviet Union focused its efforts on gaining information through obtaining the products that embodied this information; thus western nations attempted to limit the transfers of such technology by limiting the export of these products. Now, however, Soviet interests have broadened to include areas not traditionally addressed by the current export control regimes. Instead of merely the products of technology, the Soviet Union is attempting to obtain design and manufacturing know-how through Joint Ventures, electronic data links, and increasing personal contacts between East and West. [13] This represents a major shift in Soviet acquisition policy, from targeting the end results of technology to obtaining the information and skills necessary to achieve these results.

What is disturbing about this shift, from the point of view of protecting vital technologies, is that while the effectiveness of obtaining technological information from the transferring of products is relatively low, the effectiveness of transfers through these new means is very high. In the seminal work in this area, An Analysis of Export Control, done for the U. S. Department of Defense and commonly referred to as the Bucy report, Joint Ventures and technical exchanges are cited as being two of the most effective ways of transferring semiconductor technology. As part of the program of restructuring, these types of contacts have been emphasized and aggressively sought after. Thus, while the new 'openness' on the part of the Soviet Union has been welcomed by many in the West, there is also reason to be concerned that this change in approach and nature of the transfers between East and West may represent a threat, in the long term, to the West's security interests. [14] If there is indeed a threat, can the present regime be changed to meet this threat? If not, the United States and its allies may eventually end up giving the Soviet Union more, in terms of critical technologies, than the Soviets have ever been able to obtain in the past, through overt or other means.

Is There A Need For Change?

At the same time that the Gorbachev initiatives are challenging the current system of export controls, that system itself appears to be on the verge of collapse under its own bureaucratic weight. If there is any consensus among writers on the topic of export controls, it is that the current system is in need of change. The question that nobody seems able to answer is how to go about making this change? Some argue that there is no longer a need for controls, based on the decline in the nature of the threat posed by the Soviet Union to the West. [15] Others argue that part of the reason for the decline of the Soviet threat is the inability of the Soviet Union to match the West technologically, and that export controls should be maintained, if not strengthened. [16] And even if agreement could be reached on the nature and extent of the changes to be made, further questions arise on how to go about implementing these measures?

As if all this was not confusing enough, there is also a body of thought that views the current situation unfolding in the Soviet Union as being the result of the deficiencies that are inherent in the Soviet system, which after seventy years of mismanagement are bringing that system to its knees. [17] For these observers, the inability of a centrally planned economic system to deal with the complexities involved with running a modern society, combined with the burdens imposed by the weight of commitment to the Soviet military industrial complex, is exemplified in the inability of the Soviet Union to effectively use that technology which it does obtain from the West. In this light, the very premise of the need for changes to the export control regime comes into question, in that even with all the problems with the current system of export controls, and in spite of Soviet attempts to obtain western technology, the Soviet Union seems little better off as a result of the technology transfers that have already taken place, and in some respects may even be the worse for their efforts. On the evidence that to the end of 1990 there is little indication that the technology already transferred to and incorporated within the USSR is playing any part in preventing the apparent collapse of the system, the question arises of whether there is even a need to worry about transferring technology to a system tottering on the brink of destruction.

The answer to these questions, and at the same time the major justification for this study, is that changing times and situations require reevaluations of old policies to insure that they fit new circumstances. If export controls in the past were less than ideal, they appeared none the less at least partially effective and necessary, and therefore were supported by a majority of the western nations that were in a position to transfer advanced technology to the East, including neutral nations who, while officially non-aligned, complied with western guidelines to ensure their own continued access to advanced western technology. [18] Now, however, with the lure of economic gains and the prospects for reduced tensions between the blocs, many, especially in Western Europe, are calling for the loosening of restrictions that would allow businesses in the West to take full advantage of the opportunities being offered. [19] Arguments from each side in this debate can be heard with increasing frequency, and as with most arguments, the truth lies somewhere between the various extremes. The challenge is to determine exactly where.

The Western Challenge

Very few in the West would argue that restrictions on technology transfers should be totally abandoned overnight, on the mere promise of a safer world, brought about by changes in Soviet attitudes and outlook. The problem then, is trying to decide where exactly to draw the line. If there is one thing that history has taught in this regard, it is that attempts at reform, like the one that is taking place in the Soviet Union, can be short lived and require only a change in leadership to bring the process to a halt. [20] For this reason, many politicians in the West have adopted a wait and see attitude, wishing the Soviets well, but not rushing forward with open arms to embrace an effort that, as of yet, has no clear indication of where it may lead. Other leaders, emphasizing the economic advantages to be gained and responding to the call of businesses anxious to expand their dealings with the East, are putting pressure on their governments to allow such transfers under the most advantageous circumstances, i.e. without excessive control and interference from administrative measures imposed for political reasons. [21] Any approach to export controls has to try to meet the desires of both of these sides, those who fear the results of giving technology to countries that may in the future turn that technology against them, and those who would trade with all under the idea that such trade not only strengthens the West economically, but increases the chances of cooperation and understanding between nations, and thus contributes to political stability.

The West's challenge then, is to determine what goals it hopes to achieve through export controls, and how it intends to achieve those goals. It should also be apparent that the results of this examination have applicability far beyond the current case of the Soviet Union. As has been highlighted in the current situation in the Middle East and other parts of the world, where advanced technologies that have been transferred to other countries have come back to endanger the source of these technologies, the issues of when and where to transfer and conversely when and how to limit the transfer of advanced technology are both complex and not easily resolved. Still the difficulty of the problem should not deter attempts at finding a solution. Even if the question of technology transfer to the Soviet Union should no longer be an issue, for whatever reasons, the principles established here can serve as a basis for examining other situations where the issue of transferring technology between nations is involved. Nor should these results be looked at in purely restrictive terms. By identifying cases where technology has been effectively transferred to the benefit of both the receiving country and the provider, precedents for further such cooperation, where development is the goal, can be established.

Methodology and Reason for the Study

The method of this study is to examine the process of technology transfer as it relates to the Soviet computer industry during the years 1985 to 1990. The value of the new initiatives made under Gorbachev, in terms of the technology they provide, can be viewed as a function of three variables: the type of transfer and its effectiveness, the volume of such transfers and the aggregate value of what is obtained, i.e. the way in which separate initiatives combine to provide an overall increased potential. By examining each of these variables in the case of computers, it should be possible to determine if the Soviet Union, as a result of these new initiatives, stands to benefit substantially in this area. If this proves to be the case, then the next step is to determine the most effective way of influencing these variables through export controls, so as to limit their impact and maintain the West's technological edge.

The broader significance of this research and the reason for the study is the need for an evaluation of the effectiveness of existing export controls in light of the new initiatives involved in the Soviet attempts at economic restructuring. The benefits to be gained by such an examination are many. It is a new and timely topic where little research has been done, simply because the Gorbachev reforms have only recently brought about the phenomena described above. While there have been studies of technology transfer and its effect on the Soviet Union in the past, [22] this current undertaking can be justified in two ways. First, the rise of Mikhail Gorbachev and his policies designed to bring about restructuring of the Soviet economy pose new challenges to western decision makers, some of whom found difficulties in resolving the problems posed by technology transfers even before the changes that have come about under perestroika. Second, in spite of western efforts to limit the transfer of technology, there is evidence to suggest that these efforts have not been as effective as the governments that instituted them would like to believe, and that it is primarily inefficiencies arising from faults inherent in the Soviet system, and not western efforts, that have limited the loss of technology. Now, however, the Soviets are embarking on a program that may dramatically increase their ability to adapt and integrate this technology, and thus increase the effectiveness of its transfer. If this attempt proves successful, and the West wishes to maintain its technological advantage, then it must recognize the significance of these changes in Soviet policies and procedures, and adapt its own policies accordingly. Under these circumstances, a new look at an old problem cannot hurt, and may in fact be of some benefit.

Endnotes

1 Ted Agres, "The Dark Side of Technology Export: U.S. Builds Soviet War Machine," Industrial Research and Development, July 1980, p. 57.

2 Tom Kenworthy, "U.S. High-Tech Exports to East Bloc Urged," Washington Post, 18 December 1989, p. 11.

3 J. Fred Bucy, "Technology Transfer and East-West Trade: A Reappraisal," International Security, Winter 1980/81, (vol. 5, no. 3), p. 134.

4 Sylvain Wickham, "Transfer of Western Technology to the USSR: Conditions for the 1980's," NATO Review, December 1981, p. 19.

5 Harry Anderson, "Keeping High-Tech Secrets," Newsweek, 25 January 1982, p. 34.

6 S. E. Goodman, Philip Hanson, et al., "Technology Transfer and the Development of the Soviet Computer Industry"; "Soviet Assimilation of Western Technology"; and others found in, Trade, Technology, and Soviet American Relations, ed. Bruce Parrott,. (Bloomington: Indiana University Press, 1985) pp. 117-140 (Goodman); pp. 63-82 (Hanson). S. E. Goodman, University of Arizona, is one of the West's leading experts on the Soviet computing industry, and has written extensively on the subject. Philip Hanson, University of Birmingham, has written widely on the issue of technology transfer between East and West, and is author of Trade and Technology in Soviet-Western Relations, (London: The MacMillan Press, 1981). Both of these scholars, along with the other contributers to the Parrott volume, paint a less than optimistic picture of the Soviet Union's ability to make use of foreign technology.

7 J. Fred Bucy, Chairman of the Defense Science Board Task Force on Export of U.S. Technology, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," Office of the Director of Defense Research and Engineering, 4 February 1976, p. 6. Finding II of this report lists the effectiveness of several types of technology transfers according to industry and transfer mechanism.

8 David A.,Wellman, A Chip in the Bloc--Computer technology in the Soviet Union, (Washington D.C.: National Defense University Press, 1989), p. 11. Wellman gives a concise summary of the Soviet programs initiated under perestroika dealing with computers. Specific Soviet measures, along with their implications, will be dealt with in the course of this study.

9 David Dyker, "Gorbachev's Economic Revolution--The realities of perestroika," conflict studies 218, The Center for Security and Conflict Studies--Institute for the Study of Conflict, 1989, p. 8. A good summary of Soviet proposals with regard to Joint Ventures.

10 Vadim Medvedev, as cited in Bill Keller's, "Key Kremlin Aide, Seeing Crisis, Asks a Freer Economy," New York Times, 6 October 1988, p. A1.

11 Peter Galuszka and Rose Brady, "The Chill is Gone, and U.S. Companies are Moscow-Bound," Business Week, 5 June 1989, p. 64. This is just one example of the literally hundreds of articles that have appeared in the popular press over the past several years, discussing the new opportunities for business brought about by the change in East-West relations.

12 Ivan D. Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," Soviet Economy, September 1987, (vol. 3), pp. 192-218. An interesting article because it was written by the Deputy Chairman of the State Commission on Foreign Economic Relations, USSR Council of Ministers, and thus carries with it the weight of official sanction in the views it presents, Ivanov emphasizes both the need to cooperate with the West, and the mechanisms by which this cooperation can be brought about.

13 Mikhail Ryzhkov, "Joint Ventures as a Channel for Transferring Technology," USSR Journal of Foreign Trade, no. 5/1989, pp. 12-13. Summary of a seminar held in Moscow in November 1988, organized by the UNCTAD Secretariat with the USSR Chamber of Commerce and Industry and the USSR Ministry of Foreign Economic Relations.

14 Author's conversations with personnel in the Defense Technology and Science Assessment Agency, the U.S. government agency charged with monitoring technology transfers that might

have security implications for the West. Conducted in Washington, D.C. on 27 July 1990.

15 Matthew May, "Europe angry over Eastern bloc ban," (London) Times, 26 October 1989, p. 35.

16 David Hughes, "Soviet Attempts to Buy U.S. Computers Continue Despite Customs Crackdown," Aviation Week & Space Technology, 12 June 1989, pp. 279-280.

17 Interview with Mr. Kenneth Tasky, Technology Transfer Assessment Center, Washington D.C., conducted on 26 July 1990. His comments indicate that a growing number of observers are becoming convinced that the Soviet Union has proved so inept at using western technology, and are so far behind in certain areas, including computers, that it is hard to imagine circumstances in which the Soviets could reverse their current decline.

18 Holman Jenkins, "High Tech in State of Siege," Insight, 26 December 1988, p. 16.

19 Paul Magnusson, Peter Coy, Rosemarie Boyle, and Zachary Schiller, "High-Tech Exports: Is the Dam Breaking?," Business Week, 4 June 1990, pp. 128-130.

20 Probably the prominent example of this phenomenon is the fate of Khrushchev's economic reforms, which were rapidly abandoned by those that overthrew him in 1964. The same argument can be made about Kosygin's reforms, which floundered as their proponent fell victim to ill health.

21 Bill Gertz, "High-tech export ban may be relaxed at summit," Washington Times, 19 December 1989, pg. 3.

22 Anthony Sutton, Western Technology and Soviet Economic Development, (Stanford: Hoover Institutional Press, 1973), 3 vols. If not the definitive work in this area, then certainly the most ambitious. In over 2,000 pages, Sutton attempts to document every case where western technology and goods have had an effect on Soviet development. Other works in the field have dealt with either specific branches of Soviet industry or various aspects of technology transfer between East and West.

CHAPTER 1--THE NATURE OF TECHNOLOGY TRANSFER

Introduction

How does one document the transfer of an idea? Since mankind's earliest times, the sharing of information has been the engine which has driven the advancement of civilization. Societies that were able to learn from others and adapt to changing situations, as a rule, flourished. Those, on the other hand, that shunned contact with other cultures, that rejected new ideas in favor of established ways and refused to adapt to changes in the world around them, have usually suffered a less than enviable fate. Yet for all the importance that the transfer of technology would seem to entail, relatively little attention has been paid to the actual mechanisms which are involved in such transfers, the ways that information is transmitted and, more importantly, accepted and integrated by the receiving group. [1] That such transfers take place is well documented; how these transfers occur is far less clear.

The passing of time has not decreased the importance of such transfers to the progress of society, and if anything such transfers have become even more important today. In the world political economy that has taken shape in the last half century, integration and the sharing of ideas has been the cornerstone on which any country that wants to guarantee its economic survival and well being has, out of necessity, been forced to build upon. [2] Isolationism, as a political policy, still has its adherents in today's world, and even economic isolationism on occasion has been used as a rallying point and a means of creating or strengthening national pride. [3] No rational politician, however, would dream of isolating his country from the flow of technical information that characterizes the world today. To do so would not only be against the better interests of any nation, it would at best condemn that nation to a position of inferiority in relation to the other countries in the world community, and at worst might even threaten the security, if not the very existence, of such a nation.

With the significance of the transfer of technology all too apparent, as well as the implications of what may happen when such transfers are not encouraged or for other reasons do not take place, one would expect that the ways that technology is transferred would be fairly well defined. Such, however, is not the case. [4] In certain instances, the transfer of technology is obvious and easy to follow. The spreading of a new theory of design, the importation of a new product into a region, or the building of a factory to produce these new products locally can all be fairly well followed and documented. But how does one quantify the knowledge that accompanies a product or the skills that go into its manufacture? Understanding what is involved in these events is essential because of the effects they can have on the surrounding environment, on society and ultimately on the course of human development. The advent of gunpowder and the weapons that came with it can, in large measure, be tied to the fall of feudalism. [5] By giving a common soldier with little other training the means of defeating a knight whose training might take years, the nature of warfare was drastically changed. By eliminating the supremacy of armored warriors on the battlefield, their significance as protector and defender of an area was greatly reduced, with profound consequences for the prevailing social order. By replacing the artistry of the armorer with the technical skills involved in manufacturing firearms, another step up the industrial evolutionary ladder was also taken, with these new skills eventually spreading to other fields of endeavor.

In some respects, the passage of time has had little effect on the basic mechanisms of this process. [6] While the technologies involved have changed over the centuries, the mechanisms for transferring these technologies have remained remarkably the same. Craftsmen passed their art from master to apprentice; as new skills evolved, these new techniques were passed from one generation to the next, with journeymen sometimes traveling great distances to study with the masters in a given field, then returning to their homes where they, in turn, became the local masters and centers of learning in their respective areas. Trade guilds became key organizations for the practicing and passing on of skills within a field. As education became formalized and institutions of higher learning spread throughout Europe, universities became centers of study, standardizing and passing on the basics in the fields of mathematics, engineering and the physical sciences. The advent of the Industrial Revolution brought with it not only new technologies and manufacturing skills, but the need for those involved in industry to stay abreast with and adopt these skills if they were to continue to remain competitive. Still, the ways in which these new technologies were spread continued much as they always had before, with those possessing advanced technologies passing them on to the lesser developed, much as the master passed on his knowledge to the apprentice.

If there is a change that has come about as a result of the passage of time, it is that while the mechanisms of transfer have remained the same, the conditions surrounding and shaping these transfers have been altered significantly. As the pace of technological change has quickened, not only is there the need for countries to adopt the latest technologies in order to compete in newly created world markets, but they must do so rapidly to keep up with the ever increasing pace of technological development. Improvements in communications and transportation facilitate the movement of both the products of these new technologies and the technologies themselves, on a scale previously unknown and unthinkable. Skills in manufacturing that were once the realm of the artisan, have become the domain of the industrial manager, while a secondary trade has begun in the transfer of the means of production; entire plants and manufacturing facilities are bought and sold, with entire populations finding themselves both exposed to and expected to master the new methods. Complexity, in terms of the technologies involved, has also increased, compounding the problems of assimilation and integration for those seeking to keep up with the rest of the world. Those that master these difficulties, prosper; those that fail, or are slow in assimilating these new skills, find themselves falling behind in the race to keep up with the flurry of new products, technologies and skills making their appearance.

This situation, at least in part, is the result of the increases that have taken place in the past several years, both in the amount and the complexity of information being dealt with, and the speed at which this information is transferred. Whereas in times past information might take months or years to travel from one source to another, and decades or even centuries before any benefit could be derived from the transfer of ideas, modern means of communication have resulted in such transfers taking place in a matter of seconds, while the effect of these transfers can be seen in a matter of days. Not only has the speed at which information is transferred increased exponentially, but the rate at which new information is created has also dramatically grown. Both are characteristic of the world in which modern man finds himself, and both play a key part in shaping that world and man's relationships within it. [7]

The phenomenon of technological complexity is another way of characterizing the differences that exist between the current situation and previous ones. Everyone recognizes that the world today is a far more complicated place than it was fifty years before. If one were to map the changes in the world in the last fifty years, in terms of innovations, new materials, new techniques and a whole range of other areas that affect the way that mankind works and lives, one would probably find that the significant changes in this period would outweigh all those that had occurred during the previous five hundred years. [8] Surprisingly though, this increased complexity has brought with it a decrease rather than an increase in integration time that normally accompanies the assimilation of new ideas. Upon examination, what one finds is that the increasing complexity of advanced technologies often brings with it new ways of dealing with this complexity. Telecommunication networks allow new discoveries to be disseminated quickly over distances that were unthinkable one hundred years before. Video technologies allow for the sharing of information simultaneously across the globe. Even the products of this technological revolution, in turn, can act as accelerators in this process, as computers, perhaps the icon of the technological revolution, now are employed to design and manufacture still more complex machinery, far beyond the capabilities of any single man or groups of men.

Still, the mechanisms for transferring this new information have not really changed, in that new ideas still must be transmitted in some manner so that the receiving group can act on and benefit from these new ideas. While the speed of transfer, the distances involved and the very complexity of the information being carried have all increased, the actual process of assimilating this new information remains the same, much as athletes continue to improve on their performances in sports without changing the nature of the game. Further, not only are the processes basically the same, but the effectiveness of various types of transfers also remains fairly stable. [9] Continuing the analogy to sports, just as better athletes tend to win more matches, the better mechanisms for transferring technology tend to be more successful in accomplishing their goal, that is, increasing the technological skill or level of capability of the receiving party. Numerous other factors play a part in this equation; the presence of an established infrastructure in the receiving society, the level of education, cultural and linguistic differences, etc. [10] Overall, however, the more successful ways of transferring technology tend to prove themselves over time, and thus are the ones that should be the focus of any discussion of technology transfer.

Transfer Mechanisms [11]

As might be imagined, the mechanisms for transferring technology are as many and varied as the ways that one can think of going to work in the morning. While some may appear more logical or efficient than others, there are numerous ways to go about transferring information, each of which may make sense given a specific set of circumstances. Still, for the purpose of analysis, three general categories can be identified: [12]

1. Transfers of materials. Sometimes referred to as 'embodied technologies' [13] these include the transfer of actual materials and machinery, the products of technology, and in certain instances the manufacturing capability to produce these products. This area has long been the focus of studies about technology transfers, since it is the most obvious and represents the desired result of any transfer, that is, a product or capability that the receiving body did not have, or could not develop without excessive cost or effort. [14]

2. Transfers of information: Unlike actual products and manufacturing processes, information may not represent the embodiment of technology, but may be of greater value in terms

of the ability to recreate or produce the products that embody a given technology. Technical information, patents, trade journals and other related documents all contain a wealth of information, and hold the added advantage of being easily transferable, especially in an environment of telecommunications, computer data links and facsimile (FAX) facilities.

3. Transfers of know-how. Closely related to, though separate from information, are the knowledge and technical skills in a field needed to make use of the information available in order to create the products that embody a technology. Even when both the elements of material and information are present, there is still a need for the ability to combine these two to achieve a useful purpose. This ability or technical expertise can be summarized in the term know-how, the ability to make use of both production capability and information to achieve the desired results. Joint Ventures, technical education, and academic exchanges are all examples of the ways that technical expertise can be transferred from one group to another. [15]

While the effectiveness of each of these varies according to the circumstances involved, some generalizations as to the efficiency of each transfer mechanism can be made. Of the work that has been done on the effectiveness of various types of transfers and the mechanisms which embody them, the Bucy Report is seminal in terms quantifying the various types of transfers. [16] (For a summary of the finding of this report, see Appendix A) Still, to better understand the nature of each of these types of transfer, their relative strengths and weaknesses, and how they relate to one another, a brief discussion of each may help.

Transfer of Materials

The most recognizable type of transfer, and the one that has been the focus of most of the attention in export control, is the transfer of goods, both in terms of finished products and the manufacturing capability to produce these products. [17] Even in its simplest form, the introduction of a technology that was previously unknown in a society can have profound effects upon those receiving it, as in the case of the introduction of gunpowder and firearms into a region that previously had only bows and arrows. Variables such as who controls the new item, who has access to it, how quickly it becomes adopted, and the extent to which it is used, all play a part in determining the role that the new technology will have in the society. Once introduced, this process is normally an evolutionary one, that is, it will probably bring about changes and results that cannot easily be reversed. Once accepted, the new technology becomes the standard for the society, until it too is replaced by a still newer technology.

One of the factors that plays a decisive role in the acceptance of these materials into any society is the ability of the society to assimilate both the goods and the technologies associated with them. [18] To be accepted into a society, a certain basic understanding of the use of the object and its capabilities must either be present or be created. In this regard, sending automobiles to a country that has no roads, no fuel and no provisions for support in terms of maintenance and repair, will have little affect on the region as a whole, at least until the necessary infrastructure is created. [19] The same can be said for introducing computers into an environment that cannot take advantage of the capabilities that computers have to offer. Thus, the overall state of development plays a large role in the ability of a society to exploit the opportunities that a new piece of equipment has to offer.

Another factor relating to the effectiveness of the transfer of material is the ability of the society to recreate the technology, or build upon it. [20] As long as a society cannot reproduce a given product, i.e. it does not have the necessary technological skill or manufacturing capability, it remains dependent upon outside sources to provide this item. [21] This dependency, in turn, can be exploited by the country providing the product; by withholding the material in question, the provider can in effect apply a brake to the development process. Also, the failure to master the technological skills involved limits the capability of the receiving nation to adapt the given technology to the specific conditions of the region, something that broadens the product's utility, and thus its appeal. Automobiles that fail to function in a given climate, be it tropics, desert or arctic will have little demand from the local population. The people in the best position to modify a product to the specifics of a region are obviously those who live there and have first hand knowledge of what features are desired. To do this successfully, however, the local people must also understand the basics of the operation and manufacture of the object. Without these, integration and widespread adoption of the technology will be slow and hindered at every step of the process.

The ability to modify and produce a product thus is one of the factors that can be used as an indicator of a successful transfer process. Once the receiving society has the ability to manufacture the product on its own, it is no longer dependent on outside sources. The sooner the receiving society is able to adapt a given technology to its own circumstances, the sooner that technology is likely to be accepted on a larger scale and truly integrated into a society. To reach this stage, however, several preconditions must be met. The manufacturing base of the receiving country must be developed to the point that it can work with the technology involved and produce the products that embody a given technology. This requires not only manufacturing facilities, but people who are trained and capable of running them. The society itself must be at that stage of development where it can integrate and use the products of technology, otherwise there will be no demand for these goods. Finally, the people in the society must themselves be ready to accept and use the products. Perhaps the clearest example of this need is the case of computers in the West. When computers were the domain of a few specialists in the early fifties, their impact on society was relatively small. It was only with their widening use and acceptance in society that their influence has become more pronounced.

All this leads to one of the key subsets with regard to transfers of materials, that of transferring production facilities. While products can be moved fairly easily from one region to the next, there is little or no guarantee that there will be any lasting benefit unless the technology that is embodied in these products is in some way internalized in the receiving society. One way of overcoming this problem is the assimilation of the technical skills necessary for local production, which can be accomplished by the transfer of the manufacturing process itself. In its most complete form, entire production facilities can be involved, so-called 'turnkey' operations where a plant or process is set up and ready to function at the turn of a key. The transfer of production facilities offers many advantages in terms of shortening the process of technical assimilation, but while seemingly ideal for installing a new technology into a region, such transfers may still be ineffective if the capability is not present to run and maintain such facilities. Other factors, such as cost, availability and the need for some minimal domestic infrastructure all can limit the utility of such transfers, not to mention the sheer difficulty of dismantling, shipping, and setting up such facilities. [22]

Thus, while transfers of material are the most common and conspicuous way of transferring technology, they do not address all the problems that are involved in the integration of technology, and the mere presence of a product within a society is no guarantee that it will be used effectively, if at all. To do this requires the ability both to adapt the product to local conditions, and eventually to master the skills involved in its manufacture. The failure to be able to do this at best leaves the receiving nation in a position of dependency upon its suppliers; in the worst case, it may slow or even stop progress in this area. Thus, while the transfer of goods can have a definite impact upon a society, this impact becomes truly manifest only with the presence of another essential element in the transfer process, that of technical information.

Information Transfers

While transfers of goods or materials incorporate some types of basic information, the transfer of technological information in and of itself represents a second major type of technology transfer. Technical journals, patent information, [23] manufacturing licenses, and other types of documentation relating to products and/or manufacturing procedures all are forms of information transfers that can either supplement, or in some cases take the place of, the transfer of the actual product. While the value and effectiveness of this type of transfer is also dependent on a number of factors, including the medium of the transfer, the technology involved and the ability of the receiving body to make use of this information, there is no question that this type of transfer is of major significance, perhaps more so than the actual transfer of products.

One of the problems already outlined with regard to the transfer of materials is that actual products often do little to indicate how they are created, the steps and materials that went into their manufacture and other specifications (strength, flexibility, manufacturing tolerances, performance requirements, etc.) that apply to these products. While reverse engineering, the process of taking apart a particular item in order to determine technical data, is often used to gain this information, this process is slow and cumbersome at best; at worst, it still may not reveal all the information that is necessary in order to recreate the actual product. [24] Here technical information, the manufacturing specifications of a commodity and possibly even the steps in the manufacturing process itself, can be detailed in writing or other forms of media, making it far easier for those receiving the technology to duplicate the process.

The advantages of such transfers are obvious. Not only is such information necessary if a true picture of the technological process is to be gained, but additional information, such as insights by the original producer, can be included, thus saving the receiving group from having to make 'the same mistakes twice.' Technical information can be transferred more easily than actual products, and far faster. With the advent of the revolution in telecommunications, technical drawings and graphic representations can be passed instantaneously though telephone and other data links, while computer networks allow not only access to such information, but the ability to interact and query concerning the information being passed. Finally, cost is another consideration. While some expense is involved in all such transfers, it is hardly comparable with what the cost might be if the actual products were involved, much less that of an entire production facility. Taken together, all these factors favor the seeking and use of information over material.

This is not to say, however, that information transfers are a panacea, or a foolproof way of getting around the limitations that come with material transfers. To be effective, information must come in a format and package that is readily understood by those receiving this information. As anyone will attest to who has tried to put together a product where 'assembly is required', the value of written information varies directly with its clarity, coherency and ability to accurately depict the process that is called for in the actual assembly. Depending on the complexity of the process involved, accurate descriptions may still not be of any use if the receiving body is incapable of executing the process described. Other problems, caused by differences in language, technical skill and even culture may hinder the implementation of the instructions, no matter how expertly the process is reflected. Finally, even if all of the above conditions are met and the process is fully understood, the lack of the necessary production facilities makes the information of little more value than the paper that it is written upon.

Thus there is yet another element involved in the transfer process. All the information in the world does little good if those entrusted with this information do not have the capability of doing anything with it, of using its potential to produce something of value. An infrastructure must be present in the receiving society, comprising both the facilities needed to exploit a given technology and the people who are trained and qualified to use those facilities and put a given technology to practical use. Together, these comprise a third element and are the basis of the ability to combine materials with information. While possibly the most difficult to describe, it can at the same time be the most important item in integrating technological information and its products, so that the technology has a lasting effect on the society surrounding it. This element, simply stated, is know-how.

Technological Know-How

At first glance, it might be difficult to distinguish the difference between information and technological know-how. Yet if one approaches the question in terms of the difference between animate and inanimate objects, the distinction may become clearer. Information, as it exists on a sheet of paper (or reflecting current technology, in the bits and bytes of a computer) is an inanimate entity; in and of itself it cannot accomplish anything and has little value other than as a potential in the hands of those who possess it. To be of value, this information must be put to use, must be utilized in some manner such that it either creates or establishes the preconditions needed to create something of value to a society. To do so successfully, requires a certain degree of capability or expertise on the part of those people possessing that information. Just as a book does little for a person who cannot read, so information does little for those who do not have the ability to exploit that information. This ability, then, is the essence of technological know-how.

Returning to the analogy of animate/inanimate objects, it takes people to convert information into something of use, therefore the distinguishing characteristic of technological know-how is its human element. [25] In spite of all the advances that have been made in technology, as well as the conceptualizing that has been done about artificial intelligence, human beings are still the essential element in any dealings with science and technology. While machines may be able to perform certain operations faster than humans, or with more skill and precision, it still requires human reason, human insight, human genius to carry out any operation. While hardware represents the end result of this process and in some cases the production capability, and information provides the technical basis, it is the human element that brings the first two together and gives the whole its meaning. To talk of technology transfers without recognizing this element would be like discussing life on earth without giving due recognition to the part played by the sun.

Not only is the human element essential in terms of the inspiration needed for creation, but in spite of all the advances in technology, humans are still the best processors of information. While operations can be quantified and described in technical literature, it is still often far easier to demonstrate and learn by actual application. One need only think about trying to teach a child to tie his shoe through writing down the steps, as opposed to showing what is to be done and then practicing till the procedure is down, to realize the advantages of hands on experience in trying to pass on even the most rudimentary of skills. Here too is probably the best demonstration of one of the most efficient ways that technology can be transferred. Not only is direct human contact an effective way of transferring know-how, but it can incorporate both the transfer of hardware and information. Active participation in this process not only allows for timely feedback, it helps reinforce the understanding of what is taking place and all that is involved in a process, something which is a key element for further modification and development.

Thus, as reflected in the findings of the Bucy Report, it should come as no surprise that the transfers that are deemed most effective normally incorporate this human element. [26]

While the human element plays an essential part in the technology transfer process, it too suffers constraints, primarily in terms of the technical background necessary to efficiently convert information and hardware into a functioning unit. Human beings, without the necessary equipment, can do little in the way of exploiting or producing technology. Humans, even with the necessary equipment and know-how, still require information. Therefore, it can be argued that each of these three mechanisms is, to at least a certain degree, dependent upon the others. In order for the transfer of technology to be truly effective, all three must be present to some degree.

The Transfer Process [27]

Having looked at the mechanisms by which technology can be transferred, the next logical step is to examine the way that these mechanisms are employed, or the actual process of technology transfer. If one looks at the nature of trade, especially between countries of unequal development, it can be argued that almost all such exchanges involve at least one nation gaining something that it did not already possess, thus the underlying reason for the trade. Traditionally, this has meant lesser developed countries getting technically developed goods in return for raw materials, lower technology products and even cheap labor. Yet do all these involve transfers of technology, and if not, then what defines such transfers?

While at first it might seem that the transferring of products embodying a certain technology, by definition, transfers the technology itself, it must be remembered that if the information that goes into making that product is not readily apparent, or the know-how that is necessary for manufacture is not present, then the transfer of a product does little to increase the technological level or skills of the receiving nation. In this regard, the trade relations between the colonial powers of the eighteenth and nineteenth centuries and their lesser developed colonies did not represent an overt attempt at the transfer of technology, since there was little interest on the part of the dominant countries in raising the technological level of their colonies. Still, in spite of intentions, it can also be argued that one of the results of these transfers was the creation of new expectations among the receiving countries, new desires that led to increased demands, either for goods or for the means to fulfil these demands for goods. These demands, in turn, often led to the eventual production, domestically, of items that previously were available only from abroad, and the development of local capabilities that formerly did not exist. This phenomenon was further aided by the tendency of developed nations not only to export products, but the means of production, factories and plants that when they became outmoded by the current standards of the developed nation, could still be run at a profit in these lesser developed areas of the world. This process has been documented by James Kurth, and is cited as part of the classical pattern of imperialistic exploitation. For the purposes of this study, it is significant to note that whatever its initial intent, the process inevitably contributed to the development of the junior partner in such exchanges, and thus serves as a model of the way that technologies are transferred.

Kurth's model is worth examining in some detail as it establishes a framework with which to examine the pattern of technological transfers between highly developed and lesser developed nations. In his article, "The Political Consequences of the Product Cycle: Industrial History and Political Outcomes", [28] he elaborates on the product cycle and the work of Raymond Vernon, a noted authority on international trade and transnational companies. [29] The four phase process Kurth describes, consists of:

> 1. Innovation of a product and growth of its sales in the domestic market.
> 2. Saturation of the domestic market and export of the product to foreign markets. Exports will go first to those countries whose demand structures (e.g. national income per capita) are most similar to that in the home country. When these markets are in turn saturated, the export drive will move on to countries whose demand structures are less similar, and normally whose economies are less developed.
> 3. Manufacture of the product within foreign markets. In the home country the manufacturing of the product has reached a plateau, while investment in these new countries, combined local demand and other favorable conditions (access to cheap labor and raw materials), create favorable conditions for local development.
> 4. Export of the product from foreign countries to the original home market. The combination of cheaper production costs in the new country, combined with the probability that the originating country has moved on to the next level of technology, allows for this to take place, however since there still may be a demand for the product in the country of origin, it may be imported from the country that received the technology to fulfill these demands in the country of origin, where it is no longer economically efficient to maintain the means of production. [30]

While originally designed to describe the relationship that existed between the imperial powers and their colonies, many parallels can be seen in the relationships found today between the industrial nations and those of the developing or 'third world' as it has come to be known. What distinguishes the situation today, however, is the nature of the technologies that are being transferred, as well as the environment that such transfers are taking place in and the speed at which they occur. In recent times, the development and implementation of new technologies and their products have grown dramatically, to the point that one can speculate that one-third of the products found on the market today were not available twenty-five years ago. The speed of this massive change has been brought about, in many cases, by the very advent of these technologies; in this regard, the technological revolution has been self-generated and is self-sustaining, as new technologies create the capability for still greater change. Here, once again, there is no better example of this than computer technology, where microprocessors give the possibility of performing in seconds tasks that would have taken weeks or even months using traditional means. With the advent of computer assisted design and manufacturing (CAD/CAM) the rates of change, measured in the creation of new products, continue to increase.

Still, referring to the previous discussion of transfer mechanisms, the material portion of this transfer process is only part of the equation. Without people who are educated and trained to take advantage of these tremendous new capabilities, technology offers little if anything to the receiving country. Without the necessary infrastructure, research facilities, manufacturing concerns, transportation and communications links, etc., even trained and knowledgeable personnel will have difficulties exploiting the possibilities made available by transfers of technology. Just as an individual must be of a given age in order to perform certain functions in society, so too must an economy be at a certain level of development in order to make effective use of all that these technologies have to offer. This does not imply that a nation must already have all of the elements of a developed infrastructure in order to assimilate technology from an outside source; however, the more elements that are present, the easier and quicker the assimilation process will probably be.

Applying these new parameters to the transfer process today, two parallel, though not necessarily reinforcing trends can be seen. An increase in the technological skill possessed by a society furthers the stage of its development and its ability to assimilate new technologies, as well as the speed at which this process takes place. Part of this is the result of technology itself, as new materials, computers, telecommunication networks, data bases and the like give the scientific and manufacturing communities the ability to deal with an ever increasing amount of complex information. At the same time, however, the very complexity of these new technologies, as well as the level of development needed to exploit this information, may act to block or hinder the transfer process. If the necessary infrastructure exists, in terms of facilities, equipment, and trained personnel, then the transfer process will be effective and will add to the technological skill of the receiving group or country. If an infrastructure does not exist, then an equal but negative reaction can be the result. Societies that cannot participate effectively in this process, either because of a lack of personnel, facilities, material or combinations there of, stand to be left behind as these deficiencies are compounded by the inability to effectively incorporate new technologies and raise the level of technological skill. In this regard, technological skill is the key to development; the 'mastery of the applications of advances in science to manufacturing techniques' becomes the basis for further advancement, while the failure to master these skills can effectively halt a society's progress. Thus, for a transfer of technology to be effective, for it to be able to raise the level of technological skill, the receiving group must either possess the infrastructure needed to take advantage of the technology, or be in a position to develop such an infrastructure,

Related Factors

Outside of the constraints placed upon the transfer of technology based on its very nature, it should be noted that there are other factors as well that can come into play and affect the success of such transfers. Economic considerations play a large role, since in fact most technologies revolve around products and the nature of trade. Returning to the Kurth model, the transferring of manufacturing capabilities, along with the development of the necessary infrastructure that allows for the receiving society to fully exploit these capabilities, can often result in the receiving society becoming a competitor with the society that first provided the technology. While ideally the originator will have already passed beyond this stage in their own development, this is not always the case. Cheap labor, access to raw materials, and the use of proven technologies without the immediate need to develop or innovate, all are factors that allow developing countries to compete with older more established economies. Once assimilated, further development of a technology may take place in the receiving nation, causing it to become a rival center for technological development to the originator of the technology. For examples of this, one need only to look at the rapid development of Asia, which now leads the world in several areas of technology that originally were imported from the West. These cases of the student outstripping the teacher can give rise to some hesitation as to the ultimate utility of such transfers, and thus serve as an argument to limit their extent, in an effort to prevent the creation of rival economic powers.

The same type of considerations are present when it comes to discussing technologies relating to national security. Because of the importance placed on preserving each nation's sovereignty [31], leading technologies often are applied to the development of military capabilities, which, it is hoped, will increase the security of that nation. The decision to transfer a technology with this type of potential is thus subject to political considerations as well as economic, since it would hardy be prudent for a nation to provide a capability to a potential adversary that might some day threaten the security and well being of the originating nation. [32] Because of the complexity of modern technology, not to mention the multiplicity of certain technologies which allows for their use in either peaceful or hostile pursuits, the line of what constitutes a threat is often blurred; the same technology that provides nuclear power can also provide the means necessary to produce the material needed for nuclear weapons. Thus, political considerations, as well, can play a part in the transfer process when issues of national security are involved, and as will be seen, security concerns frame much of the debate surrounding the transfer of technology from West to East, and especially the transfer of computer technology.

Summary

Summarizing what has been discussed, technology transfers involve more than merely the transferring of a product that embodies a certain technology. To be an effective transfer, the process must include those elements that will allow the receiving group or nation to assimilate the technology, reproduce it and adapt it to local needs. Without this integration into the receiving society, the effect the technology will have will be minimal at best, and it cannot be considered a true transfer of 'knowledge relevant to industrial capability'. [33] To be effective in increasing the level of technological sophistication of the receiving nation, the technology must not only be integrated in terms of use, but it must be assimilated so that it can be reproduced and used to advance the general level of capabilities of the society, or technological skill. To do this successfully, certain preconditions must exist, the primary of these being the presence of an infrastructure, in terms of material, facilities and skilled personnel. The actual transfer of the technology can take place in several forms which can be broken down into three general categories: materials, information and know-how. The effectiveness of each of these as a vehicle for transferring technology depends on the conditions that exist in the receiving society, however past experience has demonstrated that some of these methods are more successful than others, and that methods combining these elements with active human participation have the greatest chance of success.

In addition, other considerations, primarily political and economic, may come into play with regard to the effectiveness of technology transfer, specifically in terms of the limitations placed on such transfers, usually by the country or group that is in a position to provide advanced technologies. The latter are artificial in nature, in that these often take the form of restrictions that are knowingly implemented, as opposed to conditions that are the result of the stage of development the receiving country and its ability to assimilate technology effectively. This last category most often takes the form of export controls, and can be seen in the efforts that have been made to monitor and restrict the transfers of western technology to the Soviet Union. To restrict this flow effectively by such means, however, requires an understanding of the relative effectiveness of each category of transfer, as well as the aggregate effect that combinations of different methods of transfers may have. The problem with western efforts to create an effective export control regime, is that this understanding has not always been in evidence. Just as it does little good for the farmer to close the gate while leaving gaping holes in his barnyard fence, so does it do little good to place restrictions upon certain types of transfers of technology that are inherently ineffective, while allowing other, more efficient types to flow freely.

Endnotes

1 A computer search of the University of Surrey Library located 47 books dealing with technology transfer. Of these, most were case studies of either specific countries, or sectors of industry; while some of these devoted several pages to developing a conceptual framework for examining the topic with respect to a specific area, not one dealt exclusively with the theory of how technology is transferred.

2 For one of the best contemporary works on International Political Economy Theory, see Robert Gilpin, <u>The Political Economy of International Relations</u>, (Princeton: Princeton University Press, 1987).

3 It is interesting to note that this type of approach was used by Stalin in the 1920s and the 1930s, under the banner of 'Socialism in One Country'. Some observers have cited the results of this period as the beginning of the Soviet Union's problems in dealing with technology, precisely because of the isolation imposed on the country, limiting its contacts with the more advanced industrial West.

4 As noted above, there is no 'classic' work in the field that lays out a universally accepted theoretical framework for the question of how technology is transferred, therefore the author has outlined his own approach for the purpose of this analysis. One early work in this field that is useful, though limited by its size and scope, is Richard L. Lesher's and George Howick's, "Assessing Technology Transfer," a study done for the National Aeronautics and Space Administration in 1966. A good collection of papers on the topic, coming from a conference held at the Massachusetts Institute of Technology is William H. Gruber and Donald G. Marquis, ed., <u>Factors in the Transfer of Technology</u>, (Cambridge: The M.I.T. Press, 1969). A very comprehensive treatment of the topic of controlling technology transfer can be found in the essays in <u>Controlling International Technology Transfer--Issues, Perspectives, and Policy Implications</u>, ed. Tagi Sagafi-nejad, Richard W. Moxon, and Howard V. Perlmutter. (New York: Pergamon Press, 1981).

5 A very informative account of this process from a pair of renowned military historians can be found in John Keegan and Richard Holmes's book, Soldiers--A History of Men in Battle, (London: Hamish Hamilton, 1985).

6 A short historical account of several examples of technology transfer in the past can be found in Thomas P. Hughs' essay, "Transfer and Style: A Historical Account," Controlling International Technology Transfer--Issues, Perspectives, and Policy Implications, ed. Tagi Sagafi-nejad, Richard W. Moxon, and Howard V. Perlmutter. (New York: Pergamon Press, 1981), pp. 42-63.

7 Futurist Alvin Toffler's book, Future Shock, (London: The Boldley Head, 1970), is a classic work on the effects that technology and the ever increasing amount of information found in society may have on man and his everyday life.

8 A similar figure is presented in Lesher and Howick, "Assessing Technology Transfer," National Aeronautics and Space Administration, 1966, p. 9. "We are generating more new knowledge in 1 year than we generated in a full decade less than half a lifespan ago."

9 The first eight pages of the Bucy Report give a good summary of the findings with regard to these mechanisms and their effectiveness. See, J. Fred Bucy, Chairman, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," Office of the Director of Defense Research and Engineering, 1976.

10 Lesher and Howick, "Assessing Technology Transfer," National Aeronautics and Space Administration, 1966, p. 38.

11 Though the concepts in this section are fairly well established, their organization in the construct presented, as well at the reasoning for this organization, is that of the author. Cases where similar ideas have been expressed by other writers, when known by the author, are noted.

12 For several alternative models to that presented by the author, see William H Gruber and Donald G. Marquis, ed., Factors in the Transfer of Technology, (Cambridge: The M.I.T. Press, 1969), pp. 4-8.

13 For a brief discussion of the difference between 'embodied' and 'disembodied' technologies, see Morris Bornstein, "East-West Technology Transfer--The Transfer of Western Technology to the USSR," OECD, 1985, p. 24.

14 As noted earlier, a majority of the works on technology transfers are case studies dealing with either products or industries. For an excellent collection of essays dealing with various areas of Soviet industry, see Bruce Parrott, ed., Trade, Technology, and Soviet-American Relations, (Bloomington: Indiana University Press, 1985), pp. 63-240.

15 To get an idea of the significance attached by many to the concept of know-how, the following portion of the Bucy report is cited."...manufacturing know-how is of overwhelming importance to our national security." Bucy, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," p. 1.

16 J. Fred Bucy, Chairman, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," Office of the Director of Defense Research and Engineering, 1976.

17 An examination of either the current or proposed CoCom lists or the extracts published by member nations bears out the emphasis that is placed on the control of products and manufacturing capabilities. See, "Consolidated list of goods subject to Security export control," pamphlet of the British Overseas Trade Board, Department of Trade and Industry, March 1991.

18 For an excellent discussion of assimilation of technology in the case of the Soviet Union, see Phillip Hanson's essay, "Soviet Assimilation of Western Technology," Trade, Technology, and Soviet-American Relations, ed. Bruce Parrott, (Bloomington: Indiana Press, 1985), pp. 63-81.

19 Several essays dealing with various aspects of the question of developing an infrastructure in countries where one does not exist can be found in Manas Chatterji, ed., Technology Transfer in the Developing Countries, (London: MacMillian Press LTD., 1990).

20 Lesher and Howick, "Assessing Technology Transfer," p. 37.

21 A discussion of the economic aspects of dependency can be found in Raymond Vernon's, Sovereignty at Bay--The multinational spread of U.S. enterprises, (London: Longman, 1971), pp. 181-186.

22 Traditionally, the Soviet Union has shown a preference for turnkey plants when they could be obtained. Such acquisitions, as will be discussed in the next chapter, played a large role in the development of the Soviet chemical industry in the 1960's.

23 Patents are an area often ignored in literature dealing with the ways that technology is transferred. For a discussion in greater depth, see Sigmund Timberg, "The Role of the International Patent System in the International Transfer and Control of Technology," Controlling International Technology Transfer--Issues, Perspectives, and Policy Implications, ed. Tagi Sagafi-nejad, Richard W. Moxon, and Howard V. Perlmutter, (New York: Pergamon Press, 1981), pp. 64-84.

24 Bucy, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," p. 5.

25 While written to support a different thesis, Howard Reiss's, essay "Human Factors at the Science-Technology Interface," contains several useful insights. Found in Factors in the Transfer of Technology, pp. 105-116.

26 Bucy, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," pp. 7-8.

27 For an alternative view of the transfer process, see Lesher and Howick, "Assessing Technology Transfer," pp. 34-43.

28 James Kurth, "The Political Consequences of the Product Cycle: Industrial History and Political Outcomes," pp. 312-339, found in, International Politics--Anarchy, Force, Political Economy and Decision Making, ed. Robert Art and Robert Jarvis, (Boston, Little Brown, 1985).

29 Raymond Vernon is a noted economist and authority on developing economies. For Vernon's original description of the

product cycle, see Sovereignty at Bay--The multinational spread of U.S. enterprises, (London: Longman, 1971), pp. 65-77.

30 Kurth "The Political Consequences of the Product Cycle: Industrial History and Political Outcomes," pp. 313-314.

31 Realist political theory holds that all nations seek to maintain their sovereignty, a desire which can be used to analyze the reasons behind the actions of the country's leaders. Even if one does not wholly agree with this concept, it seems reasonable to assume that, given the choice, most nations would prefer to maintain the capability to decide for themselves on courses of action that affect their nation, which is the essence of sovereignty.

32 The most recent example of this is the 1991 conflict in the Middle East, where technology sold to Iraq in such areas as chemical production, as well as advanced military hardware, was a major concern for those facing Iraq, many of whom were the original suppliers of these technologies.

33 As has been seen, many definitions could be constructed to try to include all of the aspects that have been discussed in this chapter, however for the sake of consistency this definition of technology will continue to be used throughout the study.

CHAPTER 2--TECHNOLOGY TRANSFER AND THE SOVIET UNION--
THE PRE-GORBACHEV ERA

Introduction

The transfer of technology plays a part in the life and development of every nation, therefore it should not come as a surprise that it has played a role in the evolution of the current Soviet state. But what has been the source of these technologies, and more importantly for the purpose of this study, to what extent have such transfers influenced Soviet development? If the effect has been relatively small, then it would be logical to question whether there is even a need to worry about such transfers. If, on the other hand, it appears that such transfers have played a substantial role in that development, then the examination of such transfers acquires added significance.

The transfer of technology from West to East is by no means a recent phenomenon. Peter the Great set the precedent for large scale importation of ideas and know-how during his program of westernization in the late seventeenth and early eighteenth centuries. [1] From that time onward, Russia has sought western assistance to aid in its development. This trend was particularly apparent at the end of the nineteenth century when, under Count Witte, the country attempted to industrialize through a massive influx of western machinery and industrial expertise. [2] Yet even though these early efforts were pronounced, there has been a continuing debate as to their importance and even for their need. Beginning with the time of Peter, one of the key elements in the debate between the Westernizers, those who favored importation of western ideas, and the Slavophiles, who stood against such practices, was whether there really was a need for Russia to seek such assistance, or whether in fact the country could and should develop on its own. Lest this seem like an arcane and historical debate, it is interesting to note that the same arguments continue today, with one of the conservative critiques of Gorbachev's programs being his emphasis on importing western ideas and technical know-how. [3]

As mentioned in the last chapter, there have been a number of studies written on the significance of the importation of western technology to Soviet industrial development. [4] Most authors are in agreement that, in terms of the sheer quantity of material and because of the significance attached to such transfers by the Soviets themselves, there indeed has been a quantifiable impact.

But have these various inputs really had an effect on Soviet development, and if so, what has been the nature of this impact? While the results, as will be seen, vary from case to case, it should be possible through an examination of what has occurred in the past, to come up with some generalizations about the position occupied by imported technology in the Soviet Union prior to 1985, which can then serve as a basis of comparison for what has been observed in the Gorbachev era.

History

After the Bolshevik Revolution of 1917 and the destruction caused by the Civil War that followed, the Soviet leadership displayed a keen interest in receiving western economic assistance, even at the same time that they were decrying, for political reasons, the faults and failings of the capitalist world. During the period of the New Economic Policy (NEP), Joint Ventures with western firms were encouraged by the new Soviet government as a means of rebuilding the country's shattered industry. [5] Even when direct western participation in economic ventures was done away with after 1928, a western presence, in the form of engineers and technical specialists hired by the Soviets, continued. [6] This influence was so extensive as to lead

Fred Busy to conclude that, "by 1930, there was not a single important industrial process (in the Soviet Union) which did not derive from transferred western technology." [7]

The 1930's and the communist program of rapid industrialization served to reinforce the Soviet use of western technology. Western inputs were seen not only as a means of repairing what had been destroyed during the Civil War, but as a source of capabilities that had never existed before in the Soviet Union. Entire plants and in some cases whole industries were imported from the West and established on Russian soil; in just one example, the Soviet automobile industry can be traced to plants bought from the Ford Motor Company. [8] This period was significant in that the Soviet leadership appeared to make the conscious decision to abandon efforts to use domestic innovation as the basis of development, and to concentrate instead on using proven western methods to rapidly increase the country's industrial potential. [9] During World War Two, or the Great Patriotic War as it is known in the Soviet Union, much of what had been built in the twenties and thirties was destroyed, but at the same time the aid given to the Soviet Union under Lend Lease not only helped to ease material shortages, especially in the area of transportation, but allowed Soviet designers access to material they might not otherwise have seen. [10] In the years following the war, the Soviets made use of both industrial machinery and personnel taken from Germany as war reparations, while the 1960's saw them again importing factories and technical know-how from the West, especially in the areas of plastics and chemicals. In this way, the trend of importing western technology continued, with the Soviets turning to the West for assistance in those areas in which they were weak or did not possess any native capabilities.

Another method of measuring the part played by the West in Soviet industrial development is to examine the amount of Soviet imports from the West. In 1925, shipments of western equipment accounted for 13% of total Soviet imports; in 1930, the percentage had risen to 40%, and averaged over 50% in the immediate post-war years. [11] While figures show that Soviet imports of western equipment declined in the 1970's, (owing possibly to worsening political relations between East and West, culminating with a near break in relations over Afghanistan), these figures were again up in the 1980's. [12] Anthony Sutton, analyzing this repeated borrowing from the West in his three volume study of the history of western technology and Soviet economic development, comes to the conclusion that, "by far, the most significant factor in the development of the Soviet economy has been its absorption of western technology and skills." [13] Yet while it is hard to dispute that western technology, in numerical terms, has played a part in Soviet development, it may be a misrepresentation to assume that this automatically means that the technology embodied in the material transferred to the Soviet Union has, in fact, had a substantial impact on its level of development. The Soviet economy today, in spite of its all too oft cited failings, is a mature system which even western experts acknowledge is more advanced than the West in some areas. [14] To get an idea of the role that foreign technology has played in the Soviet system, it is necessary to examine the way that this technology was utilized by the system during the period prior to 1985 and the coming of the Gorbachev reforms. This view, in turn, can be used to contrast the differences, if any, in the role that technology transfer plays in Gorbachev's attempts to revitalize the economic system.

The Soviet Industrial System

Soviet industry, as the product of a command economic system controlled by a central planning organization, presents a picture far different than the one presented by its western counterparts. Decisions in the West that would be made based on economic considerations are instead based on political and administrative factors in support of a centrally determined economic plan. This central planning mechanism has proven itself slow and cumbersome, stressing quantity and fulfillment of production goals over quality and demand. [15] The system does, however, permit the government to channel resources into desired sectors, while maintaining control over the economy as a whole. This ability to prioritize is a key strength of the system, and has allowed the Soviets to mobilize their resources to achieve specific goals, particularly in areas where technology is concerned. [16] One result of this system is an industrial plant that is unevenly developed, that on the one hand supports a huge and very successful space program, but on the other cannot make reliable television sets. [17] In the words of Thane Gustafson, a leading authority on technology transfer between East and West, "the Soviet technological landscape is a complicated picture...ranging from valleys of backward technology to summits of world leadership." [18]

One result of this practice of targeting specific areas through resource allocation where the interests of the state are involved, is the development of not one, but two industrial complexes in the Soviet Union. The first one deals with the military and defense matters; the second one encompasses all those areas normally associated with the civilian sector in the West. This arrangement has evolved and is perpetuated because the government continually has given priority to the military in its economic plans; "the defense industrial sector has first call on the highest quality human and material resources available to the economy." [19] This high priority allowed the military "to mobilize the best brains and the best resources to overcome administrative obstacles and gaps" that plagued the rest of the system, and enabled the Soviet Union to cope successfully with the technological challenges of the arms competition. [20]

Evaluating the effectiveness of this system has been difficult at best. As a closed system, traditionally hostile to the West, the type of access needed to make a detailed study has not been available until recent times, and even now information remains sketchy. Still some observations can be made, based in part on western perceptions and in part upon what the Soviets themselves have said. That the Soviet Union has made great strides in terms of military strength is generally recognized and can be attributed to the emphasis that has been placed on this area. Yet because of the priority given to the military, the civilian sector has continually taken a back seat in the economy, resulting in, among other things, a dismal record in the production of consumer goods. [21] The lack of an effective pricing system in either the military or the civilian system does little to encourage efficiency in production or the use of resources. Poor labor productivity and the lack of an effective incentive structure is another problem inherent to the system. Soviet sources estimate that the productivity of the Soviet worker in industry is just over half that of his American counterpart, and is worse in some areas, such as agriculture. [22] One way of overcoming such problems is through innovation in the production process, that is, using technical advances to increase productivity; but here the Soviets have had more than their share of trouble. As one observer states, "with a command economy, the Soviet Union generally has been unable to provide incentives for innovation that work as well as those growing out of the price system in the (West)." [23]

The Problems with Innovation

The problems the Soviets have had in the area of innovation, to a large degree, can be attributed to the nature of their system and the fact that it offers little incentive for change. These problems, in turn, also have a direct bearing on their apparent difficulty in taking full advantage of western technology. Having made the decision in the early days of industrialization to de-emphasize domestic research and to concentrate instead on expanding production capability, the development of a research and development base to support Soviet industry initially lagged. [24] Even once a large system of research institutes developed in the Soviet Union, there was still a lack of incentives to encourage applying the results of research to the manufacturing process. Limited funds and economic plans that emphasized meeting current production goals left little in the way of resources that could be dedicated to overcoming this shortfall in innovative capability. [25] Even in those cases where research was directed from above, endless bureaucratic procedures and obstructions owing to parochial interests, often stifled innovations before they had a chance to be implemented. The basic goals of the central planning structure not only limited the incentive for research, but in some cases, actually worked against it.

An examination of the non-military industrial sector reveals several prime examples of why innovation and change have been shunned by most of the Soviet economy. Under the central planning concept, incentives are geared to rewarding people for current output and successful completion of the goals of their plan. The costs and delays involved in re-tooling, plus the loss of productivity during such periods, provide little incentive for bringing about change, no matter how beneficial it might be in the long run. [26] The Soviet press has published cases where scientists physically have had to go out and 'sell' new ideas to industries, while industrial managers were criticized for viewing innovation as "uncertain, unprofitable, and unnecessary." [27] Even once new ideas were developed and accepted, the system lacked the mechanisms needed to ensure that the results of research were rapidly incorporated into production. [28] The same bureaucratic lethargy that hampered the development of new ideas also slowed their implementation. Instances even exist where advanced technological processes, developed by Soviet research, have been sold under contract to western firms where they have been in use for several years, yet the same processes still have not been adopted in the Soviet Union. [29]

The Soviet defense industry presents a different picture. Because of the priority this sector has enjoyed, giving it first choice of technical personnel and almost unlimited resources, an extensive research and development base has been established to support military production. By targeting specific areas and concentrating their efforts, the Soviets have been able to overcome many of the problems with innovation inherent in the civilian sector. This, in turn, has allowed them to stay abreast with, and in some cases surpass, the West in the development of defense related technologies. On the production side, the way in which defense contracts with industries are written is designed to overcome the hesitation toward implementation of new ideas and production techniques. [30] Bonuses are based on achievement of technical standards rather than pure output, strict quality control is enforced, and military personnel are involved in every step of the production process to ensure that the equipment produced meets military needs. If there is a failure on the military side with regard to innovation, it is the inability, owing to the closed nature of the system, to effectively diffuse technology developed for the military to the civilian sector. [31] Thus, the advances achieved by the one relatively effective research and development organ in the economy do little to benefit the economy as a whole.

In summary, it should be pointed out that the Soviets themselves realized the problems they were having with innovation, and tried to correct them. In 1969, Brezhnev called for a major campaign to increase indigenous innovation, while the ninth Five Year Plan for the period 1971-75 substantially increased the funds allotted for research and development. [32] These efforts, however, proved less than successful, due in part to the unwillingness of Soviet leaders to sacrifice their emphasis on production goals in order to encourage innovation. [33] While Soviet scientists have often proven to be very good in the initial stages of the research-production cycle, they have been unable to bring about the rapid development and implementation of new ideas. In those sectors, such as the military, where the Soviet Union placed a high priority, it has shown that it can overcome its difficulties with innovation, but only with the commitment of large numbers of people and amounts of resources. This, in turn, has stripped the civilian sector of the resources it needed in order to keep up with the 'state-of-the-art' in the world industrial market. [34] The solution that the Soviet leadership arrived at to deal with this problem, of how to make up for the inability to generate new technology and bring it into production, has been the same one used by preceding generations to assist in internal development; import the needed technology and production facilities from the West.

Western Technology and the Soviet System

The decision to turn to the West for the technology it needed has not been an easy one for the Soviet Union to make. Professor Bruce Parrott of John Hopkins University has written that there were two divergent views held by the Soviet leadership on this issue. The first view supported the belief in the moral superiority of the socialist system and its eventual triumph, thus downplaying the value of western technology to the East. The second allowed that the West was in fact forging ahead of the East; therefore, every effort had to made to keep within striking distance of the capitalists. [35] For the Soviets, evidence existed to support both views. Starting from a position of relative industrial backwardness, the Soviet Union had made great strides in the years since the revolution. Most western analysts concede that the products of technology the Soviets are incapable of producing are extremely rare, and that only time and commitment separate them from any advantage they might gain through imports from the West. [36] On the other hand, the Soviets recognized that science and technology were the very areas where market economies hold a greater advantage, both in overall level of application and the ability to generate new skills and know-how. [37] In the end, the deciding factor which favored importing technology from the West was the limited nature of the Soviet Union's own resources. By taking advantage of technology from the West, the Soviets sought to lessen the strain on their own research and development (R&D) assets. Not only did such transfers cut costs, but they allowed the Soviet Union to concentrate efforts on areas that were felt to be critical, such as defense. Still, official Soviet policy prior to 1985 played down the value of such inputs. From the leadership's perspective, while western technology was nice to have, it was by no means essential and could be done without. [38]

Unofficially, the benefits to be gained by exploiting the West's advanced technology base were immense. In areas where the Soviets were behind the West, they could save years in research time needed to attain an equivalent state of development. By buying proven technology, they avoided costly mistakes and errors common to the research process. [39] The Director of the Soviet Academy of Foreign Trade wrote that the cost of purchasing foreign manufacturing know-how was ten times lower than the economic effort that would be required by the domestic R&D infrastructure [40] Finally, with the broad spectrum of western technology available, the Soviets were able to pick and choose what they needed to eliminate bottlenecks in their own system, thus aiding their overall level of development. This 'supermarket' approach can be seen in the dual strategies the Soviets followed when obtaining western technology. The first was to acquire the materials needed to develop specific weak areas in their industry, such as oil or chemical equipment. The second was to acquire technology related to management skills, such as computers which, when combined with other Soviet capabilities, served to stimulate and improve economic performance as a whole. [41]

While the Soviet leadership appeared to favor using western imports as a means of increasing production and matching world technological levels, they were also wary of the risks involved. When Soviet purchases of western technology accounted for close to one-quarter of the Soviet investment in machinery in 1978, an internal political debate arose as to whether this represented an unacceptable degree of dependence upon the West. [42] Another concern was whether, by importing the results of western research and development, the Soviet Union was undercutting the development of its own abilities in this area and further aggravating an already acknowledged problem. [43] Soviet fears in this regard were heightened by the Nixon-Kissinger view of detente, which held that increased western trade with the Soviet Union would cause the latter to become intertwined economically with the capitalist world. [44] Even with these reservations, however, the Soviet Union continued to seek the advantages to be gained from western technology. As one expert noted at the time, "It is simply more efficient and less expensive to borrow from the existing repository of knowledge than to waste time and resources on innovations that may have little utility for the production process." [45]

The Collection Process

The general decision to import western technology was based upon the inability of domestic agencies to provide Soviet industry with the technical innovations needed to achieve and maintain production capabilities comparable to those of the West. Once the decision was made to import a technology relating to a specific area, obtaining that technology, or the collection process, became a function of the central planning apparatus. Industrial Ministries forwarded their requests for technology and equipment to the State Committee on Science and Technology, GOSTEKHNIKA (GKNT), which bore primary responsibility for the coordination of research and development work throughout the economy. A major function of the GKNT consisted of developing strategies to acquire western technology and to integrate it with domestic R&D efforts. [46] Upon approval of its request, the ministry was allotted funds for direct purchase of the desired material, or other arrangements for acquisition were made. These ranged from legitimate means, such as applying for non-restricted patent information, to covert operations mounted by the Ministry for State Security (KGB). As one specialist on East-West trade noted: "The Soviets have so many approaches, that once they know what they want, they will never give up." [47]

Over the years, the Soviets literally have become experts at exploiting every legitimate source of technical information available to them. In order to conserve scarce hard currency assets, they favored buying limited numbers of items that could be examined to gain information or be used as models for Soviet produced equivalents. [48] The Soviet Union also tried to take full advantage of technical data published in the West; among other examples, the Soviet Embassy in Washington has a standing order for each of the 80,000 technical reports deposited annually at the United States Department of Commerce's National Technical

Information Service. [49] When asked to send specific specialists to international conferences, the Soviets would often not send the individual requested, but someone who could make the best use of the material being presented. [50] Their effort even extended to the point that select Soviet lawyers were trained to be experts in western corporate law, so as to be able to take every advantage of trade negotiations. [51]

On the illegal side of collection, Soviet efforts were no less intense. If the direct transfer of technology or equipment to the East was prohibited by trade restrictions, the Soviet Union had a network of operatives and front organizations that would attempt to transfer the desired material through apparently legal transactions until it was safely in Soviet hands. [52] Using agents, co-opting citizens, taking advantage of unsuspecting businessmen and moving goods through neutral and third world countries, the Soviets were able to collect western technology that might otherwise have been denied to them. [53] It has been estimated that 80% of KGB operations in the U.S. are dedicated to the undramatic, year-in-year-out collection of technical data. [54] The Soviet Consulate General in San Francisco was believed to have 30 technically trained intelligence personnel targeted specifically against Bay Area electronics firms and the micro-processing industry in California's 'Silicon Valley.' [55] Still, while highly publicized because of the types of items targeted and the notoriety of such operations, these efforts account for but a small portion of the flow of technical information from West to East. The majority of the technology obtained by the U.S.S.R. and its allies comes from open sources and trade on the world market. [56]

The Western Response--Export Controls and CoCom [57]

The western response to this collection effort has been to try and impose a number of limits or controls on the types and amounts of technology that are allowed to pass from West to East. Individual countries have always controlled imports and exports across their borders, normally regulated by customs agents or other government officials, so that the concept of export regulation is not a new one. What was new in this case was the size and nature of the task that faced the West in monitoring what was being sent to the East. Not only was the scope of Soviet operations enormous, but the problem of control was further complicated by the growing number and complexity of the technologies involved. Added to this was the fact that any attempt at export controls that hoped to be effective had to be coordinated and agreed upon by all those possessing the technologies involved. It did little good for one country to refuse to export a given technology for security or other reasons, when the same item or technology could be readily obtained from another source. [58]

To meet this challenge, the countries of the West in 1949 formed the Coordinating Committee for Multilateral Export Controls, or CoCom as it has come to be known. Born out of cold war fears that sensitive western technology which could bolster Soviet military capabilities might be transported to the East, CoCom has been characterized as a "gentlemen's agreement" to coordinate both the technologies that should be prohibited from export and the actions taken to prevent such transfers. [59] Early members of CoCom included the United States, Great Britain, France, Italy, the Netherlands, Belgium, Luxemburg, Norway, Canada, West Germany, Portugal, Japan, Greece and Turkey. [60] Technologically advanced neutrals such as Sweden, Switzerland, Austria and Finland did not join, fearing that such a move would threaten their neutrality. However, while these countries have often been cited as alternative sources of advanced technology, they have, for the most part, informally abided by CoCom guidelines, partly out of fear of unduly antagonizing the West and jeopardizing their own access to advanced technologies, and partly because of their own security concerns. [61] Member nations agreed to respect CoCom guidelines once established, though enforcement of those guidelines was left in the hands of the individual nations.

While the operation of CoCom has been shrouded in some degree of secrecy, its day to day activities include: "the development of lists of technologies and products that will be embargoed, controlled, or monitored; weekly consultations on exceptions to these lists; and consultation on enforcement." [62] In terms of materials subject to export control, three lists are maintained:

> 1) a munitions list, covering all items of military equipment or significance,
> 2) an atomic energy list, including sources of fissionable materials, nuclear reactors and their components, and
> 3) a list of industrial/commercial items. [63]

Consultations are held on a regular basis to consider requests by individual nations for exceptions to CoCom guidance in cases where questions arise on whether the export of a specific piece of equipment or technology violates established guidelines. Enforcement meetings coordinate actions of the member nations to ensure that guidelines are not circumvented.

The effectiveness of CoCom in preventing the transfer of technologies from passing East is a topic of some debate, and underscores the many problems involved in trying to monitor and control such an immense area as East-West trade. One of the greatest problems facing CoCom as an agency is that compliance with CoCom guidelines is voluntary in nature, with no formal mechanisms for enforcement. While the member nations, as a rule, have been willing to comply in theory, the actual efforts on the part of member nations to monitor and control the export of items on the CoCom lists have depended on the resources that each nation has been wiling to expend. In the case of the United States and Great Britain, these efforts have been fairly extensive; in the case of some of the smaller nations, with fewer resources to dedicate to maintaining export controls, these efforts have tended to suffer. Finally, in spite of the attention given in the press and government circles to the illegal transfers of technology that CoCom was designed to prevent, these efforts form only a small percentage of the Soviet collection effort. The majority of the technology being transferred to the Soviet Union, in terms of trade and technical material, is being obtained legally and is not subject to CoCom control. [64] Thus, while the argument can be made that CoCom has been successful in preventing certain militarily sensitive technologies from reaching the Soviet Union, in terms of the overall flow of technology these form but a small percentage of the flow and are in an area where the Soviets have shown a substantial capability in generating technologies of their own.

Evaluating the Significance of Western Technology

In evaluating the significance western technology has had for the Soviet system as a whole, it is worthwhile to look briefly at two cases where western inputs have played a part in the development of specific areas of Soviet industry. As a caveat, it should be noted that such examinations can at best be general in nature, are open to interpretation, and as such often reflect the bias of the observer. An example of the ambiguities involved can be seen in the literature on the Kama Truck Plant. Thane Gustafson has cited this as a case where the Soviet Union already possessed the basic technology needed to build the complex, and that western input was only "a reinforcement of the Soviets' already considerable skill." [65] At the same time, however, a Deputy Minister in the Soviet automobile industry has written that, "It would have been hard to create such a large modern enterprise (as Kama)...without technical cooperation, which draws on all the best available in the country and abroad." [66] Still, even with such differing viewpoints, it may be beneficial to look at these examples, for they demonstrate two different approaches to the use of western technology by the Soviet Union, with two different results.

The first of these examples is the Soviet chemical industry. [67] Created in the 1930s with western assistance, by the late 1950s the chemical industry found itself approximately ten years behind the West in technical ability and incapable of meeting the needs of the country. [68] At this point, a campaign was launched to modernize the industry that included massive purchases of western machinery; literally entire plants were imported from the West and installed. The results of this campaign were both impressive in terms of the production increases achieved and instructive from the standpoint of the Soviet use of western technology. By 1971, the chemical industry was hailed by the Soviets as achieving the greatest rate of growth of any industry in the past l5 years; what was left unsaid was that it was also the industry most heavily dependent on western machinery. [69] In just one case, showing the degree of this dependence, by the end of the 1970s, western equipment accounted for over two-thirds of the Soviet output of synthetic fibers. [70] Further, the Soviet reliance on foreign imports may have inhibited the growth of indigenous Soviet research and development in chemicals. As Gustafson notes, "Twenty years of western technological assistance has not provided an independent innovative capacity that can support the further advance of the industry." [71] Thus, while increases in production were achieved through the transfer of technology in terms of machinery, the impact, in terms of learning from this technology and developing an independent capability in this area, was limited at best.

The case of the Soviet computer industry represents a different approach by the Soviets to the use of western technology. Soviet computer development began in the early 1950s and was considered to be within a year of the West when a decision was made to downplay the use of computers. [72] This attitude did not change until the early 1960s when the Soviets realized the potential significance of computers for the military and initiated a crash program to catch up with the West. [73] These attempts were unsuccessful until the late 1960s, when the

Soviets illegally acquired an IBM 360 which became the basis of their Ryad series computers, still in use today. [74] While a copy of the IBM machine, the Ryad was the result of Soviet efforts to understand the technologies involved in order to bring the machine into production and use. [75] This was necessitated in part by western restrictions on computer sales to the East, but was also driven by the Soviets' desire to be self-sufficient in an area of strategic importance.

Taken together, these two cases reflect not only differences in the Soviet approach to using western technology, but differences in the resulting degree of dependence upon the West. For the chemical industry, massive imports provided a jump in production capability but did little to increase the potential for further independent development; to progress beyond the current stage required still further imports of western material. In computers, short term gains were less pronounced because of the approach used, but may have been balanced by the attempt to at least maintain the basis of an independent computer R&D infrastructure, and thus avoiding dependency. As Gustafson notes, "In the case of computers, instead of accepting dependence on the West, the Soviets have made a serious effort to develop their own independent capabilities." [76]

Having looked at why western technology is needed by the Soviet Union and the process by which it is obtained, it may be worthwhile to speculate about what the Soviet Union hoped to achieve through such imports and whether these imports achieved Soviet expectations. What is the true value of the western technology to the Soviets, and has it led to a significant increase in their industrial capability vis-a-vis the West? The key issue here is the ability of the Soviets to make use of the information and materiel they receive from the West, for "it is only when imported technology can be fully absorbed in the economy and improved upon that technological gaps can be reduced." [77] In terms of knowledge, the essence of disembodied technology, the Soviet collection efforts have amassed huge amounts of western technical material. In the area of technical literature alone, the Soviets have literally thousands of specialists whose sole purpose is to examine and digest this material, keeping them abreast of western 'state-of-the-art.' [78] This knowledge is further supplemented by Soviet capabilities in reverse engineering--the examination of finished products to determine the procedures used in their production. U.S. government officials estimate that the Soviets have saved billions of dollars in R&D costs for advanced micro-circuitry alone through such methods. [79] Countering this impressive collection of information, however, there are signs that obtaining this information and being able to put it to use have proven two different things for the Soviet Union. For all the effort that has gone into the collection process, the general state of Soviet industry suggests that the information gathered has not been translated into improved industrial capability. One East European source has estimated that it took an average of five to seven years to copy a western product and bring it into production. [80] This difficulty in bridging the gap from theory to practice and applying the western knowledge that has been gained, has been a severely limiting factor for the Soviet use of western technical information. "A foreign patent..(as one observer comments)...will be more difficult to use than a fully built foreign plant." [81]

With respect to embodied technology, the benefits have been more direct. By importing machinery and equipment, the Soviet Union has been able to overcome shortfalls in production capabilities and shore up weak areas in its industrial development. However, as was seen in the case of the Soviet chemical industry, this has not contributed to the ability to progress beyond the level of the technology at the time of the transfer, and may even hinder further development by undercutting the need for an independent R&D base. Indeed, there would seem little incentive for spending precious time and resources in developing domestic designs when it is quicker and cheaper to 'buy it from the West.' Problems also exist with incorporating western equipment into Soviet production cycles. The Soviet press has reported that "great amounts of western equipment and material have simply gone to waste," because of problems with compatibility and integration. [82] Such problems reflect back on the weakness of Soviet innovation, which also affects the ability to take full advantage of western material.

What has been missing from both of these efforts is the third element of the model for effectively transferring technology outlined in the first chapter, the transfer of know-how, primarily through personal contact, or the 'human element'. While the Soviet Union prior to 1985 was active in its acquisition of both equipment and information, the Soviet government was reticent about allowing either Soviet specialists to travel to the West, or allowing western specialists into the Soviet Union. Part of this can be traced to the fear of outsiders that was one of the pillars on which Stalin's reign was built; part, as well, may have been the unwillingness to allow outsiders to see first hand the problems with the Soviet system that were known to exist, but which the authorities where loath to admit. [83] As a minimum, this failure slowed the integration process for those technologies that arrived without sufficient know-how to incorporate them; in the worst case, failure to allow for the transfer of know-how made those technologies which were obtained from the West next to worthless. In the late 1970s and early 1980s this problem appeared to be recognized by the Soviets themselves, as a trend developed for favoring cooperative production arrangements, where Soviet specialists would work with western personnel associated with a newly purchased facility, easing the implementation of new methods and procedures. [84] Still, it would not be until the Gorbachev era that official hesitation about allowing Soviet citizens to work with westerners would take a dramatic shift.

This is not to imply that technology transfers up until 1985 did not have their uses or benefits. They have helped the Soviet Union to bridge critical economic gaps at minimum cost to domestic R&D resources, and allowed the Soviets to concentrate their efforts on areas they considered to be of strategic importance. [85] Western imports also allowed the Soviets to modernize sectors of their industry which, because of a lack of internal resources or development, might otherwise have remained backward by western standards. [86] In a few cases, improvement due to western imports has been dramatic; in most cases, the direct improvements were modest at best. [87] Yet without western technology, the Soviets would have had to reevaluate their decisions on resource allocation. Soviet capabilities were such that eventually they could have produced any item they received from the West, but at a substantially greater cost in resources. [88] With limited resources, however, they could not have produced everything they needed through their own efforts, and would have had to redirect or restrict many of their initiatives. Thus western technology has been invaluable as a kind of buffer that helped make up for the economic shortcomings of the Soviet system.

What western technology did not do for the Soviet Union was help it achieve its stated goal of catching up with the West economically. [89] Even with all of its efforts at obtaining western technology, the best that can be said is the Soviet Union has avoided falling further behind than it already was, and even this claim may be questioned in light of recent events. [90] Also, contrary to what is assumed in most popular literature on the subject, western technology probably has not contributed as significantly to the Soviet defense effort as some would like to believe, simply because the Soviet Union placed its highest priority, along with its best scientific minds and material, on military development. [91] This does not mean that the Soviets did not try to obtain western military technology where they felt it might help, but their capabilities are such that if they saw a need in this area, they did whatever was necessary to fulfil that need.

The most important point in all this, however, may be that in terms of increasing Soviet capabilities, western technology has not given the Soviet Union the ability to innovate and take full advantage of the material that it receives from the West. As has been seen, the Soviet Union is as much in need of expertise in integrating technologies into existing systems as it is of new technology itself. The Soviet Union has become very adept at obtaining western material, but its record for using western technology as a basis for its own innovations and advances in technological skill is mediocre at best. The Soviets realize their deficiencies in this area and have tried to correct them; however, the very nature of their system works against such changes. Thus, they have been caught in a cycle that fosters dependency upon the West.

Summary

In summarizing what has been seen with regard to the Soviet use of western technology, a number of points come to mind. There seems little question that the Soviet Union has a history of turning to the West to obtain technology and technical assistance, either in areas where the Soviets were deficient themselves, or where it was cheaper to obtain what was needed from the West than to go through the process of domestic development. This has been due, in part, to the problems caused by the nature of the Soviet economic system itself, a system that is resource intensive in its approach to development. By stressing output over efficiency, this system drives up the cost of production while at the same time impeding development by failing to offer incentives for domestic innovation. In those areas where the Soviets have felt the need to innovate, as in the case of defense, they have proven the ability to do so, but at a cost much higher than would be needed to achieve the same results in the West. Also, because of the limited amount of resources available within the system, dedicating resources, both human and material, to certain areas of the economy has meant a shortage of resources available to other areas, and resulted in uneven economic development overall. This, in turn, has reinforced the need to borrow from the West as a 'quick fix' for the failure of the Soviet Union to develop in these other areas, and has compounded the problems by undercutting the development of an infrastructure that might otherwise have supported domestic development.

To gain the information and material that the Soviet Union needs from the West, the Soviets have over the years established a tremendous collection effort to obtain western technology in all its various forms. While comprising both overt and covert means, i.e. legal and illegal, the majority of these efforts, in terms of trade and obtaining technical documentation, have not violated the restrictions emplaced against this collection effort. Monitored by CoCom, these restrictions have tended to center around technologies that have military application or are in other ways sensitive. While evaluations of the effectiveness of these efforts at control vary, what is key for this analysis is that the CoCom restrictions do little to address what has been a major thrust of Soviet efforts in this area, the exploitation of open source material and literature.

Finally, while there have been various studies as to the effectiveness of Soviet use of the western technology that they have gained through this collection effort, the most telling conclusion that can be drawn is that overall, in spite of the efforts they have made, they have failed in taking advantage of what they have obtained in order to close the technological gap between themselves and the West. The reasons for this are complex, and go far beyond the scope of this study; for the proof, however, one need only to look at the state of the Soviet economy today. If the measure of a successful technology transfer is "that it increases the technological skill of those receiving the technology," [92] then it would appear that very little technology has been transferred to the Soviet Union. Still, there are cases where the use of western technology has appeared to have had more of an impact than others, and these may shed some light on ways in which western technology has benefited the Soviet Union, and conversely explain those where it has not. With this in mind, the next step is to return to the area that is the focus of this study, and has been a focus of Soviet efforts to catch up with the West by using western technology: the case of Soviet computers.

ENDNOTES

1 While the stories of Peter's enchantment with western technology probably have grown over the years in the western histories of Russia, there is still little question either about his desire to modernize his country using foreign technology, or about the problems that this caused him at home because of internal opposition to these policies.

2 An excellent history of this period, with supporting data, can be found in chapters IV and V of P.I. Lyashchenko's two volume History of the Economy of the USSR, (Moscow: Government Publisher of Political Literature, 1956), vol. II, pp. 112-172. A more concise version can be found in William L. Blackwell's The Industrialization of Russia-An Historical Perspective, (Arlington Heights: Harlan Davidson, Inc., 1982), pp. 33-35.

3 While representing an extremist view, one of the harshest critiques of Gorbachev comes from Pamyat, the radical nationalist group that condemns any western inputs into Russian society. Even more reasoned observers, however, stress the point that the Soviet Union should not adapt western ways, but should develop in its own manner. See Mikhail Antonov, "Go in one's own way," Molodaya gvardiya, no. 1, 1988., pp. 195-200.

4 In addition to Anthony Sutton's monumental work, others worth noting are Phillip Hanson's, Trade and Technology in Soviet-Western Relations, (New York: Columbia University Press, 1981), George Holliday's, Technology Transfer to the USSR, 1928-1937 and 1966-1975: the Role of Western Technology in Soviet Economic Development, (Boulder: Westview Press, 1978), and Mikael Sandberg's, Learning from Capitalists--A Study of Soviet Assimilation of Western Technology, (Goteborg: Almqvist & Wiksell International, 1989). Attempts to measure the effect of technology transfer on industrial growth in the Soviet Union include, M. L. Weitzman, "Soviet Post-War Growth and Capital-Labor Substitution", American Economic Review, vol. 60, no. 4 (September 1970), pp. 676-692; S. Gomulka, "Soviet Post-War Industrial Growth, Capital-Labor Substitution and Technical Change: A Re-examination", in Z. M. Fallenbuchl ed., Economic Development in the Soviet Union and Eastern Europe, vol. 2, (New

York: Praeger, 1975), pp. 3-47; and P. Desai, "The Production Function and Technical Change in Post-War Soviet Industry: A Re-examination", American Economic Review, vol. 66, no. 3 (June 1976), pp. 372-382.

5 U.S. Congress, Office of Technology Assessment, Technology and East-West Trade, (Washington, D.C.: Government Printing Office, 1979), p. 206.

6 Anthony C Sutton, Western Technology and Soviet Economic Development, vol. II (Stanford: Hoover Institution Press, 1973), p. 16.

7 J. Fred Bucy, "Technology Transfer and East-West Trade: A Reappraisal," International Security, Winter 1980/81, (vol. 5, no. 3), p. 145.

8 Mark E. Miller, "The Role of Western Technology In Soviet Strategy," ORBIS, Fall 1978, p. 558.

9 Sutton, Western Technology and Soviet Economic Development, vol. III, p. 357.

10 As an example of the impression that western trucks made on the Soviet Union, it was remarked to the author by a Soviet emigre that years later the word 'Studebaker' was taken as a sign of the highest quality possible. In a case where western aircraft designs were copied by the Soviets, at the end of the war an American B-29 bomber was forced by mechanical difficulties to land on Soviet soil. While the crew was returned, the airplane was impounded and became the model for TU-4 bomber designed by Tupolov.

11 Sylvain Wickham, "Transfer of Western Technology to the USA: Conditions for the l98Os," NATO Review, December 1981, p. 19.

12 Ibid. See also the figures for U.S.-Soviet trade for the period 1978 to 1988 in an article by Leanne Grossman, "U.S. and Soviet Officials Discuss Trade Expansion, Announce Several Agreements," Business America, 4 December 1989, p. 24. It should be noted that such figures do present some problems in terms of analyzing their true significance. As pointed out by Professor Phillip Hanson, a better measure of the importance of these imports would be to determine their share of the total

amount invested in equipment. While difficult to determine for Soviet industry overall, in certain areas, as in the case of the Soviet Chemical Industry, there are examples where the percentage invested in western machinery has been substantial, over 50 percent according to some sources.

13 Sutton, Western Technology and Soviet Economic Development, vol. III, p. XXV.

14 Thane Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, (Santa Monica: Rand, April 1981), p. 20.

15 U.S. Congress, Technology and East-West Trade, p. 210.

16 Interview with LTC James Wright, Assistant Director, School of International Studies, Ft. Bragg, NC, 13 April 1982.

17 Complaints about Soviet TV sets are almost legendary. Because of the rush to fulfill monthly plans, these sets prove to be extremely unreliable, and are often sighted as a leading cause of fires in Soviet homes. Data published in Ekonomika i zhizn (no. 28, July 1990) registered consumer complaints about color TVs at over 20%.

18 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 20.

19 Miller, "The Role of Western Technology In Soviet Strategy," p. 547.

20 Ibid., p. 548.

21 Paul R. Gregory and Robert C. Stuart, Soviet Economic Structure and Performance, (New York: Harper and Row, 1974), p. 5.

22 Miller, "The Role of Western Technology In Soviet Strategy," p. 544.

23 Peter L. Kahn, "Squeezing the Soviets: Will a New Cold War in High-Tech Trade Freeze the Soviet Union's War Machine?," Foreign Service Journal, February 1982, p. 27.

24 Sutton, Western Technology and Soviet Economic Development, vol. III, p. 357.

25 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 36.

26 Ibid., p. 16.

27 Ibid., p. 53.

28 Wickham, "Transfer of Western Technology to the USA: Conditions for the 1980s," p. 20.

29 John W Kiser, "What Gap? Which Gap?," Foreign Policy, Fall 1978, p. 90.

30 Interview with Professor Stephen Rosefielde, University of North Carolina, Chapel Hill, NC, 9 April 1982.

31 Interview with LTC Wright.

32 E. Willenz, Soviet Technological Progress and Western Technology Transfer to the USSR: An Analysis of Soviet Attitudes, U.S. Department of State, External Research Study, INR/XRS-35, 12 October 1978, p. 2.

33 Interview with Professor Rosefielde.

34 Kahn, "Squeezing the Soviets: Will a New Cold War in High-Tech Trade Freeze the Soviet Union's War Machine?," p. 27.

35 Willenz, Soviet Technological Progress and Western Technology Transfer to the USSR: An Analysis of Soviet Attitudes, p. 2.

36 U.S. Congress, Technology and East-West Trade, p. 241.

37 Miller, "The Role of Western Technology In Soviet Strategy," p. 544.

38 Interview with Professor Rosefielde.

39 Richard N Perle, "Raiding the Free World's Technology," Defense, February 1982, p. 14.

40 Miller, "The Role of Western Technology In Soviet Strategy," p. 563.

41 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 22.

42 Wickham, "Transfer of Western Technology to the USA: Conditions for the l980s," p. 20.

43 Willenz, Soviet Technological Progress and Western Technology Transfer to the USSR: An Analysis of Soviet Attitudes, p. 3.

44 Miller, "The Role of Western Technology In Soviet Strategy," p. 540.

45 Ibid., p. 553.

46 U.S. Congress, Technology and East-West Trade, p. 211.

47 Interview with Mr. Ron Wahaia, Defense Intelligence Agency, Washington, D.C., 2 April 1982.

48 Miller, "The Role of Western Technology In Soviet Strategy," p. 552.

49 "Soviets Walk Right in, Take American Technology Home," Chicago Tribune, 13 April 1981, sec. 2, p. 1.

50 Comments from discussions during a NATO conference attended by the author on Soviet Scientific Research, held at NATO Headquarters, Brussels, 24-26 September 1986.

51 Interview with LTC Wright.

52 Ted Agres, "The Dark Side of Technology Export: U.S. Builds Soviet War Machine," Industrial Research and Development, July 1980, p. 57.

53 Perle, "Raiding the Free World's Technology," p. 10.

54 Agres, "The Dark Side of Technology Export: U.S. Builds Soviet War Machine," p. 56.

55 Harry V Martin and Robert Carroll, "Electronic Companies Combat Increased Soviet Spying," Defense Electronics, July 1981, p. 34.

56 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 66.

57 Information on the Coordinating Committee for Multilateral Export Controls (CoCom) is restricted, owing to the nature of the organization. Much of the material in this section was confirmed in an interview with Col. John M. Carney, Military Advisor to the U.S. Delegate to CoCom, conducted at CoCom Headquarters in Paris on 18 February 1991. Other sources are as noted.

58 Interview with Col. Carney.

59 U.S. Congress, Technology and East-West Trade," p. 153. It should be emphasized that no formal agreement exists regulating the actions of CoCom, and that it has been suggested that one of the reasons for CoCom's continued operation may be due to this very lack of written regulation.

60 U.S. Congress, Technology and East-West Trade, p. 153.

61 Holman Jenkins Jr., "High Tech in State of Siege," Insight, 26 December 1988, p. 16.

62 U.S. Congress, Technology and East-West Trade, p. 155.

63 Ibid.

64 Thane Gustafson and others have made this point. While the covert collection of defense related technologies is the prime concern of both CoCom and individual governments in their national export control policies, and receives a majority of the attention given to technology transfer in the press, this makes up a relatively small percentage of the material that is actually transferred between West and East. While it can be argued that

this is precisely the material that needs to be controlled, a major contention of this paper is that the developing of the mechanisms for exploiting and domestically generating technology, which can be achieved through legal transfers, may eventually give the Soviet Union the capability of generating the technologies it needs, thus negating the effects of western controls on selected items relating to security.

65 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 23.

66 Miller, "The Role of Western Technology in Soviet Strategy," p. 558..

67 An excellent history of the development of the Soviet chemical industry can be found in Ron Amann's chapter, "The Soviet chemicalisation drive and the problem of innovation," found in Industrial Innovation in the Soviet Union, ed. Ron Amann, and Julian Cooper. (New Haven: Yale University Press, 1982) pp. 127-211.

68 U.S. Congress, Technology and East-West Trade, p. 227.

69 Miller, "The Role of Western Technology In Soviet Strategy," pp. 557-558.

70 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 22.

71 Ibid.

72 U.S. Congress, Technology and East-West Trade, p. 232.

73 Ibid., p. 233.

74 Perle, "Raiding the Free World's Technology," p. 15. It should be noted that authorities have debated exactly how much the Ryad series owes to the IBM 360. A more detailed look at this particular case can be found in the next chapter.

75 An excellent description of the Ryad can be found in N. C. Davis and S. E. Goodman's, "The Soviet Bloc's Unified System of Computers," ACM Computing Surveys, vol. 10, (June 1978), pp. 93-122.

76 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 41.

77 U.S. Congress, Technology and East-West Trade, p. 226.

78 Interview with Professor Rosefielde.

79 Martin and Carroll, "Electronic Companies Combat Increased Soviet Spying," p. 37.

80 U.S. Congress, Technology and East-West Trade, p. 223.

81 Gustafson, Selling the Russians the Rope? Soviet Technology Policy and U.S. Export Controls, p. 41.

82 Cited in Harry Anderson, "Keeping High-Tech Secrets," Newsweek, 25 January 1982, p. 36.

83 While the exact reasons may never be know, it has been speculated that one of the reasons the USSR refused to participate in the Marshall Plan after showing some early interest, was the realization by Stalin that this would mean westerners having access to the Soviet Union. Such access, the logic ran, would have allowed the West to see first hand the extent of the damage that the Soviet Union had suffered during the war, and might have tempted western governments to take advantage of the Soviet Union in its weakened state.

84 U.S. Congress, Technology and East-West Trade, p. 231.

85 Miller, "The Role of Western Technology In Soviet Strategy," p. 561. Even though changes took place during this time period, these changes still were insufficient to overcome many of the barriers that existed to increasing western involvement in Soviet industry. One of the primary of these was the prohibition on foreigners owning Soviet property and capital assets. This, in turn, limited western firms, and in particular Multi-National Corporations (MNCs) from investing in the Soviet Union, and serving as a conduit for the transfer of technology. MNCs in particular, have proven to be an important channel for international technology transfer. Whether the current changes regarding foreign ownership in the Soviet Union will reverse this situation remains to be seen.

86 Interview with LTC Wright.

87 Miller, "The Role of Western Technology In Soviet Strategy," p. 559.

88 Interview with Mr. Ron Wahaia.

89 For years the West has lived with the mistranslation of Khrushchev's comment that "We will bury you"; (his actual statement translates as "We will overtake you".) Still, the intent of this and other statements by Soviet leaders has been clear. In the competition between East and West, strength and success belonged to the system that was economically superior. The Soviet system, while being advertised as one of advanced Socialism, still started out at a comparative disadvantage to the West, and has never been able to close the gap between the two systems. Thus, the need to catch up with the West in terms of economic development has always been a goal of the Soviet leadership.

90 Computations of comparative lead times in technologies is an imprecise science at best, however such efforts continue to be made as graphic representations of the relative state of development in given areas of technology. (Yearly examples can be found in the Soviet Military Power series published by the United States Department of Defense.) It is also interesting to note that the same figures are often cited by both those arguing that the West is losing its technological advantage, and those arguing the the West's advantage is so great that there is little to be concerned about. The truth, in such cases, is in the eye of the individual interpreting the data.

91 Kahn, "Squeezing the Soviets: Will a New Cold War in High-Tech Trade Freeze the Soviet Union's War Machine?," p. 28.

92 The definition of technology transfer used in this study, as stated on p. 5 in the Introductory chapter.

CHAPTER 3--TECHNOLOGY TRANSFER AND THE EARLY DEVELOPMENT OF SOVIET COMPUTERS

Introduction

As was pointed out earlier in this work, though a phenomenon of only the last several decades, there is not a facet of life in an industrialized nation that is not affected by computerization. For any nation that wants to be competitive in the world, either economically or militarily, computers are essential. This alone is enough to explain the Soviet interest in western computer technology, for if the Soviet Union wanted to compete with the West it had to stay abreast in this vital area. But there is more to the case of Soviet computers than just a study of Soviet efforts to acquire this technology. The accomplishments of Soviet science, as have been seen, are not inconsequential, especially in those areas that were felt to be significant and warranted the priority allocation of resources. Thus, if there is an area that one would expect the Soviet Union to be able to keep up and compete with western developments, it should have been in the computing sciences. That the Soviets have not, and the reasons why they have been unable to do so, are two of the underlying themes of this study.

Few analysts, either Soviet or western, would argue that the Soviet Union is not significantly behind the West in the area of computer technology. [1] Yet in spite of Soviet efforts, which have been substantial, such is the state of affairs today. Two obvious questions then, are how did the Soviet Union allow such a situation to develop, and what has been the nature of the attempts to rectify this situation? Surely a country with its resources in skilled personnel (over one quarter of the world's engineers) and background in mathematics (key to the design and workings of all computers) should find itself leading this field, especially given the strategic importance that computers hold. [2] The answers to these questions are neither simple nor straightforward. Instead, they combine many factors which, over time, interacted in such a way as to create the current situation. To begin to unravel these answers, it is necessary to examine the history of the development of computers, both in the West and in the East.

To understand the reasons that explain the failure of Soviet science to generate its own computing technology, and the subsequent need to turn to the West for technology in this area, it is necessary to examine the early development of the Soviet computers, specifically the period 1945-1975. By tracing this development, along with the progress of western computer developments during the same time frame, it should be possible to assess the progress of each and the ties that relate each to the other. This task is complicated by the fact that the Soviet Union has been less than forthcoming with information about its industrial developments, especially in areas it feels are related to its national security. Still, by looking at the state of western computer development and comparing this with what is known of corresponding Soviet work, it should be possible to make an evaluation of the influence of West upon East. This, in turn, should allow the evaluation of the importance that western technology holds for Soviet computer development today, and may be expected to hold in the future.

A Few Words On Computer Generations

At this point, it may be worth digressing for a moment to discuss some of the technologies involved in computers and computing. Computer development is broken down loosely into 'generations', based on the types of technologies that are used. These generations, as commonly accepted, are:

First Generation--Computers having vacuum tubes as their basic components.

Second Generation--Computers using transistors in place of vacuum tubes

.

Third Generation--Computers utilizing integrated circuits as their basic components, replacing transistors [3].

It should be noted that there are no hard and fast rules in these categories, and in fact some machines may combine elements of more than one generation. More significant are the technologies themselves, for each represents a major advance in the development of the computer. These technologies, along with related developments in the areas of internal memory, input/output devices, and external storage, serve as a framework for tracing the evolution of computers and comparing the development process in the East and the West.

History [4]

The Early Years 1945-1950

The early origins of computers and computing are well documented and need only be touched on here. [5] Mechanical calculators, developed for processing large amounts of numbers in scientific problems, first appeared in the 1930s. World War II and the need to do large numbers of calculations to produce firing tables, led to the development of an electrical calculator, the ENIAC (Electronic Numerical Integrator and Computer), in 1945. [6] While a major accomplishment, the ENIAC did not have a memory that could store programs and thus was not a true computer in the sense that is recognized today. That honor was to go to the EDSAC (Electronic Delay-Storage Automatic Computer) developed at Cambridge University in 1949. [7]

In the Soviet Union, as is the case with most items that even remotely border on matters related to state security, the origins of Soviet computing are shrouded in secrecy. It is known that in 1941 the Soviets did have at least one of the early mechanical calculators. [8] After the war, they showed interest in obtaining the documentation for the ENIAC, and even tried to buy the whole machine. [9] Finally, in 1950, they built a punchcard calculator, the EV-80, that resembled the IBM 604. With this step, the Soviet Union entered the computer world.

It is interesting to note the imperatives that drove these early computer developments. In the West, a core of engineers and scientists carried out the early research and brought the importance of computers, in terms of their capabilities, to light. In the East, no such block or lobby existed, or if it did, its actions were severely curtailed. During the last years of his life, Stalin railed against the study of cybernetics, one of the elements essential to computer development. [10] In a dictatorship not known for tolerating dissenting views, this in itself was a hindrance to early research efforts. The other major group that could have spurred Soviet computer development consisted of the German scientists who had been captured and taken back to the Soviet Union at the end of World War II. While extremely gifted, their experience did not provide them with any background in this area, for the emphasis in Germany during the war had been on rocketry and atomic physics, and not on 'computing'. Anthony Sutton has even gone so far as to suggest that this lack of background among the Germans acted to curb early Soviet efforts. [11] In any case, there appears to be no Soviet counterpart to the group in the West that recognized the potential value computers held, and pushed for their development.

First Generation 1950-1957

The first generation computers that were produced in the early

1950s appear today as the Wright brothers' first plane must appear in light of modern flight and space travel. Still, their significance was in their very being, for they represented a capability that man had never had before. Further, developmental work with these early models set the stage for what was to follow.

In the West, UNIVAC I (Universal Automatic Computer-1951) became the first computer commercially available on a large scale. It was followed in the next seven years by over 300 other systems, all available to the general public. Internal memory, aided by the introduction of magnetic core memory devices (1952), increased the ability of machines to store information and the instructions needed to process this information into useful data. Input/output devices, primarily paper tape and punched cards, were slow at first, but improvements in reading devices, plus the development of buffering techniques that allowed computers to engage in more than one operation at the same time, helped to increase computing speeds. External memory was initially stored on large magnetic drums, though IBM did produce a commercially available magnetic disc storage device in 1956.

The first Soviet computer of this era was the MESM (Small Electronic Calculating Machine), designed by S. A. Lebedev of the Ukrainian Academy of Sciences and acknowledged by one western expert as "an important achievement close to the technical state of the art." [12] This was followed by the BESM-1 (Large Electronic Calculating Machine), a medium sized computer, the Strela (arrow), and a small computer, the Ural-1. Internal memory was accomplished primarily by magnetic drum; magnetic core memory was not yet available. Input/output devices were the same as the West, though the quality of Soviet paper products often led to problems with tape and punch card readers. [13] Magnetic disc storage devices were unknown. Total output for the period was extremely limited. "Between 1950 and 1959, the USSR is estimated to have produced fewer than 400 computers, most of which were the small Ural-1." [14]

Comparisons between East and West during this period reveal each of the two sides coming to grips with the new technology in their own way. While the Soviets were not, as far as can be determined, in the forefront of computer technology, neither were they very far behind. In just one example, the BESM-1 "was, in some ways comparable to the first American 'supercomputer,' the

NORC." [15] As with any new field, there were false leads. One of particular importance was the early choice by the Soviets to emphasize analog over digital computers. The latter were more capable and eventually became the world standard; the former, however, were easier to build and for a period received official favor in the Soviet hierarchy. [16] The only other major difference between the two sides is one of scale. Whereas in the West hundreds of systems were produced, with some of these systems having extended production runs, the total Soviet production of computers was less than 500. This disparity in numbers was to play a significant part in future Soviet development.

Second Generation 1957-1965

Second generation computers, as noted earlier, were distinguished by the replacement of vacuum tubes with transistors, themselves a new technology at the time. The two characteristics of computer design and performance affected by the introduction of solid state electronics were size and speed. Decreased size meant that computers of greater capacity could now be built and installed in smaller areas, making them both more functional and more available to a larger segment of their potential users. Speeds increased as a result of the decrease in size and improvements in design and manufacturing techniques.

Along with these two factors, solid state design increased reliability, something that moved computers from the realm of a scientific curiosity to an item of interest for fields ranging from engineering to business.

In the West, second generation computers became available in the late 1950s and were dominant until the mid-1960s. Improvements in core manufacture brought significant increases in internal memory capability and access time. Input/output rates for punch cards also increased, while devices such as cathode ray display and non-impact printers became more readily available. The capabilities of external storage devices also showed great increases due to the expanded use of disc storage. In terms of usage and acceptance of these new machines by the consuming public, one need only look to the example of the IBM 1400 series, where "IBM sold an estimated 15,000 of the extremely successful [series]...." [17]

Second generation Soviet computers started from the same general position as their western counterparts, but progress was slower and uneven in terms of mutually supporting developments. Magnetic cores for internal storage, used on many first generation western machines, were not seen on Soviet computers until 1958. Further, "no particularly significant technological advances were apparent in Soviet central processors and internal storage before 1965." [18] As a result, while the IBM 7030 had up to 256K of internal storage in 1961, the Ural 14 could boast only a 64K storage five years later. Input/output devices caused problems either because they were not available or they were slow and unreliable. External storage continued to depend on magnetic tape or drum, for Soviet manufacturers "had great difficulty in trying to produce magnetic storage devices." [19]

Problems of the type mentioned above were not unique to computers, but rather tended to mirror the problems encountered throughout Soviet industry. In an economy driven by command directives from above, rather than responding to market demands from below, there was little incentive for technical advancements and improvements. Development required the allocation of resources, money, skilled people, and equipment. In the Soviet Union all of these tended to be in short supply, and as noted, there was no strong sponsor or organization to provide these resources. The most likely candidate for supplying this support, the military, did not yet appreciate the full significance of computers. "Although the military had the capability to insist on the massive commitment of resources that would have been necessary to close the 'computing gap' with the West, that task was clearly not on the top of its list of priorities." [20] The absence of a market system also caused problems with the quality and suitability of those items that were produced, for there was no incentive to make computers that actually met the needs of the user. Finally, there was the question of scale and exposure. Production itself was a problem, as Soviet industry had difficulties mass-producing the complex technologies involved. As seen in the example of the IBM 1400, computers in the West were, if not common, then at least no longer unique; the more they were used, the more people were exposed to them and the faster the innovation cycle was regarding changes in their design and use. Such was not the case in the Soviet Union. While work on developments continued, these efforts were normally isolated and thus not mutually supportive. Moreover, the 'computer culture' that was developing in the West failed to materialize in the East. All these problems were characteristic of the Soviet system as a whole, and as a result the system itself can be blamed as much as any other factor for the failure of Soviet computers to keep pace with their western counterparts.

Third Generation 1965-1975

The third generation of computers brought with it the technology that, more than any other, has come to represent the computer in the eyes of the public--the integrated circuit or microchip. Computer microchips carried out the functions previously performed by transistors in the second generation; one early processing chip, the Intel 4004, replaced over 2000 transistors while taking up a fraction of the space. [21] This decrease in size, as with the transition from tubes to transistors, meant not only faster processing times, but because more chips could be packed into a computer, greater power and storage capability. Computers could be manufactured that were small enough to be used in areas where their size had previously been restrictive, and were becoming cheap enough so that they were no longer the domain of the government and major industries. Thus the advent of the microchip, possibly more than any other technology, signaled the arrival of computers as they are known today.

In the West, third generation computers were also "marked by greater modularity of design," [22] that is, they could be broken down and configured to meet the needs of individual users while still maintaining compatibility. Perhaps the most famous of these computers and one of the most popular, with over 35,000 units produced by 1970, was the IBM 360. [23] Its processor and internal storage, benefitting from integrated circuitry, recorded impressive improvements in operational times. Its performance was further aided by the general use of magnetic disks for external storage. Another factor in the success of this system was the large number of Input/Output devices and peripherals developed to support the line. The overall capabilities of this and other machines of the third generation, combined with the ability to adapt to the needs of the user, played a large role in expanding the use of computers beyond the traditional areas of science and technology and into the texture of society as a whole.

At the time that the West was producing its third generation computers, the Soviets were at least a generation behind. Their largest computer of the era, the BESM-6 (of which 150 were produced during a twelve year period), was much less powerful than its western counterparts. Its performance, in the words of one expert, "was severely degraded by a slow and inadequate core memory and by a lack of suitable and reliable peripherals (magnetic secondary storage and input/output devices)." [24] The first significant Soviet third generation computers to appear in the mid-seventies were models of the Unified System series of computers, commonly referred to as the Ryad (the Russian word for series or line). These computers were noteworthy in a number of respects. Their performance, while not up to western levels and marred by technical flaws, was nonetheless impressive and represented a major leap in Soviet capability. Like western third generation computers, Ryad was a modular series designed to provide compatibility throughout a number of layers of users. It represented a joint effort on the part of the Soviet Bloc as a whole, with the countries of Eastern Europe sharing development and manufacturing responsibilities. Their most significant feature, however, was that these computers relied on third generation technology that had come from the West rather than from domestic efforts. According to Seymour Goodman, one of the West's leading specialists on Soviet computing technology, "The entire project [had] been based on a massive transfer of western technology." [25]

Soviet third generation computers marked a watershed of sorts in Soviet computing for a number of reasons. While their first and second generation predecessors had appeared within a year or two of comparable machines in the West, the Soviet third generation was a full ten years behind the western lead. Indeed, while the

West had been operating at the third generation level for several years, the Soviets were still developing and introducing new second generation machines. This phenomenon did not go unnoticed in either the West or the East. In the former, writings began to emphasize the 'gap' in the capabilities between the two Blocs in the computer field; in the East, though obviously not publicized, it appears that the gap was strongly debated at the highest levels of the party and the government. [26] The results of these debates are evidenced in the nature of the third generation that eventually appeared, for the Ryad series was designed to take advantage of and emulate western developments of the day. Soviet first and second generation computers, while sometimes borrowing from the West in terms of basic knowledge and technologies, were still independent efforts that reflected their own designs and innovation. In sharp contrast, this was the first time that the Soviets had consciously sought to obtain and duplicate western efforts rather than rely on their own developments and initiative. The reasons behind this decision will be examined shortly. For now, it is sufficient to note that as of the third generation of Soviet computers there has been a conscious and continuous effort on the part of the Soviet Union to use technology transferred from the West to aid in its computer development.

The Extent of the Western Influence on Soviet Computers

Having looked at the development of first, second and third generation computers in both the West and the East, it should be possible to make an evaluation as to the extent that the former have affected the latter. As noted earlier, this is far from an easy task for a number of reasons, among them being the lack of information available from the Soviet Union and the general unwillingness to admit, much less discuss, efforts at obtaining western technology. Still, based on what has been established, it is possible to draw some conclusions as to the extent western technology has been used to assist Soviet developments, the effect these inputs have had on the overall development of Soviet computer capabilities, and finally, what implications this may have for western decision makers who must deal with questions concerning the transfer of technology to the East.

The first years of Soviet computing seem to owe little to western efforts or inputs.

> By world standards, the Soviet computer industry got off to a good start in the early 1950s.
> Accomplishments included one of the first electronic

> digital computers with internal program storage, a large scale scientific computer, and the serial production of a small general purpose machine. By 1953, the year that Stalin died, the Soviets were a respectable third, after the US and UK, on the world computing scene. [27]

As has been noted, early computer development efforts were somewhat hampered by the lack of a strong sponsor or supporting group within the Soviet bureaucracy. However, those efforts that did take place were basically sound and produced creditable results. Early developments may have paralleled the West in some respects, but this is to be expected with emerging technologies where the development of similar ideas may occur in several places at the same time. Further, even in those cases where the concepts involved had their origins in the West, the machines that resulted were distinctly Soviet in conception and design. Even if the Soviet Union was behind the West in some areas, the evidence suggests it was still progressing fairly well with domestic efforts.

The gap between western and eastern capabilities began to grow with the second generation of computers. While it has been suggested by some that the Soviets were already committed to copying the West, this does not appear to be the case. "Soviet progress was not insignificant: a number of new models (not terribly innovative but not close, compatible copies of Western machines) appeared during this period, and there was something of a 'love affair' with cybernetics." [28] The major problem for the Soviets was not one of theory but manufacture, due in large part to problems endemic to Soviet industry as a whole. As the Soviet Union began to fall behind in the implementation of computer technologies, a debate arose within Soviet computer circles. "The Slavophiles, followers of the academician Sergei A. Lebedev, argued that regardless of what was happening in the West, the Soviet Union must continue developing its own line of computers. The Westernizers, worried by the accelerated computer production in the United States, Europe, and Japan, lobbied for copying western designs--and the Westernizers prevailed." [29] The Westernizers carried the day, and with their victory began the wholesale copying of western computer designs evidenced in the third generation of Soviet computers.

This decision to try to stay abreast with the West by co-opting western technology had several impacts on the Soviet computer industry. In effect, it "passed a no confidence vote on the emerging Soviet electronics and computer industry because it failed to come up with the supporting computer systems to match the USA. ... [with the result that] ... Domestic projects were scrapped." [30] As a result of this decision, imports of western related computer technology rose sharply, from $5,000 in 1965 to over $1 million in 1967. [31] Beginning with the third generation, almost every major Soviet system has been based on Western designs; in some instances the copies were so close to the originals that they even included Western part numbers. [32] Thus, because of a conscious decision on the part of the Soviet leadership in the 1960s to rely on imported technology to make up for the shortcomings in their own industrial production, western technology has become the leading influence on the development of Soviet computers. As one commentator notes, "The bureaucratic party attitude became 'West is best; East is least.'" [33]

The period from 1975 to the beginning of the Gorbachev era represented little change in the patterns established in the previous ten years. In terms of imports of computers and computer related material, "data in the volume of Vneshnyaya Torgovlya on trade in computers (is) very sparse and since 1984 no data (has) been published." [34] The data that is available shows an increase in imports of computers, in millions of rubles, from 1975 to 1982, followed by a decline in 1983 and 1984. However when figures are added in for imports of 'computer parts' this upward trend continues. [35] While rough at best, these figures seem to bear out belief that the Soviet Union was dependent, to a substantial degree, on imports of foreign computer technology to support its domestic market. An equally telling fact would seem to be that in the same period, Soviet domestic computer designs have all but disappeared from view. Those new computers that did appear, as the Agat, a Soviet version of the Apple II, were shameless copies of western designs. [36]

The Effect of Technology Transfer on Soviet Computer Development

The key element to be determined in the issue of technology transfer as it relates to Soviet computers, is the effect that such transfers have had on the overall level of Soviet development in this area. As has been shown, the Soviets began with an independent capability in early computers that, while lagging behind the leaders in the West, nonetheless showed promise and seemed to fulfill the needs of the country at that time. The realization of the importance of computers, however, combined with the inability of Soviet efforts to keep abreast with western developments, led to the decision to actively seek western technology in order to bridge the gap that was developing between East and West. The rationale for this decision was fairly obvious, and has been applied to other areas of the Soviet economy as well. Not only would the Soviets be able to keep within striking distance of the leading western technologies by copying western developments, but they would save millions and possibly billions of dollars in research and development costs. In an environment where resources are limited at best, this had to be an attractive incentive. This co-opting of established western designs was carried out to the extent that, in the case of the Ryad system of computers, not only was the system designed to take advantage of the large amount of software that was available for the IBM 360, but technical manuals were direct translations of the original documentation. [37] While the theory and rationale behind the decision to borrow from the West is clear, the two questions that arise from the implementation of these policies are, were they successful in achieving what they hoped to do in terms of closing the computing gap between East and West, and what have been the consequences of this decision for Soviet computer development?

Initially, it would seem that the Soviets did achieve at least part of their objective. While evaluations of Soviet capabilities in the late 1960s placed the Soviets ten to fifteen years behind the West, by the mid-1970s this estimate had been cut to four to six years by at least one western observer. [38] The introduction of the Ryad, after some initial technical problems, was heralded as a great advance in Eastern Bloc capabilities, and did in fact allow for the exploitation of a large amount of western assets built around the IBM 360 series. Other Soviet computer systems were developed that closely paralleled western computers, often being built around established western processor chips. All these facts have led Goodman and his colleague Bill McHenry to state that, "The Soviets have progressed well beyond what existed around 1970, and their earlier history is such that it is unlikely that they would have come as far since then without the intensive pursuit of technology transfer." [39]

There exists, however, an equally convincing body of evidence that the import of western technology has not been the panacea that people in both the West and the East might have thought. In the first place, western embargoes on leading technologies, especially in areas such as computers, if not keeping western computers out of Soviet hands, at least made them more difficult to obtain, and prohibited the Soviet Union from buying large amounts of any but the simplest computer. Second, in those cases where western computers and computer technology were imported, there have often been problems with its incorporation and effective use. Stories where western computers were imported, only to stand idle because they could not be successfully integrated, often appeared in the Soviet press of the 1960s and 1970s. More recently, the growing complexity of the technologies involved has made their absorption even more difficult. Underlying these problems are the same difficulties that led to the original decision to import western technology, the inability of Soviet industry to produce domestically the computers necessary to meet the country's needs. In the words of one leading Soviet computer official, "We have no industrial base to make the necessary computers." [40]

What the observer of this process is left with is a paradox, in that while the Soviets sought to close the computer gap between East and West by importing western technology, they may in fact have reinforced the problems that led to that gap in the first place. When they turned to the West, the Soviets shelved their own domestic efforts--efforts that while lagging behind those of the West, nevertheless gave them an independent capability in an area of critical importance. By relying on the acquisition of western technology, they condemned themselves to a perpetual second place in computer development. While it may have been hoped that western technology would allow the Soviet Union to catch up and overtake the West, this does not appear to be the case. In shifting resources away from their domestic efforts to copying those of the West, the Soviets sacrificed the infrastructure their industry needed to be an innovative force of its own. In short, by relying on the West, "The Soviet Union has failed to develop an indigenous computer and electronics industry which can produce volume, or surpass western technical excellence." [41] Thus, what may have been a short-term gain for the Soviets from the infusion of western technology, resulted in a long term loss because of the failure to develop their own capabilities in this area.

Technology Transfer and the Role of Export Controls

From what has been seen in the case of Soviet computers, several observations can be drawn that may be useful in the analysis of the process of technology transfer. The first point, which has been made before in general terms but which is especially borne out by this case, is that the Soviet Union hoped, through inputs of foreign technology, to strengthen its domestic abilities in this area. Rather then merely being an effort to explore what was available, as a means of staying abreast with developments in the rest of the world, this was a full scale effort to obtain and copy proven western designs.

> Since the early 1970s, there has been a drastic change in the character of Soviet hardware. Before then there had been Western influence in the designs of Soviet computer equipment, but not much close functional duplication, that is, the use of the same architecture, instruction sets, and data interfaces. In the last 12-15 years, functional duplication of well established US systems has become the rule. [42]

That the Soviets hoped to do this seems obvious from what has been outlined above. The goal of the policy after the 1970s was one of wholesale assimilation of western technology, often at the expense of domestic designs, in an effort to keep up with the West.

This does not, however, necessarily mean that the Soviet Union achieved what it set out to accomplish in terms of keeping up with the West and even closing the gap. Though unknown at the time because of a lack of information in the West, it now appears that Soviet successes with this policy were limited at best. Even in those instances where they succeeded in obtaining advanced microelectronic technologies, there were problems in exploiting these technologies, and in taking full advantage of the information that was gained. One western expert categorizes these problems into three basic failures with regard to computers: the failure to be able to mass produce the copied technology, the failure to be able to ensure reliability and quality control, and the failure to generate independent domestic efforts using imported technology. [43] While the technical details of these difficulties go beyond the scope of this paper, the same types of difficulties can be seen in other areas of the economy as well. In the words of one Soviet official, "We don't lag behind the U.S. in basic research .... But when it comes to adapting scientific discoveries to industry, we have a problem." [44]

With regard to export control, it is sometimes heard that western efforts at controlling the flow of western technology have been responsible, to a large degree, for Soviet failures to develope a strong computer industry. According to the logic of this argument, by denying the most advanced computers and technologies through export controls, the West has been able to keep the Soviet Union in a position of inferiority vis-a-vis the West. The part that export controls have played in the failure of the Soviets to develop a western style computer industry, however, appears limited at best. While it is true that the Soviets did attempt to obtain restricted computer technology, and that western efforts often did prevent high end computer equipment from reaching the East, [45] the Soviet problems with using and integrating the computer technology that they obtained legally suggests that even if they had been able to obtain more sophisticated machinery, it would have been next to worthless in upgrading the general level of computing in the Soviet Union. While such computers probably would have gone to the defense sector, which admittedly has a better record in terms of innovation and those skills needed to take advantage of the things that western technology has to offer, compartmentalization of information, as well as the limited numbers of such computers involved, would have made their impact minimal at best. In the one case where an illegally obtained western computer was the basis of a relatively successful wide scale application, the Ryad, the problems involved along with the amount of time that it took to develop and put this series into operation were excessive. [46] This, in turn, leads to serious questions as to the utility of such efforts, in terms of obtaining such material in the case of the Soviet Union, or trying to protect such material in the case of the West. The Soviet inability to effectively make use of transferred technology has led some commentators, with an element of irony based in truth, to suggest that the worst thing that the West could do to the Soviet Union would be to flood the country with the latest in computer technology in an attempt to overload a system ill equipped to deal with these technologies, and leading to a catastrophic breakdown.

What significance do these observations hold then for policy in the area of technology transfer and export controls? Returning to the model proposed in the opening chapters, technology can be transferred three general ways: in products, in information about these products and in the capability to turn information into products or know-how. Western efforts have tended to focus on controlling the first of these, especially the most advanced in terms of technology, and to a lesser degree the second; they have only focused on the third in terms of the transfer of production capabilities that integrate all three. [47] This emphasis can be justified in that, until recently, the major Soviet emphasis has also been on acquiring hardware and information, though it can be argued that the main weakness of the Soviets with regard to computers has been in the third of these areas. Even when they were able to get western computing technology, legally or otherwise, the Soviet inability to take advantage of this material, as well as to reproduce it in large quantities so as to have a significant effect on the rest of society, reflected their deficiencies both in the areas of innovation and production. Further, by shelving their domestic efforts in order to pursue those originating in the West, the Soviets reinforced these weaknesses, for as long as they continued to copy western technology, they were never able to develop the ability to generate technologies of their own. Returning to Kurth's description of the production cycle, the failure to develop an independent production capability and the ability to modify and innovate both hampers domestic development and maintains a situation of dependency on outside sources. In the case of Soviet computers, the failure to either master domestic production or obtain foreign production capabilities has been a major stumbling bloc in establishing the type of domestic infrastructure in computing that might have brought Soviet development in this area far further than it has to date.

Summary

In summary, what has been seen is the evolution of a sector of the Soviet economy that is of great importance to the Soviet

Union's survival and economic well-being. Paradoxically, it is also an area in which the Soviets find themselves reliant upon the West, their long time ideological enemy, for technology and industrial know-how. What is even more intriguing is that this state of affairs came about as the result of conscious decisions by high-ranking officials of the party and state. While these decisions were intended to allow the Soviet Union to catch up to the West, the result has been to limit research and development efforts--efforts that might eventually have provided the Soviet Union with an independent capability in the field of computers. That the Soviets possessed the beginnings of such a capability is reflected in their work through the second generation of their computers. That this capability was either sacrificed entirely, or at least severely curtailed, is witnessed by the fact that all major Soviet computers since then have been based on western designs already in existence.

This does not necessarily mean that the USSR is a 'computer cripple.' "Although the majority of the Soviet computers are based on technology that is ten to fifteen years old in the West, many experts point out that the technology of the 1970s is nothing to ridicule. Among other things, that generation of hardware sent spaceships to the moon." [48] Still, by copying from the West, the Soviet Union doomed itself to second place in the race to develop computers with greater capabilities because it sacrificed its own domestic research assets in the process. Thus, as computer technologies became more sophisticated and complex, the Soviet Union lacked the very basis that it needed to effectively exploit these new developments. In the words of one writer, "The Soviets will always be fighting from a position of weakness, given their previous history, unless...[they can]... develop an electronics and computer industry along western lines." [49] This was one of the challenges that faced Mikhail Sergeevich Gorbachev when he assumed leadership of the Soviet Union in 1985, and one he would attempt to address through a series of measures that would not only radically alter the Soviet approach to technology transfer, but literally the face of Soviet society.

ENDNOTES

1 The issue of 'lead times' in terms of technology is a tricky one at best. Calculations of how long it would take the lesser developed of two countries to achieve an equivalent level of development to that of the more advanced can vary widely based on the type of technology, the factors that are weighed in determining the levels of development and the biases of those making such evaluations. Estimates in the case of the western lead in computing technology over that of the Soviet Union usually fall in the range of four to ten years, with a recent British government estimate falling at just over eight.

2 Erwin L Williams, "Soviet Acquisition of Western Computer Technology," research paper, Maxwell Air Force Base: Air Command and Staff College, 1986, pp. 6-7.

3 Marilyn Bohl, Information Processing with Basic, (Chicago: Science Research Associates, 1984), pp. 14-15.

4 Technical data in this section, unless otherwise noted, comes from Richard W. Judy's, "The Case of Computer Technology," found in East-West Trade and the Technology Gap, ed. Stanislaw Wasowski. (New York: Praeger Publishers, 1978), pp. 43-72.

5 An excellent time line for the history of computer development can be found in the volume Illustrated Chronology and Index, in the Time-Life series, Understanding Computers, ed. Lee Hassig (Richmond: Joseph J. Ward, 1989).

6 Harry Wulforst, "The Day the Computer Went Ballistic," Soldiers, October 1987, pp. 48-50.

7 Richard W. Judy, "The Case of Computer Technology," East-West Trade and the Technology Gap, ed. Stanislaw Wasowski. (New York: Prager Publishers, 1978), p. 44.

8 George Rudins, "Soviet Computers: A Historical Survey," Soviet Cybernetic Review, vol. 4, no. 1 (1970), p. 6.

9 Seymour E. Goodman, "Soviet Computing and Technology Transfer," World Politics, no. 4 (1979), p. 541.

10 Nicholas Daniloff, "Why Soviets Are Behind In Computer Technology," U.S. News and World Report, 14 August 1984, p. 38.

11 Anthony C. Sutton, Western Technology and Soviet Economic Development, (Stanford: Hoover Institute Press, 1973), vol. 2, p. 325.

12 Goodman, "Soviet Computing and Technology Transfer," p. 541.

13 Judy, "The Case of Computer Technology," p. 54.

14 Ibid., p. 53.

15 Goodman, "Soviet Computing and Technology Transfer," p. 542.

16 Ibid.

17 Judy, "The Case of Computer Technology," p. 51.

18 Ibid., p. 54.

19 Ibid., p. 57.

20 John P Hardt, "Stages in Soviet Economic Development: A Sixty Year Record." Address presented at the University of Southern California on 31 October 1977.

21 Bohl, Information Processing with Basic, p. 153.

22 Judy, "The Case of Computer Technology," p. 51.

23 Bohl, Information Processing with Basic, p. 198.

24 Goodman, "Soviet Computing and Technology Transfer," pp. 549-550.

25 Ibid. p. 547.

26 Goodman, "Soviet Computing and Technology Transfer," p. 554. While we may never be sure what exactly was said by party and

government officials at the time, Goodman, Beam and others who have had access to Soviet officials during the period have all reported that such a debate did take place. The idea that the central government would even enter into a discussion of, much less mandate a policy designed to foster the acquisition of foreign technology may at first seem strange to western readers not familiar with the nature of the Soviet system, however there exist enough other examples of such centrally controlled decisions and projects in Soviet history that such an account is highly plausible.

27 Seymour E Goodman and W.K. McHenry, "Computing in the Soviet General Economy: An Introductory Interview," DTIC Report (1984), p. 41.

28 Goodman and McHenry, "Computing in the Soviet General Economy: An Introductory Interview," p. 41. As often happens after a period of repression, the death of Stalin brought about a revival of interest in Soviet academic circles in the field of Cybernetics.

29 Alix Beam, "Atari Bolshevicks," The Atlantic, March 1986, p. 29.

30 "Soviet Computing," Janes Defense Weekly, 19 October 1986, p. 866.

31 Sutton, Western Technology and Soviet Economic Development, p. 321.

32 Paul Walton, "The State of Soviet Microelectronics," Byte, November 1986, p. 143.

33 Ibid., p. 138.

34 From the working notes of Professor B. P. Pockney, University of Surrey, for 1989.

35 These figures are not only revealing, but they present a classic case in the types of problems one runs into in dealing with Soviet statistics. Total imports for each year are listed at the top of columns breaking down the total into individual

categories, followed by a country breakdown of where these imports came from. However, the sum of the country breakdown varies from the totals listed, in some cases by a substantial amount. In addition, a second category, "parts for computers" is also listed, though data for this category is not recorded before 1982. As noted in the text, it is interesting that at the same time that parts begin to be listed, a downturn in the import figures for computers begins. Does this mean that before 1982 these categories where combined? While a rough calculation at best, adding the two categories shows a continued growth in the import of computers and computer related parts, which supports the trend already identified.

36 A fascinating description of this Soviet attempt to clone an Apple II is found in Leo D. Bores, "Agat, A Soviet Apple II Computer," Byte November 1984, pp. 134-136, 486-490. The author of the article was actually allowed to use the Agat, which ran Apple II software but was slow, had limited memory capability and was having problems with production quality control. An interesting side note is that the case for the computer was red, possibly the only Personal Computer (PC) in the world to hold that distinction.

37 Goodman, "Soviet Computing and Technology Transfer," pp. 553, 555.

38 Walton, "The State of Soviet Microelectronics," p. 138.

39 Goodman and McHenry, "Computing in the Soviet General Economy: An Introductory Interview," p. 51.

40 Cited in Beam, "Atari Bolshevicks," p. 24.

41 "Soviet Computing," p. 866.

42 Goodman and McHenry, "Computing in the Soviet General Economy: An Introductory Interview," p. 42.

43 Hardt, "Stages in Soviet Economic Development: A Sixty Year Record."

44 Alix Beam, "Russia Gropes For A Way To Enter the High-Tech Age," Business Week, 11 November 1985, p. 98.

45 See Jay Tuck, High-Tech Espionage. New York: St. Martin's Press, 1986, for a good summary of covert Soviet operations designed to gain technology. The effectiveness of export controls is always a point of contention, if for no other reason that when they are successful, there is little to indicate the impact of that success, and when they fail, there is little to show the extent of the failure, or even that such a failure occurred. With the exception of a few well publicized instances, such as the case of Toshiba where Norwegian software was combined with Japanese machine tools to give the Soviets a capability that they formerly did not have, information is scarce. This is to be expected in that if successful, the Soviet Union is not likely to advertise the fact out of fear of greater western restrictions, and the West itself may wish to cover up its failure so as not to encourage other attempts. While illicit transfers of technology are an interesting topic, they are not the main focus of this study, both because of the problems with information and the fact that they make up a relatively small portion of the technology being transferred between East and West. In this sense, legal transfers hold a much greater prospect for positively affecting the level of computer development in the Soviet Union.

46 See Goodman's article "The Soviet Bloc's Unified System of Computer," in ACM Computing Surveys, vol. 10, no. 2 (June 1978), pp. 93-122, for an in depth description of the Ryad and the problems with its development.

47 While the overall intent of the export control regime imposed by CoCom has been "to maintain the technological lead times of the West" (as stated in discussions with Col. Carney), to do this it has focused on specific items that embody these technologies, simply because they are easier to track and monitor. The problem of trying to control ideas, which is the central focus of this study, has been considered too difficult, and therefore has not been addressed in most of the material on export control.

48 Beam, "Atari Bolshevicks," p. 29.

49 "Soviet Computing," p. 867.

CHAPTER 4--GORBACHEV'S ECONOMIC REFORMS

Perestroika--A Brief Overview

So much has been written and said about Mikhial Gorbachev and his reforms since he came to power in 1985, that to add anything would seem redundant at best were it not for the magnitude of the program and the spectacular changes that these reforms have brought about. However, with all that has taken place in the past six years, in terms of the withdrawal from Eastern Europe, the reunification of Germany, new initiatives in arms control and domestic political changes, it is often forgotten that the original impetus behind these changes was economic, rather than political reform. From the beginning of his rule, Gorbachev has sought to remake the Soviet economic system in order to answer the demands placed upon the country by the nature of the modern world. The irony is that while his reforms, both domestically and internationally, have changed the very nature of the world order, they have done little if anything to improve the state of the Soviet economy.

The history of Gorbachev's attempts at economic reform has been well documented, and needs only to be briefly recounted here. [1] Faced with the myriad of problems that have already been outlined, Gorbachev's early attempts at reform amounted to little more than tinkering with the system, trying to make minor adjustments in the economy while leaving its basic structure and institutions intact. Recalling the tactics employed by his mentor Yuri Andropov, Gorbachev's first reforms, including the anti-alcohol campaign and enforcement of rules against unwarranted absenteeism and corruption, were designed to bolster labor discipline and increase productivity by making the system more efficient. [2] As it became apparent that these measures, while garnering some initial successes, amounted to little more than treating the symptoms of the disease rather than the cause, additional measures were introduced, becoming bolder in their scope as they attempted to grapple with the faults that lay at the very basis of the system. In the course of five short years, what would have been totally unimaginable at the beginning of the reforms, now has become accepted by most, if grudgingly, as inevitable; the adoption of some type of market economy.

Along with the attempts to increase efficiency through tightening labor discipline, there was also a general recognition that stagnation in the economy had led to technological stagnation as well. One of the early elements introduced to overcome problems in this area was the concept of *uskoreniye* (acceleration), a speeding up "of scientific-technical progress, particularly in the fields of engineering and machine-tool technology", [3] to overcome the lack of technical innovation that was seen as hindering economic development. This accelerated effort was required to establish the necessary preconditions or basis that would then serve as the launching point for what was envisioned as a period of rapid growth and development. The line of reasoning behind this was reminiscent of the justifications used in the 1930s for the push to establish the necessary industrial base that would allow for the rapid passage from socialism to communism, though declarations now stressed the parallels between these actions and those of Lenin during the period of the New Economic Policy. [4] It was also at this time that discussions of Joint Ventures with the West began to appear, emphasizing them as a means of gaining technology as well as drawing parallels to similar policies under the NEP. [5]

While a special conference had been held in June of 1985 to discuss the policies needed for *uskoreniye*, it was not until the XXVII Party Congress in February 1986 that perestroika began to evolve as a "complex program for the renewal of society." [6] In a five-and-a-half hour speech, Gorbachev emphasized the need for radical economic reform, claiming that socioeconomic development was the key to solving the country's problems. Among other proposals, he called for greater autonomy for local managers and less interference from the central planning organs; for credits and a self-financing system in manufacturing; for price and wage reform, and changes in agriculture that would give greater incentives to produce. [7] While still not defined in terms of specific measures and programs to be carried out, it was the first bold pronouncement of the body of thought that would become the basis of perestroika. In the words of one Soviet commentator, "The 27th Party Congress marked the beginning of revolutionary changes in our society." [8]

If the 27th Party Congress was responsible for setting out the conceptual framework for perestroika, the June Plenum of the Party in 1987 was the pivotal point in outlining the mechanics of this process. During its proceedings, bold new plans were announced for "restructuring", with Gorbachev calling "for the unconditional overcoming of stagnation and conservatism." [9] Along with citing many specific problems, he went on to unveil what were to become the main elements of his restructuring policies. In "Basic Provisions for Fundamentally Reorganizing Economic Management" which appeared in Pravda on June 27th, [10] and ten decrees approved by the Central Committee and the Council of Ministers in July 1987, [11] the essence of restructuring was laid out. Along with a new "Law on the State Enterprises" adopted by the USSR Supreme Soviet on 1 July, [12] the proposals covered the role of central planning, the status of the firm, the role of central administrative bodies, the system of material technical supply, prices and wages, finance and credit, the conduct of foreign trade, private and cooperative activities and agricultural reforms. [13]

While the reform package was truly massive in its scope, for the purposes of this study one area is of particular interest. In perhaps the most damning inditement of the system and its failings, in terms of the state of technological development, Gorbachev stated:

> "...the most alarming thing is that we began to lag in scientific and technical development. At a time when the western countries have begun to restructure their economies on a broad scale, with emphasis on resource conservation and the use of the latest technologies and other scientific and technical achievements, scientific and technical progress in our country slowed down." [14]

To answer this kind of problem, the State Committee for Science and Technology (GKNT) was to be reorganized to develop state scientific and technical programs, supervise their execution, and guide the work of Science and Technology (S & T) complexes whose role was also to be expanded. [15] While the rhetoric of this declaration was similar to such statements in the past, what made this different, as with the overall reform, is that this time the leadership seemed serious about implementing these measures, and that if the reform was taken seriously there would truly be new opportunities in the area of technological development that had never been present before.

Changes in the Superstructure--Restructuring the Mechanisms of Foreign Economic Relations

While the seriousness of the commitment to reform may seem surprising (given the past history of Soviet attempts at economic reform that emphasised words instead of deeds), the methods that were called for to assist the reform process should not. As in previous times, turning to the West for assistance, both for the products of technology and technology itself, became a key part of the plan to turn around the Soviet economy. What made this attempt different from previous times, however, was the importance attached to such policies. Perhaps not since the time of Peter the Great had there been such emphasis on establishing ties with the West. Calls for 'active involvement in the international division of labor' were accompanied by concrete steps to encourage integration with the rest of the world, both politically and economically. [16] For almost seventy years the Soviet Union had pursued policies that in effect isolated it from the rest of the world; now the barriers that had maintained that isolation were falling as quickly as leaves from the birch trees in autumn, and at the behest of the government no less. The contrast with the situation which existed as little as five years before was striking.

To help accomplish this integration, changes were introduced in the area of foreign trade. Reflecting the very nature of the changes taking place in the Soviet Union, these measures were summarized in an article entitled "Restructuring the Mechanism of Foreign Economic Relations in the USSR" by Ivan D. Ivanov, Deputy Chairman of the State Commission on Foreign Economic Relations, USSR Council of Ministers. [17] In substance, the reforms that Ivanov outlined were significant, however there was also a resemblance to previous attempts at 'reform through reorganization.' A State Commission on Foreign Economic Relations was established as a permanent body of the USSR Council of Ministers in 1986. The Commission was to act as a single "external economic complex...to organize and manage economic relations with foreign countries." [18] With a membership comprising top managers of Soviet agencies, including Gosplan, the State Committee on Science and Technology (GKNT), the State Committee for Foreign Economic Relations, Gosbank, and the Ministry of Foreign Affairs among others, this agency was given responsibility for preparing and securing legislation that outlined and shaped the new setting for Soviet foreign economic relations. Among other duties, the Commission was responsible for the establishment of the position of Counselor on Foreign Economic Affairs in Soviet Embassies in countries with major trading relationships, reflecting the new emphasis on foreign trade. [19]

Changes also came about in the role played by the Ministry of Foreign Trade, which had always maintained a monopoly of control over all dealings with the West. In line with the move to give individual industries and associations greater freedom in dealing with foreign businesses and obtaining foreign assistance, [20] on 1 January 1987 the Ministry relinquished control over import-export operations in many areas, but retaining control in the trading of fuel, raw materials, foodstuffs, and other areas deemed to be of national significance. [21] This represented a major break with the past, where the Ministry held complete domination in areas of foreign trade. Now it appeared that the Ministry was to execute more of an advisory role, assisting with expertise when needed and creating a cadre of foreign trade specialists through the All-Union Academy of Foreign Trade. Even in those areas where the Ministry still maintained control, associations were to abide by the new principles of *khozraschet* (self-financing) and *samookupayemost* (economic accountability) in their dealings with foreign concerns. [22]

A third major body playing a part in the reform was the USSR State Committee for Foreign Economic Relations (GKES). Originally constituted before the reforms to provide military, technical and economic assistance to foreign countries, the charter of the GKES was expanded to include supervising modernization projects within the Soviet Union with "foreign content", that is, with foreign involvement. [23] Tying in with declarations by government and party officials that what was needed was not to start new projects, but to complete those already begun and to modernize current facilities, GKES was seen as the coordinating agency for contracts signed with foreign firms in these areas. GKES was also chartered to go out and find foreigners willing to engage in such ventures, and as such was to play a role in identifying and bringing outside resources, particularly technology and manufacturing capability, to the Soviet Union. However, even as good as the intentions of these reforms appeared, they apparently failed to live up to the expectations placed on them. "On 17 January 1988 the Ministry of Foreign Trade and State Committee for Foreign Economic Relations were abolished and replaced by a new Ministry of Foreign Economic Relations...." with considerably less power. [24]

While these changes at the highest level of Soviet economic management may seem contradictory, in some cases trying to decentralize by allowing greater independence for enterprises, while in others creating new levels of bureaucracy, it is a contradiction that, if not logical in Western eyes, can be understood when viewed from a Soviet perspective. While reformers sought to loosen the controls that the Ministries held on economic development, the bureaucracies had their own interests to protect and were loath to allow any slipping of control from their grasps. These bureaucracies, in the ministries and related organizations, were a major part of the problem with implementing economic reform, as over the years they had established their own domains and thus opposed changes that would threaten their position. In this context, the creation of what appears to be yet another level of bureaucracy did hold out the promise of reform; by creating coordinating bodies as the State Commission on Foreign Economic Relations, reformers sought to cut, or at least disrupt, the traditional lines of authority. By specifically limiting the charter of these new organizations, while expanding the rights and capabilities of the enterprises below, it was hoped that a more rational, more efficient way of obtaining and managing foreign resources could evolve. Whether this is in fact what took place is open to some doubt, especially since these structural reforms were rather abruptly abandoned in favor of openly disbanding the old centrally controlled mechanisms. [25]

Changes in the Sub-Structure--The Law on the State Enterprise and Joint Ventures

While the reforms at the highest levels of the Soviet Economy are significant, it is at the lower levels, that of the industrial firms and enterprises, that the reforms must take root if anything is to come of them. While the upper levels of the economic bureaucracy may plan, project and prophesies, it is the enterprise level that must produce. In this regard, two reform actions have played a major part in changing the way that enterprises operate within the Soviet economy, and especially the way that they interact with bodies outside of the Soviet Union. These two are the Law on the State Enterprise and the rules concerning Joint Ventures, and they deserve to be examined in some depth.

The Law on the State Enterprise, which was approved by the USSR Supreme Soviet in June 1987, [26] sets out in great detail the expanded freedoms (as well as the responsibilities) of firms, and loosens the control exerted by the Ministries. "The firm now 'independently' works out and approves its 5-year and annual plans, based on control figures, mandatory state orders, limits, economic normatives, and contracts with customers." [27] Enterprises are expected to meet their proposed plan and honor all contractual agreements; otherwise they have great freedom in the way in which they run their affairs. A firm is to provide material rewards to its employees, however the details as to wages, bonuses, etc. are left up to the firm management to decide. At the same time, enterprises are to operate under 'full economic accountability and self-financing', that is, the firm is expected to generate sufficient revenue to cover its costs of operation. For those failing to meet this condition, "the Law explicitly provides for declaring bankrupt and liquidating firms that persistently make losses." [28] Other parts of the Law include provisions for greater democracy in the election of labor councils and selection of managerial personnel.

The Law on the State Enterprise also "stipulates a significant expansion, both of the rights and responsibilities of enterprises in the area of foreign trade." [29] Specifically, enterprises are now allowed and encouraged to form links with foreign economic concerns, both through 'direct ties' and with established trade associations. In addition, selected enterprises and ministries were allowed to engage in direct transactions with foreign markets, rather than having to go through the Ministry of Foreign Trade as was previously required. This included the right to negotiate for foreign financing and assistance, especially the purchase of foreign machinery and technology, for revamping the aging Soviet industrial plant. It was also seen as a step in loosening the control that the central organs held over individual enterprises and areas of the economy. By removing the need for firms to go through the Ministries for approval of foreign contracts, a large lever that the Ministries held for controlling the actions of individual enterprises was, in theory at least, removed.

While freeing some sectors of the economy from the stifling hand of state bureaucracy, the reform at the same time added requirements to these enterprises that were designed to cause them to act in a responsible and business-like manner. Enterprises are held accountable for their foreign dealings and for efficient use of their hard currency assets. Just as the state organs have abrogated responsibility for establishing and monitoring foreign transactions, so too has the state abrogated all responsibility if and when these transactions go awry. By refusing to back up debts and obligations made by enterprises, it has been hoped to introduce a degree of fiscal responsibility into the actions of enterprise managers; gone are the days when anything would be tolerated as long as the plan was fulfilled. [30]. On the other hand, as a growing number of Soviet businesses forfeit on foreign loans and the government refuses to guarantee these debts as it has in the past, foreign investors are beginning to be wary about such investments. [31] Thus, even though the intent of these measures was to allow greater access to western materials and know-how, while forcing enterprises to operate under the principles of *khozraschet* and *samookupayemost,* the failure of the latter may well limit the success of the former of these objectives.

In terms of the goal of technological modernization the reform was, in Ivanov's own words, "intended to industrialize Soviet exports and to utilize Soviet potential in R&D and manufacturing in a more productive way." [32] With foreign assistance, Soviet industry could be modernized and efficiency increased, not only so that it could pay back loans in terms of new production, but so that it could compete in the world market. Further, by decentralizing and allowing enterprises to deal directly with foreign producers, it was hoped that those inputs would be more effectively put to use. "Not infrequently (in the past), imports were used to relieve existing gaps in supply or to compensate for miscalculations in the Ministries' technical policies. To sum up, imports did not fully perform their planned function as a source of technological modernization." [33] Still, to effectively gain from such imports, as has been seen, requires more than the mere products of technology. This appears to have been recognized by the people outlining the course of the reforms in the Soviet Union, and resulted in emphasis on one particular type of dealing with the West that allowed for overcoming this problem by combining the transfer of material with information and know-how: the Joint Venture.

Joint Ventures [34]

Based on the previous discussion of the nature of technology transfer, it should come as no surprise that Joint Ventures are valued and sought after by the Soviet Union. While each method of transferring technology has its respective strengths and weaknesses, Joint Ventures combine aspects of all of the transfer mechanisms, overcoming individual weaknesses and strengthening the overall character of the transfer. A key part of this process is the opportunity for personal contacts, which not only facilitates the transfer of know-how, but allows the receiving group to develop the cadre necessary for an infrastructure that can modify and build upon the basic operation. In contrast, turnkey operations, which share some of the benefits of Joint Ventures, have been found to suffer once the installation is in place, for without the ability to modify and develop the original facility, these plants soon become stagnant and outmoded. [35] Joint Ventures, on the other hand, offer the opportunity for long term contacts with western scientists, managers and workers, thus insuring a continuing flow of western ideas and western technology.

As mentioned earlier, Joint Ventures are far from a new concept in the Soviet Union. The first Joint Venture stemming from the New Economic Plan was established in 1921; by 1925 there were 64 Joint Ventures making up 10% of overall Soviet exports. [36] While imports of western technology continued during the period of industrialization in the 1930s and again after the Second World War, Soviet fears of excessive contacts with the West, especially in areas of technology that were almost always associated in some way with defense, tended to limit such endeavors. It was only with the realization of the dire situation that the Soviet economy was in, combined with the willingness to overlook the possible dangers of close associations with the West, that the potential of Joint Ventures to become a major factor in achieving modernization began to be appreciated.

The core of the laws on Joint Ventures is contained in three decrees that were issued on 13 January 1987, and cover:

Establishment of Joint Ventures on Soviet Territory (Decree no. 6362-XI), Joint Ventures with other CMEA Member Countries (Decree no. 48) and Joint Ventures with Capitalist and Developing Countries (Decree no. 49). [37] Key elements of these decrees included setting out the legal aspects of such ventures, general rules for establishing Joint Ventures, guarantees of property rights and guarantees of independence from central planning requirements. [38] The Decree on Joint Ventures with non CMEA nations further specified that the Soviet side of the venture would maintain the controlling interest (51%) of the venture, thus effectively giving it control over all managerial decisions.

Even though the potential of these ventures had been recognized, early efforts to realize this potential were hampered by the rules the government imposed on such initiatives. As recorded by Anders Aslund, Director of the Stockholm Institute of Soviet and East European Economics and First Secretary for Economic Affairs at the Swedish Embassy in Moscow at the time these decrees were published:

> The conditions offered foreign partners were neither favorable, nor well conceived. The Soviet share of an enterprise must be a least 51 per cent; the president of the board and the managing director must be Soviet

> citizens; joint ventures must fall under ordinary Soviet jurisdiction, implying an obligation to obey thousands of unpublished legal acts, which the foreign partner had no right to see; at the same time, joint ventures would be isolated from the domestic market, being forced to purchase from, and sell to, Soviet enterprises through foreign trade organizations; 20% of the sums taken out of the country were taxed; a condition for the transfer of profits abroad was that the joint venture had earned hard currency. The most positive stipulations were that the profit tax amounted to only 30 per cent and joint ventures were not subject to state planning. [39]

Under such conditions, it hardly seems surprising that initial calls for western firms to present proposals for Joint Ventures in 1986 were met with a lukewarm response at best, or that by 1988 Pravda reported that only sixty-six Joint Ventures had been registered. [40]

This early disappointing showing led to subsequent changes in the laws governing the structure of Joint Ventures, the most significant being the relaxation of the rules on percentage of foreign ownership, allowing foreigners to obtain and control a majority interest in a Joint Venture. [41] Foreign investors were loath to enter into deals in which they could not control a majority interest, and thus have the overriding say in how the venture should be run. With sufficient other risks involved, the added fear that once an investment was made the western partner would theoretically, if not in practice, lose control of his investment, was enough to scare away all but the heartiest of investors. From the Soviet standpoint, while foreign ownership of a controlling interest was an ideological and psychological anathema, the benefits to be gained outweighed what was to be given up. Therefore amendments to the three basic documents were issued on 17 September 1987 and 2 December 1988, designed to "simplify existing procedures, develop the country's export base (and) radically improve the pattern of Soviet foreign trade...." [42]

When looking at what the Soviet Government hoped to achieve through these Joint Ventures, one other major consideration needs to be kept in mind. In addition to being an effective way of gaining and integrating western technology, Joint Ventures also satisfied what was now becoming a critical need--hard currency. In the past, firms wanting to modernize using western equipment had to go through the ministry bureaucracies to gain permission as well as the hard currency needed to make such purchases, a long and tedious process at best. Now, with the loosening of administrative regulations, firms could enter into direct negotiations and relationships with western concerns, which in the case of Joint Ventures became a ready source of hard currency. While arrangements varied based on the individual situation, in general what was sought from the western partner was technology, production and managerial skill, and capital to provide the needed production base. What the Soviets had to offer in these instances was cheap labor, relatively cheap access to raw materials, and a tremendous market potential for items produced to be sold in the Soviet Union. While this type of relationship seemed to place the Soviet Union in the same type of position as that which characterized colonies under imperialism, it was still worth the cost to the county's leadership, when weighed against what they hoped to gain.

Even with the potential advantages that such arrangements held, the changes that have been made in the laws and the incentives that have been offered to attract western partners, it must be admitted that their successes to date have been limited. Problems, in terms of currency convertibility, overregulation, bureaucratic inertia and general instability, have caused westerners to be cautious about such ventures. A great number of the ventures that are reported to have been agreed upon, have gone no further than the signing of agreements, with no other steps being taken toward implementation. [43] Even among those that are functioning, a great percentage of these are in the service sector, and have had little effect on technological awareness or production. [44] From the Soviet side, initial euphoria has given way to the practical realization that while a viable source of outside assistance, Joint Ventures are not the panacea they once were thought to be. Additional decrees on 7 March and 11 December 1989 rescinded some of the earlier conditions that were considered too favorable to foreigners by some elements in the government. [45] Still the number of such ventures has continued to increase (See Appendix B), and as more cases appear showing successful examples of what can be gained through such ventures, more interest is being shown. [46] Also, of special significance for this study, Joint Ventures continue to receive special emphasis on the part of Soviet officials in one area in particular--the area of computers and computer related technologies.

Reform and the Soviet Computer Sector

Until now Gorbachev's reforms have been dealt with in general terms, especially in those areas where they have had, or contain the potential of having, an effect on contacts with the West and the possibility of transferring western technology. Since this work uses computers as the vehicle to examine the process of technology transfer between West and East, it is essential to look as well at how the reforms have influenced this area in particular. As has been asserted earlier, if there is one set of technologies that, more than any other, acts as the flagship of the modern era, it is that set relating to computers. Therefore, it should not seem unusual that this area has been singled out by the Soviets for special attention. [47]

Indeed, it should not be surprising that current efforts to reform the computer sector actually predate Gorbachev and his economic reforms, so great was the Soviet concern about the problems in this area. In 1983, a special section dealing with Informatics, Computer Technology, and Automation was established in the USSR Academy of Sciences, the first time in over twenty years that a new section had been created in the Academy. [48] The head of this new Department was Ye. P. Velikov, former Vice President of the Academy of Sciences and a board member of the State Committee for Science and Technology. Velikov had long been a vocal critic of the dismal state of Soviet computing, and now seemed in a position to do something about it.

He announced that the basic mission of the new department was to secure a scientific base, "capable of eliminating in the shortest possible time the computer technology deficiency that threatens the development of the entire national economy." [49]

This reform was seen as an attempt to overcome several of the problems that had been identified as plaguing the computer field. The first of these was the disparity of efforts that made up the existing system. Soviet computers were produced by 4 different Ministries, with as many as 30 other Ministries and agencies providing computer related parts. [50] Each of these had "its own technology policy and its own standards which [were] not always compatible with the standards of other branches and with the needs of the users." [51] Second, was to bridge the gap between research and implementation. Because of the disunity of the computer industry's structure, it was often difficult to get manufacturing concerns to make prototypes and limited runs of new concepts for the purpose of further testing and development. New designs remained on the drawing board or in the research lab, with no one willing to risk production. Finally, there was the goal of getting greater acceptance for computers overall. Even when good products were developed, there was the usual reluctance on the part of industry to accept new equipment and changes that might disrupt their current plan. By consolidating all development under one organization, it was hoped not only to better meet the demands of industry, but to be able to lobby for greater acceptance and implementation once a new design was developed. [52]

The broad objective of the reform, in terms of reorganization, was to bring research and development in the computer field back into the hands of the Academy. Earlier in the sixties, computer development had been distributed amongst the various Ministries where each had pursued their own agendas, with little regard for what others were doing. [53] This was one reason cited by Velikov and others why the Soviet Union had fallen so badly behind the West. [54] To create this new department, twelve institutions were joined together, some with previous ties to the Ministries involved in computer development, some from other departments in the Academy of Sciences, and four which were to be created specifically for the work of the new department. (See Appendix C). The new department was given four overriding objectives: the development of supercomputer architecture and software, the acceleration of development and production of small computers for mass use, the development of a new generation of integrated chip technology, and the development of a 'native scientific and technological base' in the computer area. [55]

It is this last goal that deserves special attention, for it again raises the issue of whether it was better to develop an indigenous computer infrastructure, or to borrow from the West. The creation of this department seemed to reflect a victory for those who favored the former, and a reversal of the policy that was implemented in the 1970s over the protests of Lebedev and others. As reflected in Simon Kassel's analysis of the new reform:

> Finally, technology transfer as a means of enhancing Soviet computer technology was rejected in favor of indigenous technology development that would make the Soviet Union equal to and independent of the West in this field. The Academy's belief was that computing technology should not be dependent on scientific and technical relations with other countries. Neither should simple technology transfers from foreign experience be expected to solve the national problem. It was stressed that no matter what modern specimens of foreign computer technology might be procured, the current world-wide state of the art precluded any improvement in Soviet technology level without the development of a native infrastructure. [56]

That the lack of a computer infrastructure, along with the need to develop one, was obvious to the leaders of the Soviet computer field in 1983-84, is all too apparent. That this realization would still not detract from Soviet attempts to obtain western technology will soon be seen.

The Computer Education Reform of 1985

The Soviets also realized that part of their problem with computers came from a lack of qualified people to operate those computers they did possess, much less the massive increase in the numbers of computers anticipated as being needed to bring Soviet industry and the economy in general to a state of parity with the West. As managers in the West have discovered, the best way to overcome the initial resistance to accepting computers in the workplace is to have people who are not intimidated by them, who are willing to work with them and explore their capabilities. At the same time, once a large number of people began to use computers, development in related areas, such as software, is aided. Much has been written in the West about the 'cult of the hacker', [57] and there is merit to the argument that many breakthroughs and advances in computer programming have come as the result of individual initiatives rather than management orchestrated group efforts. Again, in the Soviet case, the lack of an infrastructure made itself manifest; but in this case it was an infrastructure made up not only of machines and buildings, but of people. The answer to this shortage came in one word--education.

In early 1985 the USSR Council of Ministers passed, and the Party endorsed, a program "to foster widespread applications of computers in Soviet education." [58] The elements of this program included a highschool course curriculum of 102 hours of instruction, including such topics as Computer Architecture (12 hrs), Programming (21 hrs), Problem Solving (29hrs), and Computer History and Computers in Society (5 hrs). [59] Designed for students in the ninth and tenth grades, it was to be supplemented by instruction in the seventh and eighth grades in the mid 1990's, as additional resources, both in terms of computers and qualified instructors, become available. The goal, in the words of member of the Academy of Sciences Andrey Yershov, was that "the computer will become the personal tool of an ever greater number of people: engineers, designers dispatchers, librarians, cashiers, operators of program-controlled machine tools, production controllers, and workers in dozens of other professions." [60]

While a definite step in the right direction, these plans were ambitious; perhaps too much so. Implementation was hampered by those elements mentioned above--a lack of computers and of qualified people to carry out the training. Estimates vary, but even conservative requirements called for 1 million computers to be used in this program; some figures go as high as 5 to 6 million. [61] While the 12th five year plan called for substantial increases in the production of the types of computers needed to support this program, production problems as well as the lack of facilities and know-how have kept these plans from being anything more than very optimistic projections. Faced with the severe shortage of the one item critical to the program--computers--schools did their best to compensate; solutions ranged from the creation of a theoretical course on computer science that could be taught without computers, to a case where computers were mounted in a traveling van, and driven to area schools on a rotating basis, allowing students at least some hands on training. [62]

As with so many cases in the history of Soviet attempts at reform, the theory behind the new education program in computers was good, but the execution was abysmal. The Soviet press was quick to pick up on the problems involved, and stories detailing these problems began to appear with embarrassing regularity. In one such case, a young student designed and built his own computer from locally procured parts and proposed that by copying his design, the shortage of computers in the local schools could be overcome; he was told by officials that his computer represented nothing that was new or interesting in the field, and therefore did not warrant production. [63] The logical solution for many was to buy computers from the West, where not only were they available, but of good quality and with a developed base of software. The problems with this, however, included export restrictions from the West, the cost even if the export restrictions could be circumvented, and the fact that the new thinking in computer development favored domestic, rather than imported products. It seemed that an impasse had been reached.

The State Committee for Computing and Informatics (GKVTI)

While the reforms just discussed occurred, or at least were conceived, before the the rise of Gorbachev, there have also been major steps taken in the field of computers that are the direct result of perestroika. In 1986 the State Committee for

Computing and Informatics (GKVTI) was created, with responsibility "for coordinating work in the creation, production, utilization, and service of computational technology". [64] Gorbachev had early on in his tenure stressed the significant part that computers and advanced electronics would play in restructuring the economy. [65] By creating a 'State Committee' specifically to oversee and coordinate Soviet efforts in this area, he seemed to be underlining this significance, as much as trying to improve the still lagging efforts in this area. It is also interesting to note that in this regard the GKVTI can be likened to another superministry created early in the reform years, the agricultural ministry GOSAGROPROM. [66]

The charter for this new organization was broad and expansive. As reflected in the resolution printed in Izvestiya in 1986, the committee was charged with:

> radically raising the technical level of computer hardware and improving its use in the economy; defining the main directions of development of computer technology and computerized information processing and overseeing the fulfillment of decisions of the Communist Party and government on questions of development, production, and utilization of computer hardware; ensuring the integrated development of the production of computer technology

> and solving inter-industry problems; coordination, oversight, and scientific methodological guidance of targeted computer technology programs; and conducting and coordinating the training and retraining of specialists in this field. [67]

Along with these lofty goals and aspirations, the GKVTI was responsible for some real world initiatives in expanding the use of computers in the Soviet Union. These initiatives ranged in scope from coordinating the efforts of the different ministries so as to achieve some kind of standardization in Soviet computers, to making computers available to the general population in an effort to increase computer literacy. In an example of one of the more innovative of these initiatives, "computer salons where the public can go to use personal computers for a fee" have been established in a number of cities across the country. [68] Thus it seemed that the GKVTI had been given a charter to bring the Soviet Union into the computer age.

Another new institution that deserves mention, at least in passing, is the Interbranch Scientific Technical Complex for Personal Computers (MNTK PC). Established in 1986, the MNKT PC was to act as a coordinating agency in the efforts to develop PC's and software that would be standardized throughout the Soviet

Union and the countries of CMEA. To accomplish this, the complex was given the job of coordinating the efforts of the Ministries, that had traditionally claimed their own portion of computer development in the Soviet Union. While the concept was good, early indications were that bureaucratic in-fighting and resistance to anyone infringing on what had been the traditional domain of the Ministries was hampering anything useful being done by this organization. [69] Indications also appeared in 1990 that the MNKT PC was receiving criticism for failing to make sufficient headway in achieving its goals.

The true impact that the GKVTI and the MNTK PC will have on computing in the Soviet Union has yet to be determined, however some early indicators seem to show that, as with too many other cases, the creation of another agency has done nothing more than put another player into the economic arena, one concerned with protecting its own members, putting forward its own plans, and preserving its own prerogatives and perks. Cited by some as an attempt to finally bring the Ministries responsible for manufacturing computers into line, the reform has yet to show any major success in this attempt, with the individual ministries still jealously guarding their share of the computer pie. [70] As with the case of GOSAGROPROM, one large central coordinating agency, rather than streamlining operations, only serves to add another layer in a system overburdened with bureaucratic layers. And while there may be valid reasons behind these Soviet actions, there still seems to be something of a dichotomy in that at the same time decentralization is being preached, centralization is still being practiced.

Summary--Some Thoughts on the Nature of the Reform

While all of the specifics of the reforms have not been dealt with here, it may be worthwhile at this stage to look at the philosophy behind the reforms, for the same logic that is the basis for the reforms applies to the changes that have taken place in the Soviet approach to technology transfer, and thus is key to understanding these changes. When it became clear that the inefficiencies that characterize the Soviet economic system were far greater than merely those of poor labor discipline, the attention of the reformers shifted to the underlying reasons for these problems. One of these was the nature of the planning mechanism and the fact that with the growing complexity of modern technological society, it was impossible for the State Planning organs to make the necessary decisions in a timely and rational manner. The creation and acceptance of new technologies was another area of concern; as has been noted, the Soviet economy had a dismal record in the area of innovation. Even when new ideas were generated, there was little or no reason for enterprises to integrate these technologies. [71] Further, the entire process of academic research and development was stifled, both by limitations of contacts with the West, and by the compartmentalization and lack of academic interchange between groups within the Soviet Union. Part of this problem was attributed to the lack of the physical means that aided development and exchanges, such as computers, data links, telecommunications, etc. Part was tied to the very nature of the intellectual environment, the restrictions placed on scholars by the closed nature of the system, a system where centralization meant not only that all decisions came from above, but that information from below must be sent up before it could be disseminated laterally. Part of the problem was the system itself, where entrenched bureaucracies fought to stop any attempt at change that might involve the loss of status, prestige and privileges that had been accumulated over the years. Other reforms in the past that had tried to address individual parts of the problem had failed because the parts were interconnected and collectively were stronger then the attempts at reform.

Gorbachev in his early years appeared to be attacking all of the problems simultaneously, however this approach has yet to prove to be any more successful than previous attempts.

When looking at the problems facing Gorbachev and the economy as a whole, they can be viewed as emanating from different levels within the economic structure, though the faults at one level are often reinforced by the practices at another. At the highest level, the central planning mechanisms were too large and unwieldy to effectively deal with a complex, modern society. While setting overall goals for the production of steel is a comparatively simple process, the identification, production and assembly of the elements that go into making a computer or any other high technology instrument, is not. Literally, the expansion of the information and data related to modern production had swamped an apparatus that had been set up to deal with the relatively simple economic situation found in the 1930s. At mid-level, the apparatus of the economy, in terms of the Ministries and other agencies that had evolved within this system, had become part of the problem. Over the years these bureaucracies had developed to the point that, along with hindering progress through bureaucratic inertia, they represented impediments to reform as they fought to preserve their own position in the face of reforms that would lessen or eliminate their influence in the economy. Finally, at the lowest levels, that of the enterprise and the individual, reform took on the appearance of a tug of war, with reformers and institutional interests each sending their own set of instructions, often contradictory, which each then expected to be obeyed. That confusion was the result of this situation was almost to be expected, along with the fact that for all the lofty goals of the reform, little in reality has been achieved.

When looking at the aims of the Gorbachev reforms, they can also be seen as operating at several distinct, though interrelated levels. At the highest levels, decision makers attempted to define what the fundamental nature of the economy should be, as well as the changes that needed to be made to the existing mechanisms. Along with philosophical changes, there came some rather significant structural alterations, as the decision to limit the influence of the the party in the operation of the economy. [72] Attempts were made to streamline the management of the economy, including the lessening of the influence of the Ministries, designed both to eliminate the bureaucratic tie-ups that hampered the system, and to allow decision making to take place at lower levels where it was hoped that decisions would be made more realistically and in a timely manner. By implementing decentralization, it was also envisioned that now the old habit of passing the blame for failure or inefficient operation to upper echelons would be eliminated. Enterprises, having greater responsibility for the way things were run, would also bear greater responsibility for their successes and failures, and thus have increased incentives for efficient behavior. And finally, as if admitting after seventy odd years of ideological struggle that there were things of value in the West, restrictions were lifted so that the Soviet economy could take advantage of what the West had to offer.

All this is reflected in what has taken place in the field of computers. Not only have the reforms affected the computer field as a segment of the overall economy but, because of the significance attached to computers for the course of the reforms and industrial modernization, they have been singled out for special attention. Perhaps no other area, with the exception of agriculture, has received the emphasis that computers have in the last five years. Ironically, again with the exception of agriculture, perhaps no area has done so poorly in spite of all this attention. Looking at the computer field in terms of structural reform, one sees all of the classic phenomena associated with reform attempts in other sectors of the economy. Because of the reluctance of the ministries to give up their portion of the computer domain, along with the general inefficiency inherent in the Soviet system, structural reform has done little to improve the domestic computer situation. The GKVTI, PC MNSK, and other agencies established to try and bring some order to the chaos that exists, have for the most part become part of the chaos. Even with the best intentions and efforts of Velikov and others to establish a computer infrastructure capable of domestically generating computer technology, it has yet to come about, and even Soviet sources are doubtful that it will come to pass any time in the near future. [73] Given this realization, the response has been the classic Soviet answer to such problems, a solution that, if not viable, at least is familiar in that it has been seen before. The solution has been to turn to the West. [74]

What makes the situation different from the past, however, is the climate and opportunities that have been created by the reforms. In earlier times, contact with the West was considered a necessary evil; only the most reliable in the eyes of the regime were permitted to enter into actual negotiations with western firms, or engage dialogues with western academics.

Unfortunately, from the Soviet standpoint, those who were the most reliable were not always the most qualified; as a result, the potential of such encounters was seldom realized. In terms of trade, when the Soviets did buy western goods, the preferred method was to buy only what was necessary in order to serve as prototypes, to be reverse engineered and copied for domestic production. Not only were the results of these efforts often less then desired, but by the time this process was complete, the technology was often obsolete. At the same time, the general isolation of the Soviet scientific and academic communities from the mainstream of world thought and research served to frustrate and limit those people in the Soviet Union who represented the best opportunity for the country to advance in these critical fields.

All this began to change under Gorbachev and his reforms. Not only did the emphasis on exchanges with the West for the express purpose of gaining technology and manufacturing expertise change, but the opportunities for greater contact and true academic interaction broke the isolation which the Soviet scientific community had long endured. Businesses were now given the right to make their own contacts, to enter into contracts with western firms and shape their own destinies without the heavy hand of the Ministries. The general relaxation of the rules and controls that had so long stifled the Soviet society as a whole, resulted in a type of renaissance, the likes of which had not been seen since the 1920s. If the structural portions of Gorbachev's reforms have run into difficulty, this particular aspect, the loosening of the constraints on contacts with the West, may be his major success to date. What this will mean for society as a whole is yet to be truly determined. What this has meant for industry and the economy in general is the opportunity to obtain from the West those things that the Soviet Union so desperately needs to modernize, and in such a manner that what it obtains may truly have a lasting effect on the shape of the Soviet economy. What this has meant in the specific area of Soviet computer technology will be the topic of the next three chapters, which focus on the areas of computer hardware, software and information technology, and what has taken place in each during the Gorbachev era.

ENDNOTES

1 For a very good collection of articles on the various aspects of perestroika and its implementation, see Abel G. Aganbegyan, ed., Perestroika Annual, (Washington DC: Brassey's, 1988 and 1989). Two volumes are available to date; more are projected. As a recurring project, not only is the material updated in a timely manner, but the volumes will eventually present a valuable history of the reform process as it occurs.

2 Marshall I Goldman, Gorbachev's Challenge--Economic Reform in the Age of High Technology, (New York: W.W. Norton & Company, 1987), pp. 1-2.

3 Peter Frank, "Changes and Developments in the Soviet Political Scene: Will Gorbachev Succeed?," Gorbachev--Economics & Defence 1989, ed. Chris Donnelly. (Sandhurst: Royal Military Academy--Soviet Studies Research Center, 1989), p. 6.

4 For an interesting discussion of the parallels drawn by the Soviets between the current reforms and Lenin's policies, see "Lenin and the Strategy of Complete Change," Literaturnaya Gazeta, 16 April 1986, p. 2.

5 Alec Nove's, An Economic History of the U.S.S.R., (London: Penguin, 1989), is the classic history of the economic development of the Soviet Union. The period of the New Economic Policy (NEP) is discussed in detail on pp. 73-150.

6 Frank, "Changes and Developments in the Soviet Political Scene: Will Gorbachev Succeed?," p. 6.

7 M.S. Gorbachev, "Report of the General Secretary to the 27th Party Congress," Pravda, 26 February 1986, pp. 1-5.

8 Nikolai Shmelev, "Advances and Duties," Novyi Mir, no. 6, June 1987, p. 142.

9 M.S. Gorbachev, "General Secretary's Report to the June Plenum," Pravda, 26 June 1987, pp. 1-5.

10 "Basic Provisions for Fundamentally Reorganizing Economic Management," Pravda, 27 June 1987, pp. 1-3.

11 About the Roots of Perestroika (and the) Direction of the Economy--Collection of Documents, (Moscow: Politizdat, 1987).

12 "Law of the State Enterprises," Pravda, 1 July 1987, p. 1.

13 Gertrude E Schroeder, "Anatomy of Gorbachev's Economic Reform," Soviet Economy, vol. 3, no. 3 (1987), p. 220.

14 M.S. Gorbachev, "Communique on the Plenary Session of the Central Committee of the Communist Party of the Soviet Union," Pravda, 26 June 1987, p. 1, as translated in CDSP, vol. 39, no. 26, 29 July 1987, p. 11.

15 About the Roots of Perestroika (and the) Direction of the Economy--Collection of Documents, pp. 91-105.

16 Aleksei Bereznoy, "Joint Ventures and the Economic Reform," Foreign Trade, no. 7 (1989), p. 33.

17 Ivan D. Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," Soviet Economy, vol. 3, no. 3 (1987), pp. 192-218. This was an unprecedented first for a western journal in the social sciences. Ivanov is described by the editor as "a prominent economist with solid academic credentials and a score of publications in prestigious Soviet periodicals...one of the architects of reform in foreign trade, and a high ranking member of his government's executive branch." His position and the fact that he willingly responded to the opportunity to present his views on the changes taking place to a western audience serve to emphasize the seriousness with which the topic was now being pursued.

18 Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," p. 197.

19 Ibid., p. 198.

20 Some of these changes will be discussed in the next section on 'the Law on the State Enterprise.'

21 Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," p. 199.

22 The definitions of *khozraschet* and *samookupayemost* present special problems when trying to render a proper English translation, simply because their meanings in Russian can vary depending on the situation in which they are used. According to the Oxford Russian-English Dictionary, *khozraschet* is primarily defined as self-supporting or running, with self-financing given as an alternate definition. *Samookupayemost* is defined as the ability to pay one's way, and when applied to enterprises is used to define the return period for invested capital. Taken together, they indicate the need for enterprises to operate in such a way that they are not dependent upon the State to subsidize their operations, unless the State has reasons for doing so.

23 Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," p. 200.

24 Leonard Geron, Soviet Foreign Economic Policy under Perestroika, Chatham House Papers, ed. Neil Malcolm (London: Pinter Publishers, 1990), pp. 19-20. Geron presents an excellent analysis of Soviet Foreign Economic Policy under Gorbachev in this work.

25 The brief history of GOSAGROPROM is an instructive case in the problems involved with implementing reforms in the Soviet economy. Formed as a superministry, it was heralded with much fanfare as the beginning of the solution to the Soviet Union's long standing problems in agriculture. Designed to bring together all of the various agencies dealing with agriculture under one central management, it proved too large and unwieldy to function effectively, became mired in bureaucratic battles with other ministries who sought to protect their interests in agriculture, and was disbanded with considerably less fanfare two years after it was formed.

26 "Law of the State Enterprises," Pravda, 1 July 1987, p. 1.

27 Gertrude E. Schroeder, Unpublished Manuscript, University of Virginia, 4 September 1987, p. 5.

28 Ibid., p. 6.

29 Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," p. 202.

30 In the author's discussions with several Soviet citizens it has been revealed that this may not entirely be the case. In place of a plan of production, enterprises are given state orders that must be filled before other production or obligations are met. While it is argued that this still allows initiative on the part of managers to meet these requirements in whatever way that they desire, with the freedom to use the resources under their control for other activities once state orders are filled, in practice the state orders are so high that realistically all that can be done is to meet these orders. As one Soviet commented, "The plan is still the plan."

31 Miriam Widman, "German Businesses Take Action to Curb USSR Late Payments," The Journal of Commerce--International Edition, 4-17 February 1991, p. 8.

32 Ivanov, "Restructuring the Mechanism of Foreign Economic Relations in the USSR," p. 203.

33 Ibid., pp. 193-194.

34 Geron, Soviet Foreign Economic Policy under Perestroika, pp. 19-20. An excellent summary of the legislation that has been passed dealing with Joint Ventures can be found on these pages in Leonard Geron's work.

35 The classic example of this is the Soviet chemical industry, where entire plants where purchased which dramatically increased Soviet production. However without continuing contact with the West, or an infrastructure that could generate technology on its own, these plants eventually became outmoded, requiring still further purchases of western equipment in order to advance.

36 "Joint Ventures: An Overview of Objectives," USSR Technology Update, Delphic Associates, 5 May 1988, p. 7.

37 All of these documents can be found in, The Mechanism of External Economic Activities: Collection of Documents, (Moscow: Pravda, 1988).

38 Geron, Soviet Foreign Economic Policy under Perestroika, pp. 22-23.

39 Anders Aslund, Gorbachev's Struggle for Economic Reform, (Ithaca: Cornell University Press, 1989), p. 140.

40 "To More Quickly Reform the Economy," Pravda, 24 July 1988, pp. 1-3.

41 "On Further Development of the Economic Activity of the State, Cooperative and Other Public Enterprises, Associations and Organizations," Vnesnaya torgovlya, no. 2 (1989), supplement.

42 Geron, Soviet Foreign Economic Policy under Perestroika, p. 23.

43 "Joint Ventures in the Soviet Union: Pace of New Registrations Picks up Dramatically During the First Quarter of 1989," PlanEcon, vol. V, nos. 10-11-12, 24 March 1989, p. 1. According to the estimates of the analysts at PlanEcon, of the 320 to 330 Joint Ventures that had been registered as of March 1989, only 20 to 30 were fully operational, and only one-quarter to one-third showed 'significant activity.'

44 Ibid. pp. 1-3. A majority of the Joint Ventures registered were small and tended to be in the service sector. As shall be seen, however, computers and computer related fields make up a substantial portion of the manufacturing and technical Joint Ventures.

45 Geron, Soviet Foreign Economic Policy under Perestroika, p. 25. Subsequent to this apparent retrenchment, it should be noted that the Soviet Union appears again to be moving away from 'half-way-house' reforms to acceptance of the need for more fundamental reforms designed to create a true market economy. New laws on ownership, enterprises, joint-stock companies, banking and foreign investment have either been proposed or are in the process of being enacted. To a large degree, these changes

in economic policy tend to reflect the political, as well as the economic debates taking place.

46 In the most recent example of the continued interest in Joint Ventures by major western firms, the Financial Times reported that Otis Elevator is entering into Joint Ventures with two Soviet partners in Leningrad, positioning itself in what the article describes as "the world's largest market." Andrew Baxter, "Otis Elevator in move to strengthen Soviet venture ties, Financial Times, 12 February 1991, p. 3.

47 Gorbachev, "Report of the General Secretary to the 27th Party Congress," p. 1.

48 Richard W Judy, "The Soviet Information Revolution: Some Prospects and Comparisons," Gorbachev's Economic Plans, Joint Economic Committee of the Congress of the United States, 2 vols., (Washington: U.S. Government Printing Office, 1987) vol. 2, p. 166.

49 Simon Kassel, A New Force in the Soviet Computer Industry: The Reorganization of the USSR Academy of Sciences in the Computer Field, (Santa Monica: Rand, 1986), p. 9.

50 The four Ministries with primary responsibility for production of electronic equipment related to computers are: Ministry of Instrument Construction, Automation Equipment, and Control Systems (Minpribor); Ministry of Radio Industry (Minradioprom); Ministry of Electronics Industry (Minelectronprom); and Ministry of Communications Equipment Industry (Minpromsvyazi).

51 Kassel, A New Force in the Soviet Computer Industry: The Reorganization of the USSR Academy of Sciences in the Computer Field, p. 12.

52 Ibid., p. 1.

53 Each of the Ministries, realizing the importance that computers hold to the Soviet economy, has been reluctant to give up control over its portion of computer production, and each traditionally has used its position to argue for more resources from the central authorities. Cooperation in this type of

environment has been difficult at best. The same attitude can be seen now in attempts now to bring some order or standardization to the computer industry by organizations such as the State Committee for Computing and Informatics (GKVTI).

54 Kassel, A New Force in the Soviet Computer Industry: The Reorganization of the USSR Academy of Sciences in the Computer Field, p. 30.

55 Ibid.

56 Ibid., pp. 18-19.

57 The term 'hacker' while widely used in the West, needs to be understood in a broader context to appreciate the role that such people have played in the general development of the computer. Unlike other industries, where advances have been made as a result of management initiatives from above, individual computer enthusiasts have made a tremendous contribution to the development of computer technology in all its areas. While an often told tale, the fact remains that Apple computer was born in a garage, and that most of the major software developers started out as enthusiasts who developed programs out of their own interest in computing. That people like this had the opportunity to explore the possibilities that computers had to offer explains to a large degree their popularity and rapid spread in the West; that they may have counterparts in the Soviet Union who are equally gifted, but have never had these opportunities may explain, in part, why the Soviet Union has never developed a strong computing infrastructure.

58 Peter B Nyren, "The Computer Literacy Program: Problems and Prospects," Gorbachev's Economic Plans, Joint Economic Committee of the Congress of the United States, 2 vols., (Washington: U.S. Government Printing Office, 1987) vol. 2, p. 202.

59 For a discussion in greater depth of the computer education program, see Peter Nyren's article listed above, pp. 200-208.

60 Andrey Yershov, "What is Information Science," Uchtel'skaya gazeta, 5 March 1985, p.2, cited in Nyren, "The Computer Literacy

Program: Problems and Prospects," p. 202.

61 "IBM in Class," Pravda, 6 February 1985, p. 3.

62 "Mobile Computer Classrooms," Television Service, 16 January 1987, as cited in JPRS-UCC-87-008, 15 July 1987.

63 Yu. Budinayte, "Dialogue With Computers--Taking Steps Toward One Another," Komsomol'skaya Pravda, 30 March 1985, p. 2.

64 "The Structure of the Soviet Civilian Computer Industry," Organizational Chart, LDA 90-10236, Central Intelligence Agency, (February 1990), p. 5.

65 M.S. Gorbachev, Perestroika, (New York: Harper & Row, 1987) pp. 78-81.

66. While the GKVTI has not, to this date, suffered the same fate as GOSAGROPROM, it is worth noting that it has suffered many of the same problems, and for the same reasons. While it was created to coordinate the efforts of the other players in the Soviet computer industry, it seems to have become a player itself, striving to secure its own share of the resources being given for computer research rather then monitoring and coordinating to see that wherever monies are allocated, are put to good use.

67 "Official Department to Develop a Network," Izvestiya, 22 April 1986, p. 3, as cited in Global Trends in Computer Technology and Their Impact on Export Control, (Washington D.C.: National Academy Press, 1988) p. 195.

68 Global Trends in Computer Technology and Their Impact on Export Control, p. 196.

69 Victor Yasmann, "The Computerization of Soviet Power," Soviet Analyst, vol. 15, no. 1 (8 January 1986), pp. 6-8.

70 Global Trends in Computer Technology and Their Impact on Export Control, p. 196. As of this writing the GKVTI still had not fulfilled the role intended for it. This does not mean that it will not eventually succeed, however after five years in existence it

seems to be suffering the same problems as many other creations of the reform. The failure of the effort to instill some order from above, as was envisioned as far back as 1984, has not meant that progress has stopped in computer development, however the creation of a unified computer infrastructure, independent of the West, that Velikov and others envisioned has not come about. This failure, in turn, has helped to maintain or even increase Soviet dependence on the West for computers.

71 A recent article in Ekonomika i zhizn is only the latest in a series of articles bemoaning the fact that while Soviet R & D efforts have produced some very good advances, Soviet Industry has proved exceedingly slow in implementing them. See, "Bamboo on Concrete," Ekonomika i zhizn, no. 8, February 1991, p. 14.

72 Early in the process of political reform, Gorbachev is reported to have stressed the need to 'get the party out of the business of running business,' and leave management of the economy in the hands of those who were trained to do so. While probably a valid analysis of one of the major problems with the Soviet Economy, this was none the less a radical departure from the seventy year tradition of the party playing a leading role in the running of the economy.

73 For a damning inditement of the lack of progress on in the Soviet computing field, see A. Ivakhov, "Supreme Soviet Committees Hear Complaints about Computer Technology," Izvestiya, 15 August 1988, p. 2.

74 In just one example of the shift in attitudes towards the use of western computer technology, S. Pachikov, member of a working advisory group of the president of the Academy of Sciences wrote an article entitled "All-Out Campaign for Computer Technology Transfer with (the) West Proposed," in Problemy i resheniya, no. 16, 16 August-5 September 1988, pp. 6-7. In this article, Pashikov proposes a strategy for catching up with the West through the use of western technology combined and the new opportunities for gaining this technology created by the changing political situation.

CHAPTER 5--PERESTROIKA AND COMPUTER HARDWARE

Introduction

The technologies that revolve around the computer are normally discussed in terms of Hardware, the actual computer and its related peripherals, Software, the programming or instructions that regulate the computer's functions, and Information Technology involving the control, transfer and use of information that is possible through the effective combination of hardware and software. [1] Of these, hardware is the traditional way in which people think about the transfer of technology from one source to another. It represents the end of the technological development cycle, the product that is the result of all the efforts that went into its creation. It can either be an item that, in and of itself, is of use or benefit to those who possess it, or more often it can give a capability that allows the attainment of still greater achievements, wealth or well being. In this sense, the true value of the transfer of a product of technology is often difficult to determine, in that it must be measured not only in terms of the value of the item itself, but in terms of the use that it is put to, and the capabilities that it brings to those who possess it.

Along with being the embodiment of the technological revolution that has occurred since the Second World War, computers are a prime example of this dual nature of the value of hardware. There is little utility in the computer alone; a computer, no matter how sophisticated, is nothing more than an assortment of electronic components. The value of a computer lies in the capabilities that it gives to those who possess it, capabilities in terms of the ability to rapidly process and transfer data, to solve difficult calculations and perform functions that would normally be beyond human capability in a reasonable or useful period of time. Computers themselves are nothing more than a tool, but a tool so powerful that society is just beginning to be able to take advantage of the capabilities they have to offer. In the words of one commentator, if one considers that the first industrial revolution "levered man's muscles, that is his ability to perform mechanical work, then the information revolution, or second industrial revolution, has levered man's mind," in terms of giving man the ability to perform mental tasks that until now had been too complex to be attempted. [2] It is the computer that lies at the heart of this revolution, and is, in fact, the lever.

There are several aspects that must be taken into account when evaluating the value of this type of technology in this particular format. What is the purpose of the transfers of these particular items and do they achieve the goals that are set for them? Does the capability exist within the society to effectively utilize the capabilities that these pieces of hardware represent? Are there people who can effectively utilize these capabilities, or must they be trained or otherwise obtained as well? How well can these items be effectively integrated into society; can their capabilities be readily exploited, or must a supporting base also be developed that allows for those advantages that computers represent to be utilized? And finally, what is the ability of the society to improve upon these technologies, in terms of modifying them to the purposes and needs of that society, and more importantly, to recreate and produce locally the equipment involved, so as not to leave the receiving country dependent upon others for its supplies in this increasingly vital sector of the economy? All these are questions for which answers may or may not be readily apparent, however all play a part in the evaluation of the effectiveness of technology transfers of computer hardware, and have application in the case of Soviet computers during the period of reform.

Soviet Computers

In 1985, it appeared that Velikov and others were winning their battle to try to create an independent computer establishment, one capable of meeting the country's needs in this area through domestic research and production. It rapidly become apparent, however, that the Soviet computer establishment was in no shape to meet the demands being placed upon it, either in terms of the capabilities of these machines or the sheer numbers involved. [3] By 1986 western experts placed the Soviet Union, in aggregate, ten to fifteen years behind the West in terms of computer hardware, with individual areas, such as memory and storage capabilities, sometimes even further behind. [4] What is even more striking about these figures is that, because of the increasing speed of technological developments in the computer field, to take the five or ten years that it would require to establish the kind of computer infrastructure envisioned, would leave the Soviet Union still further behind in this area, with the very real possibility that it would never be able to catch up to the West. Computer generations were passing at a tremendous rate;

ten years might represent two generations in terms of technological developments. [5] Thus, while it is difficult to pinpoint any one decision on the part of the Soviet leadership stating that computer technology from the West would continue to be a primary means of overcoming the Soviet Union's deficits in this area, the emphasis that has been given to efforts at obtaining this technology since 1985, makes this assumption an almost foregone conclusion.

Initially Soviet imports in the area of computer hardware followed past patterns, in that while the promise of large purchases of computers were held out as the bait to lure western companies into discussions, purchases tended to be small in number, and seemed to follow the previously demonstrated pattern of obtaining a relatively small number of machines that could then serve as models to be copied or emulated. [6] Quickly, however, the sheer numbers of computers needed exerted a strong influence and forced a shift in the Soviet approach toward obtaining western hardware. Conservative estimates on the number of machines needed just to fulfill the requirements of the computer education program alone went as high as one million, while at least one official in the computer industry predicted that by the 1990s not one million but "tens of millions...will be required." [7] Even though the press carried glowing pronouncements about increases in the plans for production of computers that would meet this need, it soon became apparent that Soviet industry could not fulfill these plans. [8] The answer was to make up for this shortfall through purchases of western equipment; the result was an increasing number of contracts being announced for the purchase of computers from abroad.

Along with the short term need for actual computers, the deficiency in Soviet industry's ability to produce the needed machines was addressed in efforts to obtain the manufacturing capability necessary to produce computer hardware. This was apparent in the increasing efforts being made to establish Joint Ventures with the West for the production of computer related equipment. [9] Most of these Joint Ventures called for production facilities to be established on Soviet soil, with the western partner providing the equipment and know-how, the Soviets providing the facilities, raw material and labor, with the goods produced being shared between the partners. [10] Factors affecting this effort included CoCom and the restrictions on the transfer of such manufacturing techniques, as well as western concerns over CAD/CAM (Computer Aided Design/Computer Aided Manufacture) capabilities that represented the cutting edge of computer manufacturing technology.[11] However, with the changing political climate came movements in the West for a relaxing of these restrictions. With the perceived decline in the threat posed by the Soviet Union, western businessmen were eager to take advantage of this new and untapped market for computer goods, and chafed at anything that they saw as standing in the way.[12]

In addition to these efforts in the area of computer production, Joint Ventures served as a conduit for computer hardware in another sense. With the general emphasis on Joint Ventures, an increasing number of western firms began establishing branches in the Soviet Union, bringing with them those items of hardware that have become part of the life of any western business, including computers and telecommunications capability. While common in the West, the equipment that accompanied these new ventures represented a tremendous new source of technology for the Soviet Union. The basic shift in the way that the Soviets interacted with the West required them to adapt to western ways of conducting business, with an important feature of this adaptation being the use of electronic data mediums, including computers. From the western perspective, firms dealing with the Soviet Union expected to conduct business the way that they did in the West; if a firm saw that it could not count on the Soviets to provide what was needed for operations in the Soviet Union, then it was easier to bring the necessary equipment with them rather than change the ways that the company did business. From the Soviet perspective, as western business practices became more prevalent, the Soviets began to adopt western ways, learning from the West and expanding still further the use and demand for the products of technology to support these practices. In just one small sign of the times, FAX numbers began to blossom on the letterheads of Soviet firms. [13] (See Appendix D)

Trade Figures

While dealing with data concerning the Soviet economy is always difficult at best, the trade figures for the period 1985 to 1989 show the tremendous increase in imports in computer related areas. Even without referring to trade figures, it would be expected that this would be the case, given the general emphasis that has been placed on imports from the West since Gorbachev came to power. Using American commerce figures to demonstrate the trends involved, it is interesting to note that trade figures at first do not seem to bear this trend out. While overall trade figures did increase, U.S. exports in non-agricultural goods remained fairly stable in the period 1985 to 1988, hovering between 550 and 600 million dollars a year, and below the levels recorded in 1979, 1981 and 1982. [14] (See chart, Appendix E) The initial appearance of an overall increase in dollar amounts for this period comes from the agricultural sector, reflecting not only the generally deteriorating state of Soviet agriculture, but a string of bad harvests during this period. [15] With this type of showing, it might appear that the Soviets have, as in the past, talked a great deal about increasing trade but actually done little in following through with actions.

Upon looking at the specific figures for computer related material, however, a different story is told. Examining the four different categories that the U.S. Commerce Department keeps for trade in computer hardware and related fields, a continuous increase can be seen in each of these areas from 1986 on, that is, the time when it became apparent that the Soviet Union would not be able to overcome its shortcomings in the computer area through its own resources and began looking to the West for assistance. Of particular note are the tremendous jumps recorded between 1988 and 1989. These can be attributed, at least in part, to changes in Soviet law making it easier for individual firms and enterprises to buy western technology, as well as the fact that many Joint Ventures, first created after the change in the laws governing JV's in 1987, were now beginning to take shape and import equipment. Partial credit, as well, goes to the liberalization of export controls announced as a 'good will' gesture in 1989. [16]

Export figures for computers and related hardware from the United States to the Soviet Union for the years 1985 to 1989, as provided by the U.S. Commerce Department (in thousands of dollars) are as follows:

Line number 847192--Input or Output units for adp * machines--

1985: 43 1986: 515 1987: 24 1988: 681 1989: 4,661

Line number 847191--Digital process units with storage--

1985: 2 1986: 10 1987: 18 1988: 243 1989: 4,250

Line number 847120--Digital adp machines with central processors--

1985: 11 1986: 33 1987: 443 1988: 287 1989: 3,930

Line number 847193--Storage units for adp machines--

1985: 22 1986: 0 1987: 7 1988: 16 1989: 1,285 [17]

*adp= auto data processing

Thus, while overall expenditures for non-agricultural imports have remained fairly stable, it can be shown that expenditures on computer related hardware have dramatically increased. The apparent contradiction in these figures can be explained in that while foreign imports of technology have been increasingly stressed, the hard currency available to pay for these imports has remained about the same, accounting for the relative stability in the figures for overall expenditures. That within these figures computer related hardware has experienced a tremendous increase speaks of the importance placed on this area, for in order to purchase this hardware, other purchases had to be curtailed or sacrificed. [18] In a system that specializes in resource allocation to those areas that it feels are critical, this is a clear sign of the importance attached to computers. Even with the shift away from centrally planned and directed acquisition to more decentralized decision making, it is still apparent that the people who are now making such decisions view computers as key to their enterprises, and are taking advantage of the new opportunities to acquire these machines.

Joint Ventures and Computer Hardware

As already mentioned in the earlier discussion of Joint Ventures, it is envisioned by many in the Soviet hierarchy that these ventures will play a major part in assuring the success of the Gorbachev reforms. It should come as no surprise then that Joint Ventures in the computer area have received special attention in the Soviet Union. As of 1 August 1989, 772 Joint Ventures had been registered with the Soviet Ministry of Finance; of these, 64 or 9 percent were in the computer or microelectronics sector.[19] Many of these, as with Joint Ventures in general, had not passed beyond the stage of signing of a letter of intent and thus were not contributing anything of substance, either in terms of specific products or to the overall improvement of the situation in the computer sector. The potential for gains, however, even if only half of these ventures come to fruition, is substantial. (A partial list of these ventures, along with comments as to their known status, is included in Appendix F.)

The exact nature of these Joint Ventures, as well as the specifics of their organization and relationships between the partners, varies from venture to venture; however, some generalizations can be made about the ones that have been seen to date. Rather than going in on the production of computers jointly developed by the partners, these ventures center around production of western designs for domestic Soviet use. [20] Several are based on nothing more than the assembly of components manufactured outside the Soviet Union, a practice not uncommon in developing countries of the third world. [21] Also, answering the current critical shortage of computers in the Soviet Union, several JV's call for the foreign partner to provide an initial supply of computers or related hardware made outside the Soviet Union, with subsequent supplies coming from local production facilities once they are established. [22] In this way, both short term needs, and longer term solutions to the problems that have brought about these shortages, are addressed.

Creating a mechanism for providing foreign partners a return on their investment in a venture remains a problem because of the non-convertibility of the ruble. While the Soviets would like foreign partners to defer returns on their initial contribution to the venture in exchange for the promise of access to an expanding and potentially profitable market in the Soviet Union, few western firms seem willing to enter into such agreements simply on future promises and good faith. One common practice has been for the the foreign partner to receive a portion of the production of these facilities. Another approach is to receive payment in 'goods in kind'. These later arrangements resemble barter agreements, where the foreign partner receives payment in another commodity that can then be exported and resold. [23] Finally, payment can be made out of scarce hard currency reserves. While the least desirable from the Soviet standpoint, this has been seen in several instances, and reinforces the importance that the Soviets place on obtaining machines in this area. In November 1990, the Soviet Union seemed on the verge of taking the steps necessary to make the ruble convertible in certain cases by establishing a realistic commercial rate of exchange; however as of yet convertibility is still not guaranteed.

It is also worthwhile noting which foreign countries have been the most active in seeking Joint Ventures with the Soviet Union in the area of computers. While Japan is considered to be one of the world leaders in computers and microelectronics, it is surprising that at present Japanese ventures make up only a relatively small portion of the Joint Ventures that have been signed with the Soviet Union in this area. [24] While sources vary as to the exact percentages, owing to the imprecise figures and differing interpretations as to what constitutes a Joint Venture, the three countries that seem to play the largest role in such ventures are the United States, Germany and Great Britain, with Italy, Austria and Finland also claiming a percentage of this trade. [25] (See Appendix G). The possible explanations for this vary, and include everything from the political disputes between the Soviet Union and Japan over the northern Japanese islands that are still held by the Soviet Union as a result of the Second World War, to cultural biases and bigotry on the part of both the Soviets and the Japanese. To date, however, the Soviets have demonstrated a distinct preference for European and US, as opposed to Asian, technology. [26] This phenomenon is significant in two respects. First, it limits the number of regions that one must examine when analyzing technology transfers in the computer area, thus simplifying to a certain degree the tasks involved. Second, it imposes limits on the technologies involved in terms of legal transfers, since four of the leading six come under CoCom restrictions, with Austria and Finland generally abiding by these restrictions as well, in order to avoid sanctions from the West.

Because of western restrictions on high end computer technology, especially in the area of microprocessor production, most of the Joint Ventures initiated to date in the area of computer hardware have dealt with less sophisticated equipment, with special emphasis being placed on personal computers. This, however, does not necessarily represent a hardship on the Soviet Union, as one of the areas targeted by the Soviets has been the acquisition of PC's, both to aid in their education program and in the general integration of computers into society. Going along with the idea that one of the key elements for expanding the use of computers is the establishment of a 'computer culture' similar to that found in the West, one can argue that the more computers available for use by the public, the quicker will be their acceptance and integration. The extent of Soviet deficiencies in this area is reflected by Soviet figures, which estimate that in 1988 there were only 200,000 to 300,000 PC's in the Soviet Union, with projections of as many as 28 million being needed. [27] Joint Ventures, such as with the Soviet-Italian-French venture INTERQUADRO which call for the creation of production facilities to help overcome this shortfall, are seen as a major part of the solution to this problem. [28]

It should come as no surprise that Joint Ventures account for such a large percentage of the trade in hardware or that they are seen as one way out of the dilemma faced by the Soviets in the computer area. Much emphasis has been given to forming associations with western manufactures and developing co-production facilities because manufacturing has always been one of the major weaknesses in the Soviet economy. In one survey of the Joint Ventures done by the United States Foreign Science and Technology Center, personal computers and other hardware JV's combined to account for over one-third of the Joint Ventures recorded in the computer field. [29] While the category of hardware is a broad one, including both different types of computers ranging from the ubiquitous PC to supercomputers as well as various other periphery devices, the goal of these ventures appears to be the same; to establish joint production facilities, using western technology on Soviet territory, for the production of computer related hardware. Imports of western computers, even in large numbers, represent only a temporary solution to the problem. Importing and establishing a production infrastructure that could eventually give the Soviet Union an independent capability in this area, appears the long term goal.

Changes in CoCom

If there has been a key element that has allowed the development of both trade and Joint Ventures with the Soviet Union, it has been the relaxation of export controls in the West in response to the changing atmosphere and attitudes with relation to the Soviet Union. At the political level, the shift in the perception of the Soviet Union as the chief threat to the West that had been painted for the past four decades has brought with it a lowering of concern about the Soviets obtaining western technology. Even in those cases where concerns continue to be expressed, the argument is made that the current situation in the Soviet Union provides a unique opportunity for modifying what has traditionally been a hostile relationship, and that failure to support this movement could result in the failure of Gorbachev and his reforms and a return to previous, more antagonistic ways.[30] Further, the willingness of politicians to reexamine export control issues has been greatly bolstered by pressures from the business community, who, sensing the opportunity for expanded sales and profits, have been quick to press for relaxation of the restrictions that have traditionally limited their ability to sell to the East. All this, combined with the emphasis placed on cooperation and integration by the leaders of the reform movement in the Soviet Union, has led to the rapid growth of trade in computers, as well as in other areas of high technology.

This change in western attitudes can best be seen in the easing of export restrictions under CoCom. As discussed earlier, CoCom has traditionally acted as a watchdog organization, monitoring transfers of materials to the East to insure that technologies which might eventually give the Soviet Union an enhanced military capability were restricted. Now, however, these efforts have come under increasing question, both in terms of the level of their restrictions, and even of their necessity. In response to these criticisms, as well as the growing pressure on the governments involved to allow western businesses to take advantage of the new opportunities being offered in the East, the Coordinating Committee met in June of 1990 in Paris to re-look CoCom's policies. The result was a major change in the guidelines affecting export restrictions in general, and computers in particular. While still maintaining controls on 'high end' computer equipment, particularly supercomputers and those machines that could be used for special military applications, (such as the computation of ballistic missile trajectory), computer technology that at one time had been considered to be sophisticated but was now commonly available in the West, was decontrolled. [31]

The specific changes in export controls affecting computer hardware, brought about as a result of the HLM (High Level Meeting) of CoCom, were broad and far reaching. Controls on "virtually all personal computers and associated peripherals, as well as some small mainframes," were lifted. [32] Access to higher level computer equipment and technology was granted through liberalization of export guidelines and the allowing of national discretion, that is, allowing individual nations to make determinations as to what they would allow to be exported without the requirement of CoCom review. [33] Specific guidelines, along with examples of how these affect computer hardware transfers, include: [34]

--Decontrol of all computers with Processing Data Rates (PDR) of up to 275 Mbps. This decontrol covers computers with the Intel 80386 microprocessor and the Motorola 68030, the two most common microprocessors found in upper level PC's, including the IBM PS-2, the Compaq Deskpro 386, and certain models of the Apple Macintosh.

--Decontrol of parameters for complete systems, allowing main memory of 32 MBytes, disk storage of 2 GBytes, and a maximum disk transfer rate of 20.6 Mbps.

--Decontrol of minicomputers, including the DEC PDP 11 series, Microvax, and 8500 series that are used in engineering facilities and laboratories.

--Decontrol of peripherals, including hard disk drives with a capacity of 165MBytes and a transfer rate of no more than 10.3 Mbps; 6250 bpi tape drives with a capacity of 10 Mbps; Local Area Networks (LANs) with a transfer rate of 20 Mbps; and standard computer displays with a resolution of 1280 x 1024 and up to 256 shades of gray or color.

--Favorable consideration licensing for the assembly of decontrolled computers and peripherals, such as those mentioned above.

--National discretion licensing for computers with a PDR up to 550 Mbps, affecting large minicomputers and mid-level mainframes used in scientific data processing, departmental processing and banking applications. A 30 day notification to CoCom is required for export of computers with a PDR between 400 and 550 Mbps. Examples of computers falling in this category are the DEC 8800 (certain models), IBM 3083, 4083 and 3081 (certain models), and the CDC Cyber 180-850.

--Favorable Consideration for computers with a PDR of up to 1000 Mbps in certain cases with proscribed destinations. Intended users would include large data processing facilities and concerns processing seismic data. Machines affected include the IBM 3081, DEC 6430 and CDC Cyber180-860.

--National discretion licensing for computers that would normally fall under the favorable consideration procedures (that is, PDR up to 1000) if they are to be used for nuclear safety applications. [35]

The reasons behind this deregulation, while largely driven by business concerns, are broader and more complex than might at first appear. Politically, much has been made of the fact that, with the apparent changes in attitude on the part of the Soviet Union, the threat posed by such transfers has diminished, and with it the need for strong restrictions. Also along these lines, is the belief that by lessening controls and giving the Soviets access to technology that will aid in their attempts at economic reform, the West is assisting in a process that, hopefully, is irreversible; thus the West is actually making a long term investment in its future security. In a less theoretical vein, the ability of CoCom to enforce controls has always been one of its weak areas. With the events taking place in the East, these changes can be understood in terms of attempting to simplify what is rapidly becoming an impossibly complex situation to monitor. One need only look at the conditions that arose during the joining of the two Germanies and trying to regulate the flow of technology between what would soon be two parts of the same country. [36] At the same time, however, the continued need for some level of controls was recognized by CoCom at this meeting, as well as concerns over an entirely new area, that of controls of the flow of technology from North to South, from developed countries to developing countries that might none the less put these technologies to use against the interests of those supplying them. [37] These concerns were again made evident when in February 1991 CoCom met once more, but postponed further liberalization of trade restrictions. [38]

The question of whether this represents a major shift in the philosophy on the part of those nations seeking to control the flow of technology to the Soviet Union or, in fact, is merely a recognition that new circumstances exist requiring new standards, can be debated. While the amount of material that has now been released from control and can be transferred to the Soviet Union is extensive, it does not represent an abandonment of the idea of regulation of the flow of technology from West to East. Indeed, the need for continued controls in certain areas, specifically high power computers and peripheral that support the types of work that might be of military value, has been continually recognized by political leaders in the West. To this end, one of the decisions of the Coordinating Committee was to redraw the current export control list with the intent both of eliminating those items that were no longer of concern in terms of export control, and to identify new technologies that now must be added. In this, the prevailing philosophy seems to be one of decreasing the overall number of areas to be restricted, but focusing greater attention to those areas that, it was felt, truly needed monitoring. [39] This review was to have been completed by the fall of 1990, and was to have served as the basis for future decisions in the area of export control. [40] When viewed in this light these changes, rather than being a stark break with the past, can be seen as an adjustment to recognize the realities of the current situation, and an attempt to deal with the future.

Joint Ventures and Computer Hardware--Some Examples

Quantifying the data available on Joint Ventures in the area of computer hardware is difficult at best. Decentralization in the Soviet economy has eliminated the central ministries as a 'clearing house' through which all such ventures must pass to gain official approval. In the West, few such formal mechanisms ever existed, and even in areas where CoCom regulation might apply, there are no formal mechanisms to insure compliance. The one institution that may have accurate records of material transfers is the state security system in the Soviet Union. Informal discussions with Soviet citizens involved with Joint Ventures indicate that all such agreements must still be reported and registered with the KGB, [41] and while glasnost has made great strides in loosening the Soviet government's control over information, that particular institution has not come forward with any record of the extent of transfers of technology from the West. Still some idea of the extent and nature of such transfers from the West, especially through Joint Ventures, can be gained by examining several representative examples of such ventures in the three countries comprising the majority of the trade with the Soviet Union in the computer field.

UNITED KINGDOM--British involvement in Joint Ventures seems to present a good cross section of involvement in several sectors of computer development. ENERGOINFORMATIKA, comprising Inpala from Britain and the Moscow Institute of Power Engineering, was created to facilitate "Design, production and marketing of computer systems and data processing networks." [42] Shipment of goods for consumption on the Soviet domestic market was to begin in 1989. MIKROGRAF, formed with Egotron, DINAMIKA with Gerald Computers and INTERTAKH with Perfect Technology all are based on joint production of computer systems and peripherals, though none of these appears to have achieved any significant degree of operation to date. Some JV's, such as Marine Computer Systems formed with ILC are targeted at specific areas within the economy, in this case "production of pc's and mini-computers for use in developing computer systems to ensure safety of navigation, raise the efficiency of operation of passenger and cargo ships and improve control of reloading operations." [43] There are also several as yet unnamed JV's in various stages of negotiations, covering areas such as the manufacture of microprocessors, floppy disks, and assembly of PC's from parts imported from the West.

GERMANY--Of all the countries entering into the Soviet computer market, Germany is the country that has been the most aggressive in pursuing the opportunities that are arising. According to the German Economics Ministry in Bonn, "more than 50 German companies have already concluded joint venture contracts with Soviet companies, while Soviet sources place the number at more than 70." [44] Of these, the preeminent company is the giant electronics firm Siemens AG. Building on contacts that had already been established through their business dealings with what was formerly East Germany, Siemens was one of the first western companies to enter the Soviet market after the ascendency of Gorbachev, signing a contract to upgrade the Moscow phone system in 1986. More recently, as reported in Izvestiya, Siemens signed a spectacular contract following the visit of Gorbachev to the Federal Republic, calling for the assembly "in the USSR computers made out of (imported) components with their gradual replacement with domestically produced elements." [45] Concluded with the Ministry for Higher and Secondary Vocational Education, as well as the production association ORBITA, the contract called for the immediate delivery of up to 80,000 PC's made in Germany to the Soviet Union, with subsequent emphasis being given to production of computers in Siemens facilities to be established in the Soviet Union. [46] The value of the three year contract was estimated by some sources as DM 1-2 billion, and was of further significance because of the nature of Soviet participation. As stated in Izvestiya, "It is important, after all, not simply to purchase such equipment in the West, but also to produce it ourselves and to organize service and training of personnel." [47]

UNITED STATES--The United States' entry into the rush to take advantage of the new Soviet markets initially was stifled to some degree by the fact that the United States government tended to take a hard line on technology transfers, and did little to encourage such initiatives. With the warming of relations between the two superpowers, however, and the implied commitment on the part of the Bush administration to do whatever it can to support Gorbachev and his attempts at reform, American efforts have become more substantial. This process has also been aided in that the Soviets have often stated a preference for American computer technology, representing a combination of the recognition of US leadership in the field, as well as the possible cultural biases against Asian concerns discussed earlier. [48] Soviet-American agreements in the area of hardware span the entire spectrum of the computer field, from PC's to supercomputers. Among the former, Joint Ventures such as DIALOG, between CRT Corporation in the United States and several groups in the Soviet Union including Moscow State University, provide for the assembly of IBM PC/XT clones using imported Asian parts; [49] Innovation Industries of Boston, in conjunction with the Ministry of Radio Industry, has plans to assemble up to 1 million personal computers in a contract worth up to $1 billion; [50] and SAMCOM, formed with Phoenix Group International, holds the premier American contract to date in the field, with plans to assemble $8 billion worth of PC's from kits shipped to the Soviet Union, for use in education as well as other areas, the largest contract of its type yet signed. [51] On the high end of the computing scale, Control Data Corporation of Minnesota has applied for permission to sell six Cyber 962 supercomputers, "one of which would be installed at the site of the 1986 nuclear accident in Chernobyl." [52] These machines would be five times more powerful then any previously sold to the Soviet Union. [53]

OTHER COUNTRIES--While the United States, Great Britain and Germany lead the rest of the world in terms of the number of agreements entered into with the Soviet Union to date in this area, this does not mean that the Soviets are not interested in other sources of computer hardware that could represent a substantial input to this category. Both Austria and Finland have taken advantage of their neutral status and been sources of hardware, especially material that might have caused questions under previous CoCom restrictions. Asia represents a tremendous potential that is just beginning to be tapped. While Japan has provided some inputs of computers and related technology in the past, including Yamaha computers sold in 1985 as part of the effort to bolster the Soviet computer education program, [54] the Soviet Union has recently taken advantage of improving relations with South Korea and Taiwan to seek electronic and computer hardware. [55] India, a traditional friend in the international arena and an upcoming force in the computer field, is another player in this game, and holds an advantage for the Soviets in that India will accept rubles as a currency of trade. Even South America holds promise for the Soviets in this area. Government officials in Brazil announced the visit in 1988 of a Soviet delegation interested in establishing a Joint Venture with Brazilian manufactures to provide up to 1.5 million microcomputers for use in the areas of education, agriculture, medicine and public service. [56]

Technology Transfer of Computer Hardware During the Era of Reform--An Evaluation

While it may be too early to judge the overall effect this input of computer hardware has had on the Soviet Union, several points can be made. First, in spite of the activity that has been shown in this area, the impact to date on Soviet computing capabilities probably has been minimal at best. When one considers that the United States has something of the order of 40 million personal computers, or one for every six people in the country, [57] the cases of most of the contracts signed with the Soviet Union, numbering in the tens or hundreds of thousands of units, seem small indeed.

With approximately 300,000 PC's currently in country, or one for every 900 people, the Soviet Union probably needs to obtain 20 million computers along with the necessary peripherals and accompanying equipment to bring itself up to western standards. [58] Peripherals represent another major concern for the Soviet Union that will be discussed later; for now, it is sufficient to say that along with computers themselves, substantial investments must be made in the area of telecommunications to provide the means necessary for networking and linking of data bases that are becoming the foundations of the information revolution. That the Soviets realize this can be seen in their efforts in these related areas. Whether they can overcome these problems, either because of internal resistance, western restrictions or the sheer cost involved, is yet to be determined.

Other problems exist as well. In spite of the publicity given to agreements with western firms in these and other related areas involving high technology, and particularly Joint Ventures which are highlighted as signs of the new cooperation between East and West, the limited results to date are a sign of the problems involved in structuring and bringing such deals to fruition. [59] The Soviets themselves point out that while many letters of intent have been signed, the number of functioning Joint Ventures remains disappointingly small. [60] Problems with the lack of convertibility of the ruble, differences in standards and requirements in terms of quality and reliability, and just having the patience needed to deal with the Soviet system all take their toll of the number of deals that actually take place in contrast with those that are planned. [61] While the Soviets often bemoan western reluctance to more actively seek such agreements, western firms often find the disincentives for participation greater than the incentives, and the possibilities for returns on their investments greater in other areas. [62] Finally, recent political instability in the country has done little to calm the fears of investors who already had ample reasons for looking elsewhere for places to put their capital.

This is not to say that these types of problems cannot be overcome, or that the limited scope of these initial transfers, in comparison with the overall size of the problem, is causing the Soviets to have second thoughts about the course that they appear to have chosen, especially when it comes to computer technology. The demand for computers is so strong that almost any means will be used to obtain them. In just one example, as a by-product of the looser restrictions on travel, a flourishing trade developed in bringing computers back from visits to the West. A Soviet citizen who managed to get enough hard currency to buy a $3,500.00 computer with printer in the West, could sell it for 90,000 rubles or $145,000.00 at the official rate once he returned home. [63] Cooperatives have reportedly been formed to perform exactly the same function on a more structured basis. While it hardly can be expected that such efforts will eliminate the deficit in computer hardware, it represents the extent to which some sectors will go to satisfy the existing demand. If the Soviet Union continues on its present course toward a more open economy that allows these demands to be met by whatever means are available, it seems likely that computers will continue their current flow into the country. [64]

But does the mere import of hardware in this case represent a concern in terms of the transfer of technology? Especially with regard to the lower end of the computer spectrum, the PC's and smaller computers whose technology is already several years old in the West, this would hardly seem to be the case. Yet the argument can be made that while these machines in themselves are not state of the art, their mere availability represents a potential transfer in terms of the exposure that they give to a growing segment of the population. Earlier examples have shown cases where, even when higher technology machines were obtained, it was difficult to integrate them into enterprises and use all of the capabilities that they possessed; Soviet operators simply did not have the background to take full advantage of these computers if they could operate these machines at all. Now, however, as more and more machines become available both in schools and in industry, an entire new generation of Soviets is becoming computer literate. Soviet computer experts speak of clubs of computer "hackers" not unlike the phenomenon seen in the West. [65] While this phenomenon, as well as the general level of computer literacy and exposure is still far below that of the West, it is in fact rising, something that could not occur if the machines were not available in increasing numbers.

Returning to the question as to the value of such hardware transfers that was raised at the beginning of this chapter, while the value of the actual technology being transferred is probably small, the intrinsic value of the capabilities that these technologies embody is potentially great. In this regard, the true extent of the impact of loosening regulations governing the export of computer hardware and its eventual impact on the technological level of the Soviet Union is yet to be seen. In the short term, the numbers involved in comparison with the scope of the dilemma, would seem to argue that little change in the Soviet Union's overall position will result. The deficits are so great that whatever numbers are involved disappear as if swallowed up in a vacuum. In the longer term, however, as reflected in the growing figures on trade and the number of Joint Ventures that have been proposed and initiated, it seems fair to acknowledge that there exists a substantial potential for increases in the transfer of technology, if not in the technology embodied in the hardware that is being brought to the Soviet Union, then in the general level of computer competency that comes with increasing availability and access. The question of whether this, in turn, will result in a major jump in the overall capabilities of the Soviet Union in the area of computers is dependent on other factors as well, for too many instances in the past have shown that the mere receipt of hardware has done little to increase the overall level of capability in a given area. Thus, there are other areas that come into play and must be considered before a final evaluation can be made.

ENDNOTES

1 For an excellent treatment on the various aspects of computer technology, see the Time-Life series, Understanding Computers, (Alexandria: Joseph J Ward), 1987. This encyclopedia contains individual volumes dedicated to questions concerning hardware, software and information technology.

2 From the prepared remarks of Dr. Phillip A Roberts, keynote address at the American Association of Technology Transfer Conference, 27 June 1990, Dayton Ohio.

3 "Shortage of Computers in Schools," Moscow home service, 26 April 1988, as reported in SWB SU/0151 C2/2, 14 May 1988.

4 As mentioned in the previous chapter, the question of 'lag time' is vaguely defined at best. Andrew Nagorski in "Russia Faces the New Age," Newsweek, 18 August 1986, p. 15, cites an American diplomat in Moscow as giving a figure of 7 to 10 years, and "if they don't get rolling quickly, they could soon be 10 to 20 years behind." (ibid.). Alex Bean in "Atari Bolsheviks," Atlantic Monthly, March 1986, p. 28 cites Dr. Seymour Goodman as giving a figure of 15 years. Current British government estimates range from 4 to 16 years, depending on the nature of the technology involved. Whatever figure one chooses, it is almost the unanimous opinion of all observers that a substantial gap exists between the Soviet Union and the West in the level of computer technology present in society.

5 Again, figures on the rate of advancement vary depending on the observer and what they are observing. Most, however, would agree that the rate of technological advancement in society is increasing almost exponentially. While the first computer generations were the dominant machines in their fields for a fairly long period of time, computers today are becoming 'old' at three to five years from introduction, and obsolete after ten.

6 Alex Beam, "Atari Bolsheviks," The Atlantic, March 1986, p. 29.

7 Vadim Bikhitin, interviewed in, "The Demand for Personal Computers," SWB SU/0183 C/1, 21 June 1988.

8 B. Naimov, "Personal IBMs at the Start," Izvestiya, 11 July 1986, p. 3.

9 See "Western Computer and Microelectronic Joint Ventures with the USSR," British Government Document, August 1989, pp. A-1 to A-19 for specifics on individual ventures.

10 Ibid.

11 David Silverberg, "Soviets Target Computer-Aided Design Technology," Defense News, 17 April 1989, p. 1.

12 Carole A Grunberg, "Make CoCom Face the Future," Journal of Commerce, 21 May 1990, p. 6.

13 For just one example, see the New Information Technologies (Novintech) flier reproduced in Appendix D.

14 Leanne Grossman, "U.S. and Soviet Officials Discuss Trade Expansion, Announce Several Agreements," Business America, 4 December 1989, p. 24.

15 From the notes of Professor B. P. Pockney, University of Surrey. Using grain harvests as an example, 1984, 1985 and 1988 were particularly bad years, with harvests in millions of tons of 172.6, 191.7 and 195.0 as opposed to 211.4 in 1897. As might be expected, agricultural purchased from the United States were particularly high in those years. See chart, Appendix E.

16 Clyde H. Farnsworth, "U.S. Eases Restraints On Exports to Soviets," New York Times, 24 March 1989, p. D-2.

17 U.S. Department of Commerce, "U.S. Trade with the USSR-- 1985-1989," provided to the author by the Department of Commerce, July 1990. A Conversation with Mr. John Crawford, Soviet Desk Officer, British Department of Industry and Trade (DTI) on 5 April 1991, in the London offices of DTI, confirmed the same general trend, though specific figures for Great Britain were not available.

18 Ibid. The same figures show a decline in the purchases of various types of foodstuffs, parts for motor vehicles and certain industrial instruments.

19 Interview with Ms. S. Kay Burnett, U.S. Army Foreign Science & Technology Center (FSTC), conducted on 1 August 1990. These figures are also referenced in "List of Joint Ventures Related to Computers," p. A-19. For a comparison, the Central Intelligence Agency estimates over 1000 JV's had been signed by 1990, with 20% involving "computer development and production, software development, and related computer services." From, "The Structure of the Soviet Civilian Computer Industry," Reference note, LDA 90-10236, February 1990, p. 7.

20 "Western Computer and Microelectronic Joint Ventures with the USSR" pp. A-4 to A-6, A-14, A-16, A-17.

21 Ibid. pp. A-4, A-5. INTERQUADRO is a good example of this philosophy.

22 I. Andreyev, "With the Participation of the Siemens Company," Isvestiya, 18 June 1989, p. 6.

23 In possibly one of more interesting examples of such barter arrangements, several years ago the New York Times reported a case where a western firm dealing in state-of-the-art electronics was offered pickled cucumbers as payment for a shipment of electrical instruments.

24 Interview with Kay Burnett, FSTC. The number of computer related Joint Ventures recorded by the Foreign Science and Technology Center was so small that Japan was not represented on the chart in Appendix G.

25 "Western Computer and Microelectronic Joint Ventures with the USSR," p. 3. Also see FSTC chart, Appendix G.

26 "Western Computer and Microelectronic Joint Ventures with the USSR," p. 3.

27 Ibid. This figure was based on an unspecified article in Pravda, 1988.

28 "Western Computer and Microelectronic Joint Ventures with the USSR" p. 2.

29 Interview with Kay Burnett, FSTC.

30 Elaine Sciolino, "Ease Soviet Trade Shultz Advocated in Final Days," New York Times, 25 January 1989, p. I-1. A more recent example of this line of reasoning can be found in John Lloyd's, "West urged to keep up Soviet support," Financial Times, 25 February 1991, p. 6.

31 "CoCom Analysis: High Level Meeting Liberalizes Low Level Technology," Export Control News, July 1990, p. 2.

32 "Summary of HLM Meeting," Unpublished Report, Defense Intelligence Agency, 1990, p. 2.

33 Ibid. p. 3

34 While every effort has been made to limit the 'technical jargon' in this work, a few such terms must be included and need to be defined. Processing Data Rate (PDR) is the speed at which a computer handles its operations, and has been used in the past by CoCom to indicate what level machines are subject to export control; the higher the PDR, normally the more powerful the computer. Millions of bytes per second (Mbps) is the rate that PDR's are measured in. It should also be noted that CoCom at this time is changing over to a new measuring system, Calculated Theoretical Performance (CTP) which measures the ability of computers to perform calculations in terms of speed, complexity and accuracy. For an excellent reference on these and other terms, see "Semiconductor Technology for the non-Technologist," United States Department of Commerce, Bureau of Standards, 1981.

35 "Summary of HLM Meeting," pp. 2-4.

36 For a brief time, there was a special organization formed in Germany just to deal with these problems. See David Marsh, "E Germany acts to enforce CoCom rules," Financial Times, 28 June 1990, p. 3.

37 Interview with Mr. Steve Saboe, Special Assistant to the U.S. Ambassador for Export Control, United States Department of State, conducted on 3 August 1990. During the interview, Mr. Saboe indicated that one of the key issues now under discussion was the need for limitations on transfers of certain technologies to be maintained, due to the fear of the consequences of critical technologies falling into the hands of countries outside the traditional East-West blocs, but which represented a growing security risk in their own right. Events of the past several months in the Middle East have only served to reinforce these concerns.

38 William Dawkins, "West Puts off technology sales relaxation," Financial Times, 26 February 1991, p. 6. These concerns were also reinforced by recent Soviet actions in the Baltic states, and the apparent backlash to the reform process in the Soviet Union on the part of the military and other conservative elements.

39 Interview with Col. John Carney, Military Advisor to the U.S. Delegate to CoCom, conducted at CoCom headquarters in Paris on 18 February 1991. Col. Carney confirmed what had been indicated earlier in the press, that the number of critical categories of technologies being monitored by CoCom was being decreased from 12 to 9, and a general effort was being made during the review process to cut down on the number of items designated for control.

40 As of this writing, the review process was ongoing. The original goal of completing the review by September 1990 was described by one individual involved as "highly unrealistic."

41 This information was given to the author by two different Soviet citizens involved with such ventures, at separate times and locations. Their identity has been omitted at their request.

42 "Western Computer and Microelectronic Joint Ventures with the USSR" p. A-6.

43 Ibid., p. A-8.

44 "Siemens Signs Contract for Giant Computer Project with USSR," Unpublished Report, Defense Intelligence Agency, 1989.

45 Andreyev, "With the Participation of the Siemens Company," p. 6.

46 "Siemens Signs Contract for Giant Computer Project with USSR," DIA Report.

47 Andreyev, "With the Participation of the Siemens Company," p. 6.

48 Anyone who has dealt with Soviet citizens for any period of time will attest to the bias in their attitudes toward non-caucasians, in spite of seventy years of education in the virtues of socialist equality. Whether this is a primary reason or not, the fact remains that the record of Soviet ventures with the Japanese has not been one of spectacular successes. Whether the return of the northern islands to Japan will do anything to change this record, remains to be seen.

49 "Western Computer and Microelectronic Joint Ventures with the USSR" p. A-14.

50 Sandra Sugawara, "Firm Plans PC Venture In U.S.S.R.," Washington Post, 12 December 1989, p. C-1. It should be noted that the Ministry of Radio Industry is a VPK (Military-Industrial Commission) member, with a sizable percentage of its production going to the Soviet military.

51 Michael Lev, "Soviet Plant, U.S. Managers," New York Times, 11 October 1989, p. F-3.

52 "Control Data Asks to Sell To Soviets," Washington Post, 13 December 1989, p. G-1.

53 Ibid.

54 "Siemens Signs Contract for Giant Computer Project with USSR," DIA Report.

55 In spite of the afore mentioned biases that the Soviets have, this has not stopped them from making several surprisingly warm

gestures to South Korea, including a meeting between President Gorbachev and President Roh Tae Woo in San Francisco, much to the displeasure of North Korean President and long time Soviet ally Kim Il Sung. The Soviet-South Korean link is an interesting one to watch; Korea in the past several years has become the Japan of the nineties in terms of being a high technology powerhouse, however it finds itself at odds with the West and particularly the United States over human rights issues and a less than liberal government. The Soviet Union, for its part, has no qualms about authoritarian regimes, represents a hugh untapped market for Korean goods, and would welcome relations with a country reaching the cutting edge of world technology, but unencumbered by CoCom restrictions since it is not a member. Recently, several Soviet officials, including the 1st Secretary of the Moscow City Communist Party Prokofiev and Col. Alksnis have cited South Korea as a possible model for the Soviet Union to emulate.

56 "Soviet's Interested in Brazilian-Made Computers," Unpublished Report, Defense Intelligence Agency, 1988.

57 Lawrence Edleman, "Computer lag irks Soviets," The Boston Globe, 29 December 1989, p. 63.

58 Ibid.

59 Yu. Medvedkov, "The Foreign Factor Becomes a Fact," Pravitelstvennyy Vestnik, no. 37, September 1990, p. 11, as appears in JPRS-UIA-90-018, 4 December 1990, p. 17.

60 For a discussion of this and other problems with Joint Ventures from a Soviet perspective, see Ye. L. Yakoleva, "Hot Spots in East-West Joint Ventures," Mirovanya Ekonomika I Mezhdunarodniye Otnosheniya, no. 4, April 1989, pp. 137-139, translated in JPRS-UWE-89-009, 23 August 1989, pp. 49-52.

61 One Soviet Trade Official made the comment to the author and several others present at the time, that "the greatest thing of value that the Soviets brought with them to a Joint Venture was the ability to navigate and work around the Soviet bureaucracy." While doubtless of value in Soviet eyes, westerners who have the option would probably rather not deal with the Soviet bureaucracy

at all, and take their money elsewhere. During the proceedings at the Forum for U.S.-Soviet Dialog, held at West Point, N.Y. 8-14 July, 1991.

62 Closely tied to the comments in endnote 61 above, the Soviets have a certain naivety in dealing with the West that is both charming and distressing Whether as a result of seventy plus years of being taught that profits are bad, or from a slightly more sophisticated realization that the deals they are offering the West might not be the most appealing, they have shown almost a total lack of understanding for concepts such as the time value of money, that is, for a Capitalist it makes sense in most situations to invest money in ventures that are likely to show a return in a reasonable amount of time, rather then invest in projects that may only show a profit after ten to twenty years. On more than one occasion, the author has been confronted by Soviets who cannot understand the western unwillingness to invest in long term high risk projects in the Soviet Union, when other investments that are both more secure and less likely to tie up assets over long periods of time exist.

63 "Crisis in computer capitalism," The Economist, 5 August 1989, p. 44. It is interesting to note that rather quickly, the Soviet Government imposed a stiff duty to dissuade such practices. Apparently the need for computers, in this case, was less important than prohibiting what appeared to be exploitive and antisocial behavior.

64 Izvestiya on 14 February 1991 ran a half page ad on page 8 advertising IBM compatible PC's, which could be bought for rubles, at market prices or less (no indication of what these prices were, though probably substantial) and would be delivered in seven to ten days. While the details of this arrangement were not given, if the offer was legitimate, it was an indication of both budding capitalist instincts in the Soviet Union and a reaffirmation of the market principle that supply will meet demand. See Appendix J.

65 "We Should Elevate Computerization to Superproject Status," Interview with Andrei P. Ershov, printed in Business Week, 11 November 1985, p. 102.

CHAPTER 6--PERESTROIKA AND COMPUTER SOFTWARE

Introduction

One of the problems with any analysis is deciding what exactly is to be analyzed. It is often difficult to separate a whole into its different elements simply because, without its constituent parts, the whole no long resembles itself and in fact may cease to exist. At the same time, however, if there are properties in the nature of one of the parts that cause it to be treated in a significantly different manner, with different variables and parameters, then the division in analytic terms may well be justified. Such is the case with computer software. Just as in science, where the elements that go into a compound may behave in a manner unique from the compound itself, software possesses a different set of characteristics, in terms of transferring technology and problems of control, than computer hardware. Both must be present, but each is, in and of itself, unique. Thus an examination of the issues surrounding software, separate from hardware, is warranted.

Software is the brains of the computer, the element that tells it how to function, that allows it to deal with the multiple tasks given computers, and gives the computer the capability to adapt to new problems and situations. From the early days of computers when instructions were entered manually or by physical means, such as the use of punch cards, software has progressed to the point that today programs containing literally millions of instructions and bits of information can be stored on microchips no larger then a button. In terms of what these programs can accomplish, computers with the proper software can solve problems that as little as ten years ago were considered virtually unsolvable, allowing man to attempt things that in earlier times he could only dream about. With the advent of Computer Aided Design and Manufacture software (CAD/CAM), the possibility exists of designing new computers with even greater powers and writing still more complex software, further expanding the computer's already enormous capabilities. The importance of software is such that, in the words of one author, "Software has surpassed hardware as the driving force behind successful computer systems." [1]

However, just as the capabilities that software represents are enormous, so too are the problems that it presents in terms of export control. In physical terms, the miniscule size of even very large and sophisticated programs makes the control and detection of efforts to illegally export software virtually impossible, a thousand times more difficult than finding a needle in a haystack. Quoting from a study done for the American National Academy of Sciences:

> It is extremely difficult to restrict the flow of software. It is too widely available, too easy to replicate and too easy to conceal. A single 8 mm digital vidiocassette, small enough to fit into a shirt pocket, can hold all of the sources and binaries to a major software package representing thousands of person-years of effort. [2]

Because of the nature of software and advances in the related field of telecommunications, it is not even necessary to physically transfer the mediums on which programs are stored; data links and computer networking allow programs to be sent great distances in a matter of seconds. Finally, there is a larger question in terms of software representing knowledge that cannot be entirely separated from the the individual who possesses it. Just as Einstein brought with him the seeds of the atomic revolution when he left Germany in the 1930s, which would then take root and grow once he was in the United States, so any programmer brings with him the ability to recreate any program that he has written, or improve upon any program once he is familiar with its nature, based on his own knowledge and experience. Indeed, the task of controlling any entity as broad and enormous as this must be considered herculean at best.

Having cited the difficulties involved, however, does not imply that attempts have not been made to limit the flow of technology in this area. CoCom lists both categories of software and specific programs that are restricted from export to the Soviet Union. Measures, such as licenses and copyrights, are also invoked as a means of preventing the unauthorized copying and use of software. Finally, in cases where a specific software program is available only in the West, the access of foreign programmers and specifically those from the East can be limited, so as to prevent them from making use of these capabilities in developing their own software. This last case raises many questions, especially with regard to academic freedom, that have yet to be resolved and serve only to highlight the enormous problems involved. For even as difficult as it may be to place controls on the transfer of technology through software, the alternative, that of not making any attempt, is equally unacceptable.

The Nature of Software

The problem with software and efforts to control it lies in its very nature. Unlike hardware, which entails a physical entity of some specific size, shape and proportion, software has none of these characteristics. Yet it is every bit as essential to the operation of the computer as the hardware itself. As defined in Webster's New World Dictionary of Computer Terms, software comprises the "programs, languages and/or routines that control the operations of a computer in solving a given problem." [3] While physically similar in terms of the way it is written and coded, software can be divided into three general categories based upon the functions that it performs: Systems programs or operating systems, which control the overall operation of the computer; Application software, programs designed to solve a particular problem or perform a specific set of functions; and Utility software, designed to interact with several application programs where a common function is required by all these applications. [4] While these different types of programs will be dealt with under the single category of software for the purposes of this study, it should be noted that each has a specific role to play in computing that, in turn, may make its acquisition desirable or even essential in a given situation. Systems software for a particular piece of hardware may go through several iterations, upgrading and making better use of the capabilities of a particular computer without the need of physically changing the hardware. Applications may run only with certain operating systems, meaning that while someone has access to both a computer and an application program, they may not be able to use that program without the proper systems software. Utilities can enhance the productivity of both an application and a given system. In general terms, in order to take full advantage of the capabilities offered by any piece of computer hardware, there must be access to the latest software in each of these areas. This, in turn, leads back to the question of controlling all of these categories of software.

As to what actually comprises software, volumes exist on the topic so that any effort here to describe what is involved must be superficial at best. Today's software, reflecting advances both in the storage mediums and growing sophistication in programming, can consist of millions of instructions, stored magnetically, which allow computers to perform complex functions at speeds that humans cannot duplicate. Coding systems for software may vary, depending upon the type of instructions or language used by the programmer to create a program. The actual process of writing and checking a particular program can take years, depending upon its complexity and the function it is to perform; [5] however, once created programs can be easily duplicated and transmitted electronically anywhere in the world. The irony here is that the item which possibly is the most essential element to unlocking the power of any computer and arguably one of the most difficult to create, is at the same time probably the easiest to transfer, and thus the most difficult to control.

Soviet Software

From the early days of computers, when writing software involved nothing more then the coding of a few commands, the creation of software has become a complex process, combining aspects of both science and art. While no one skill can be identified as of preeminent importance to the creation of software, a strong background in mathematics is helpful, as well as patience and the ability to think in abstract terms. In all these areas the Soviet Union would seem to have, if not an advantage, then at least a firm basis on which to build a robust software industry. [6] Mathematics has always been a Russian strength, and, in fact, early in Soviet computer development large numbers of Soviet mathematicians were turned into computer specialists. [7] In the sciences, theoretical thought has always been a strength of the Soviet Union, a trait reinforced in recent years by a lack of equipment which forced researchers to try to solve problems analytically rather than by experimentation. [8] Finally, Russians, if not patient by nature, have proved their ability to conquer problems through sheer tenacity. Still software development has never been a strength of the Soviet computer field, and is considered by many to be an area of severe weakness. [9]

As stated by one source:

> Software has always posed a major problem for the Soviets, especially applications software which is job specific and is difficult to modify for another area of operation. Until the early 1980's the USSR was almost totally reliant on Western software, especially for use in the fields of supercomputing, NC/CNC (Numerically Controlled/Computer Numerically Controlled) machine tools and CAD applications. Since then there have been several attempts to develop a Soviet software base but progress has been limited. [10]

The two questions that come to mind here are, first, why this should be the case given the presence of the preconditions which one would expect would allow the Soviet Union to excel in this area, and second, whether inputs of technology from the West have the possibility of overcoming the problems that have caused this weakness?

The Problems with Soviet Software Development

Aside from the general problems affecting computers identified earlier, in terms of the bureaucratic inertia, manufacturing difficulties and lack of coordination, several items can be identified as causing specific problems in the development of software. One of the most obvious is the lack of hardware. [11] While programs can be written manually, they must eventually be placed on a computer to be checked and 'debugged'. Even once a program has been run successfully, the development process normally continues as users of the software adapt programs based on their own experience. One of the strengths of western computer software is that once released, literally thousands if not tens and hundreds of thousands of people will utilize a program, identifying weaknesses and suggesting or making changes to the program as needed; "the notorious openness of the West's computer industry...propels the advance of quality software at a rapid rate." [12] Obviously, without the machines to test and run a program, the development process will be slowed. Thus, without a sufficient amount of computer hardware, Soviet software development has suffered.

Domestically, the lack of openness and the ability to freely exchange ideas has probably hindered software development as much as the lack of computers. As just mentioned, one of the strengths of the western software industry is the wide distribution that is made of programs; with telecommunication nets and highly developed commercial markets, software products may be distributed throughout the West in literally a matter of weeks. In the Soviet Union, not only does the lack of these networks hinder such distribution, but it is further limited by bureaucratic infighting between different industrial concerns and the ministries, and the general restrictions that have applied to the flow of information via any medium. In just one example of how these restrictions can affect the ability to transfer, or even gain access to, information that would benefit those working in the area of computers, for years there has been a journal entitled <u>Elektronaya promyshlenost</u> (Electronic Industry) whose existence has been verified, but whose availability has been restricted because discussions of issues relating to high technology electronics are felt to be to closely related to defense issues. [13]

As in other branches of science and education, the lack of the ability to conduct what would in the West be considered the normal process of intellectual interchange has severely hampered the software field, a field whose hallmark in the West has been the speed and ease of information exchange. On the contrary, as reflected in the findings of the American National Academy of Sciences, "The Soviet software industry is scattered over a wide range of organizations, including many in house groups that are isolated from the rest of the industry." [14]

Finally, Soviet software development has suffered from its lack of exposure to the West. Just as limitations on domestic interchanges of information have adversely affected software development internally, isolation from world trends has prevented Soviet programmers from keeping up with and benefiting from the tremendous amount of development that has taken place in the rest of the world. In a situation that seems almost out of Gogol in its absurdity, the first thing that any aspiring Soviet software developer must do is to learn English, since almost all computer languages and programs are based on the Roman alphabet, with English commands predominating. [15] While several attempts have been made to create a Cyrillic based computer language, none of these has been successful enough to gain widespread acceptance in the Soviet Union. [16] Yet even though Soviet computer programmers and software developers have the capability to deal with the West in a common language, their opportunity to do so, both physically and via electronic means, has been hampered because of the restrictions placed upon travel and other types of contact. What makes this situation all the more ironic is that with the decision to copy western computers came the need to develop programs for these machines, so that "since the early 1970s, a large fraction of the talents of East European systems programmers has been devoted to understanding and uncompiling or duplicating western operating systems...." [17] As in too many other cases, the West leads the software field, and without access to the leading trends and information in the West, Soviet software has run a very poor second. [18]

This is not to say that Soviet programmers have not attempted to make up for these shortcomings, or that they do not have certain strengths of their own. Because of the large number of highly qualified people in the Soviet computer field, Soviet programming must be credited with a certain amount of potential, even if its products to date have been generally less than spectacular. [19] This potential has been recognized in the West, with several western software firms offering jobs to Soviet programmers on the rationale that their very lack of exposure to western methods allows the Soviets to come up with some very original and unique solutions to programming problems. [20] Just as there is an element of truth in the saying that the most dangerous opponent in a duel is the untrained swordsman because he is unpredictable, Soviet programmers often come up with ideas and concepts that would not have occurred to westerners schooled in traditional methods of programming. The success of the Soviet computer game TETRAS has demonstrated that Soviet programs can match those of the West under certain circumstances, and in several areas such as seismographic computer simulations, western experts have found Soviet software programs to be superior to any found in the West. [21] However, as a general rule even the Soviets recognize and concede their weaknesses in this area, as can be evidenced in their rush to take advantage of the new opportunities for obtaining western software technology as these opportunities become more available. [22]

Controls on the Transfer of Software Technology

While many of the problems with taking advantage of western software have been generated by the Soviets themselves, this does not mean that the West has not taken actions of its own to hinder such transfers. Restrictions on software transfers in the past have represented a combination of both intentional efforts to prevent access to software programs, and measures that, while not specifically designed to limit such transfers, acted to restrict their use nonetheless. In the first case, CoCom restrictions on specific programs and certain categories of software have always been in place, and even if difficult to enforce, have acted to restrict open transfers of these materials through the threat of sanctions against those individuals and companies who did. [23] That illegal transfers do in fact occur was most vividly demonstrated by the now famous case of the Toshiba milling devices, used in manufacturing submarine propellers. The software needed to direct these devices came from Norway, and when combined with the machines themselves represented a capability of tremendous military potential that the Soviet Union previously did not possess. [24] However, even as significant as such cases were in specific areas, they appear to have done little to affect the overall level of Soviet proficiency in software development. In general, the numbers of such transfers are so low that they have had little effect on the overall level of software development. Of greater importance to this level is the transfer of general purpose software, where massive inputs might not only have affected software development, but the general level of Soviet computing and computer use.

This leads to the second category of limitations, where formal restrictions were not in place, but where Soviet actions themselves have limited their access to western software. These center around the issues of copyright laws and agreements regarding intellectual property. A major problem in this regard has been the failure of the Soviet Union until recently to agree to world copyright and licensing regulations. [25] The development of software is extremely time intensive and costly; copyright and licensing agreements play a large part in ensuring that developers maintain a degree of control over the results of their labor. Even when a particular piece of software has not been restricted by any formal export regulation, manufactures have been loath to sell their work to those who did not recognize intellectual property rights, out of fear that once out of their control, software would be duplicated and used with no regard for agreements that call for the originator to be paid for his or her work. Even though the Soviet Union has now agreed to abide by international copyright regulations, there is no international system for enforcing such measures, while the Soviet record for abiding by such international agreements has been mixed at best. In one respect, this should not be surprising; going back to the case of the Ryad, one of the reasons for adapting the IBM series for eastern bloc use was to take advantage of the tremendous amount of software that had been developed for IBM computers.[26] It would make little sense to go through all the effort to copy the hardware and then not copy the software as well. At the same time, western software developers, having seen what has happened in the past in terms of programs that have made their way to the East and been duplicated without permission or the payment of royalties, are far from enthusiastic about providing their latest developments, even for examination. The Soviets themselves have acknowledged the problem and have been working to adopt new copyright standards throughout the Soviet Union; however, their ability or even willingness to abide by these standards once adopted, remains in doubt.[27]

Yet another problem area that has limited the transfer and use of western software has been the lack of any developed base of software using the Cyrillic alphabet. As already noted, it is expected that Soviet software programmers learn English in order to use programming languages written using the Roman alphabet, however it would be quite another matter to require users in general to learn English in order to be able to operate western programs. As the number of western computers being imported or otherwise becoming available increases, the ability to use already developed western programs, as opposed to developing Cyrillic equivalents at great time and cost, is a major concern. To be of any widespread use to the computing population, western software has to be converted or in other ways be made 'user friendly' for non-English speakers. [28] This is one case where the solution of acquiring western products as a way of overcoming domestic deficiencies has limited utility, if those products cannot be used effectively. In sum, such problems have presented greater barriers to the transfer and use of western software than the formal restrictions that are in place, for it made little sense for western firms to sell software to the East if they could not be guaranteed adequate protection and remuneration for their products, and little sense for users in the East to try to obtain western products which they could not readily use.

This is not to say that transfers of software have not taken place. The advantages to be gained, in terms of time and money saved in not having to duplicate the software development process and instead benefiting from the labor of others, often far outweighs the drawbacks involved. Western software is highly prized in the Soviet Union, as demonstrated by the lengths gone to in order to obtain it. [29] From a western perspective, such transfers are next to impossible to control; the only saving grace has been that, until recently, such transfers have appeared to have had a limited impact on the overall development of Soviet computing capabilities. From a Soviet perspective, while there are advantages to copying western software, there are also adverse effects. According to Dr. William McHenry, one of the West's leading specialists on Soviet Information management, "Copying IBM allowed them to take advantage of the hugh amount of western software, but it didn't serve their purposes by supporting a homegrown industry." [30] Thus, just as in the case of computer hardware, using western software may have undercut the development of Soviet domestic software capabilities.

Transfers of Software Technology in the Period of Reform

As with the case of computer hardware, the changes brought about by the attempts at economic reform, along with the western responses to these changes, have addressed many of the problems that earlier hindered the acquisition and assimilation of software technology. Increased trade and the lowering of barriers, both formally in terms of stated CoCom restrictions and informally in terms of the willingness of western firms to do business in the Soviet Union, have made it easier to obtain western software. Warming relations have increased contacts with the West in terms of access to both material and information; Soviet software developers are now in a far better position to keep up and even integrate with world trends. The mere fact that more computers are becoming available through trade and East-West Joint Ventures is a help as well, for with exposure comes increased demand, demand that helps support the further development of domestic software efforts. [31] This process is reflected in the growing number of software cooperatives that have begun to appear, catering to the growing market for their services. [32]

Soviet acquisitions of western software in the past five years range from traditional methods to some that, spurred by the recent warming trend in East-West relations, represent original and unique ways of accessing information. The Soviets have continued seeking to buy software on the open market, and with the loosening of export restrictions the frequency of such transactions has grown proportionally. At the upper level of the software spectrum, the Soviet Union has shown particular interest in obtaining sophisticated application programs. In what was "believed to be the first deal of its kind involving 'intelligent' computer programs" a British company, Expertech, sold two highly sophisticated programs to the Soviet Union in 1989, in a deal worth 3.2 million pounds. [33] The programs, so-called expert systems, "give computers the ability to provide apparently reasoned answers to queries to specific areas of knowledge." [34] A fairly new field even in the West, this agreement is also noteworthy in that while the sale was allowed, CoCom restrictions prevent Expertech from helping the Soviets develop specific applications from the base programs. Thus, while it is significant that this sort of leading edge technology was allowed to be transferred, a question remains as to whether the Soviet Union will be able to take full advantage of the capabilities of these programs and build upon the initial technological base they provide. [35]

More basic in terms of the capabilities involved, but at the same time possibly of greater significance for the overall level of computer development, was the announcement in April 1990 that the western software giant Microsoft Corp. had developed a Russian version of MS-DOS, one of the key operating systems in the West and used in most IBM-compatible computers. [36] Going back to the time when the Soviets made the decision to copy IBM designs for their Ryad series of computers, IBM has been favored in the Soviet Union, in addition to being the preeminent computer system in the world today. [37] In the past, users of IBM computers in the Soviet Union would have to either learn the English language commands governing their machines or use home made translations to run programs. Now, however, "working with the Soviet-American computer Joint Venture called Dialogue, Microsoft has developed a method to arrange Cyrillic characters on the keyboard and automatically translate them into the mathematical language used internally by PCs." [38] The significance of this development needs hardly be underscored; with a majority of the machines in the Soviet Union being IBM compatibles, this translation will make it far simpler for Russian speakers to access and use computers, further developing the 'computer cult' that has thus far been lacking in the Soviet Union. At the same time, this system allows for the wider use of the immense number of software programs that already have been developed for IBM compatible computers. [39] Other western software manufacturers have also indicated their interest in a share of the Soviet market. Aldus Corp. and AshtonTate have both said that "they plan to market applications, such as word processing packages, for sale in the Soviet Union." [40]

Software Transfers and Joint Ventures

Not surprisingly, one of the ways that the Soviet Union has sought to integrate with the West in the software area, as with hardware, is through Joint Ventures. Referring to the chart of Joint Ventures in the computer field produced by the United States' Foreign Science and Technology Center, software makes up the largest single category of Joint Ventures. (Appendix H). Not only does this represent the Soviet interest in this area, but the fact that software development is one of the few areas where the Soviet contribution to the Joint Venture can be a significant one, without requiring a large outlay of capital or other scarce material resources. [41] In addition to the general category of software, specific initiatives have been launched in the areas of Database Management, Computer Assisted Design (CAD) and Artificial Intelligence. [42] All these areas are heavily dependent on software, though initiatives in these cases seem to be more limited, possibly because of the sensitivity of these types of programs and the fact that they are subject to closer CoCom scrutiny.

While the terms of these agreements vary, in general such ventures allow the Soviet Union both to integrate with current world trends in programming and software development, as well as giving it access to new software products. They can also allow Soviet personnel exposure to the latest in western hardware, since programmers will normally be developing software for the current or even the next generation of computers. As indicated earlier, hardware alone does little to enhance overall computing capability; it must be joined with the software needed to control the hardware in order to be of any use. Thus many of the Joint Ventures dealing with hardware production and installation include provisions for the development and maintenance of software to accompany the hardware. [43] The Aris-Tbilisi Joint Venture, (the first such agreement with a firm in France, a country that is recognized as a leader in the software development field), MIKROGRAF with the UK firm Egotror, and DIAMEKS International with the Schach Trade Implex of Germany, are all examples of JVs with agreements tying software development with hardware. [44] In a slightly different vein, a Joint Venture between MicroPro of the United States and GORISTEMATEKHNIKA representing several Soviet interests has been formed to create a Russian language version of the popular Wordstar word processing program for distribution to the computing market in the Soviet Union. [45] Finally, there have been several ventures formed to sell Soviet software in the West. Izvestiya announced in March 1988 that a Joint Venture had been formed with Scandinavian Personal Computer Systems to market software from the Tallinn Institute of Cybernetics. [46] Talks have also been held between Soviet officials and the Borland software manufacturing corporation of the United States. These discussions have included not only distribution of Borland products in the Soviet Union, but the use of Borland's developed marketing and sales system for promoting Soviet software products in the United Sates and other western countries. [47]

This last example is of particular significance, since it shows one of the strengths that the Soviet Union hopes to be able to exploit through Joint Ventures. While far behind the West in manufacturing capabilities and sheer numbers of computers in use, there is no shortage of intellectual stock dedicated to computers in the area of software development in the Soviet Union. [48] In what can only be considered an odd and ironic turn of events, the lack of hardware has forced the Soviets to dedicate tremendous amounts of intellectual capital to solving problems in this area, in the same way that Soviet science in general has tended towards theoretical solutions of problems in cases where the material needed for experimentation is lacking.[49] As has been noted, the lack of exposure to western training and techniques in programming has been somewhat of a hidden blessing, in that it has allowed Soviet programmers to develop their own style and approaches to writing software, which has led to the demand for Soviet programmers in the West.[50] What it could mean in the future is a demand for Soviet software products rather than just the people who create them.

The Significance of Software Transfers and Export Controls

Evaluating the significance of these transfers and the effectiveness of related control measures is difficult at best, if for no other reason than the imprecise nature of software itself. While a physical entity in terms of the mediums on which it is stored and transferred, it is in a very real sense an intellectual entity, the product of creative thought, without the burdens of the need to manufacture or in other ways put it into a commodity form. In its physical sense, software causes problems for the West in terms of monitoring such transfers and the technology they embody, and especially when attempts are made to in some manner to control or restrict these transfers. These problems have been further compounded by advances in telecommunications, specifically the ability to transfer entire programs anywhere in the world in a matter of seconds. In the intellectual sense, software causes problems for the Soviets in that continued access to western products in this area requires recognition of the rights of intellectual ownership of the creators of that software. Unlimited transfers and exploitation of software, without the permission of the originator and remuneration for his efforts, discourages software creators from sharing their work or even investing the time and effort needed to create these programs. Thus, the situation presents something of a paradox, in that a commodity which in and of itself is very difficult to control, requires some means of control in order to provide the incentives for its further development.

In terms of Cocom restrictions, while guidelines have been established on certain types of software, it has also been recognized that this is perhaps the most difficult area of computer technology to control. The greatest success that has been achieved in this area to date has been where the software involved has had limited application, involving a small number of highly sophisticated programs which are easier to control. [51]

Even though the case of Toshiba proves that such programs are still subject to illegal exploitation, the numbers of such cases, as well as the applicability of such programs, are limited and transfers of this type do little to affect the overall level of software development. For the broader body of software technology, there exist legal control mechanisms governing the transfer of software technology. These mechanisms, in terms of copyright laws and other guidelines regarding intellectual property, allow for the monitoring of transfers, and require at least some acknowledgement and/or payment for their use. This, in turn, provides a control mechanism of sorts in that the consequences for flagrantly violating these guidelines in terms of the loss of commercial access may outweigh the benefits to be gained by such violations. While the policing of these policies might seem to be problematical, the Soviet Union is showing a growing understanding of the need to abide by these regulations, especially if it hopes to gain acceptance and integration on a greater scale with the West. [52] Thus, while the formal control of general purpose applications, such as data bases, word processors and the like is next impossible, it should be possible at least to keep track of what is being transferred and to require some form of compensation for their use. Here the concept is analogous to the problems in the software industry as a whole, where once created, software developers and their companies must come up with some way of protecting their intellectual property from unauthorized exploitation. In this case, general compliance with these guidelines has been achieved though respect for the law and the fact that if people illegally copy and make use of others' programs, they cannot expect any better treatment for their own.

For the Soviet Union, this line of reasoning is particularly relevant in that, along with an interest in obtaining western software, there is a desire to see Soviet efforts enter the market place and accorded the same rights. To gain this, however, the authorities and institutions in the USSR must abide by the same rules covering intellectual property, thus encouraging a self-policing mechanism. As long as the Soviets had little concern for the West in terms of acceptance and integration, there was little reason to abide by these rules; once software was obtained by any means, it could and was duplicated and disseminated with little or no thought for western restrictions or prohibitions. [53] Now, however, policies are changing, with the emphasis on cooperation with the West; and with these changes have come a new attitude about the way that such rules are treated. This has led to particular attention being paid to the issue of copyrights and licenses, with the Soviet legislature recently seeking to bring Soviet rules into line with international standards in this area. [54] Thus, while formal control mechanisms remain a problem, the changes in Soviet attitudes toward such measures may provide an informal check on the wholesale exploitation of western software.

The Question of Integration

These types of issues, in turn, lead to the broader discussion surrounding integration with the West, for which computer software also serves as an interesting microcosm. While it has long been recognized that there are benefits to be gained through integration, the Soviets in the past have shown limited interest in developing the potential of such benefits. Now, however, this is seen as an area to be exploited, not only in terms of the knowledge to be gained, but because software is one of the few areas where the Soviets have something that might be of value to the West, something that can be traded and marketed for other commodities that the country needs. [55] Joint Ventures formed to develop trade and exploit 'intellectual capital' suffer from fewer of the systemic problems that plague other JVs, simply because of the nature of the material and the mediums involved. At the same time, however, arguments can be made that one of the reasons that the Soviets have developed these capabilities is because of their previous separation from the West. Going back to the belief of Lebedev, Velikov and others in the need for an independent computer infrastructure, some Soviets would argue that the last thing that the Soviet Union wants to do is to integrate to the point that it loses its independent capabilities and becomes further dependent on the West. This would be especially true in an area where the Soviets have a good chance of keeping up with, and even the possibility of taking the lead, in a field of critical importance to the computer field overall. [56] Others would argue that the reason for falling behind in the first place was just this separation, and that the only way to ever catch up is to integrate wholly with the rest of the world. [57] At the moment, at least, the latter group seems to be carrying the day.

As if this situation is not confusing enough in itself, to it must now be added the western perspective. The western view of export controls was originally based on the need to protect certain high level technologies and the capabilities that could produce these technologies. In the area of software, this was extremely difficult, both because of the nature of the medium and of the technologies themselves. Still, a certain degree of success was achieved. At the upper end, the software programs that were of concern were relatively small in number and easier to monitor; at the lower end, the lack of general integration kept the Soviets from the widespread exposure to western trends that would have added significantly to their own capabilities. All this, however, is changing; as more numerous contacts are made, the difficulty in monitoring what is being transferred becomes overwhelming, while the general level of integration at the lower end may eventually increase the level of programming expertise to the point that the Soviets will be able to create whatever they need without western inputs. At the same time, there are definite advantages to be had by integration with the Soviet Union in terms of access to those areas where the Soviets have demonstrated strengths, as well as the ability to monitor exactly what capabilities they possess. The question for the West then becomes, do the benefits of integration outweigh the costs, and does integration offer a certain degree of protection, in terms of dependency and knowledge of the capabilities of others, when traditional export restrictions can no longer be enforced?

Summary--Some Thoughts on the Transfer of Software Technology

As already noted, one of the strengths of western software development has been the ability to distribute, access, make use of and modify software in an extremely short amount of time. At home, the Soviets have been limited by the lack of hardware (computer and telecommunications), by the fragmented nature of the computer industry (compounded by bureaucratic infighting and turf disputes), and by governmental restrictions on information flow. All these problems have been taken up in one way or another by the reforms. [58] The efforts at upgrading Soviet hardware in the computer area have already been addressed, while information transfers will be covered in the next chapter. Reorganizations in the computer industry have attempted to overcome the types of blockages that are the result of the nature of the system itself, with varying degrees of success. However, it is the area of general information flow and access to sources of information that were previously restricted, that may have the greatest impact on technological development of the Soviet Union. [59]

While openness without the tools to exploit the opportunities openness presents may seem like a hollow advantage at best, it is a situation that still may give the Soviets their greatest potential in the long term, especially as the tools become increasingly more available. Specifically with regard to computers, the combination of greater access to the West and integration with the current world standards can do nothing but improve the situation in this area. At the same time, greater integration at home, along with the freer flow of information and ideas allowing for dissemination of this information, compounds the value of the technology the Soviets receive from the West by allowing it to be utilized by a larger segment of the population. Hardware shortages will hamper this process in the short term; however, as the possibilities and capabilities offered by computers become apparent to a broader spectrum of society, the desire to take advantage of these capabilities will further speed the drive to obtain both hardware and software. As seen in the case of the Latvian computer professor,[60] the desire to gain up to date capabilities can and will lead to creative ways of overcoming what have been traditional choke points in obtaining this material. In this sense, the two trends tend to reinforce one another. Greater openness fosters greater demand, which in turn takes advantage of the opportunities provided by greater openness.

Relating this specifically to the area of computer software, the reforms have in fact begun to address those areas that have been at the base of the problems related to software, and by doing so have begun to create the infrastructure needed to make software development a viable part of the computer industry. The increasing number of computers, especially those from the West or based on western designs, will eventually if left undisturbed provide the necessary hardware to support software development. Drawing from the western experience, where "the most significant recent development in computer software has been the commodization caused by the arrival of IBM and Apple personal computers and their clones," [61] the more computers that are available the greater will be the strength of the software sector. At the same time, greater access to the West, through Joint Ventures and other means, will further strengthen this process by allowing both the ability to access western software and the techniques that go into its development. Finally, domestic reforms, in terms of greater freedom of information exchange and greater demands for software products, will create the environment needed to sustain the growth of a viable software industry. While this process may not occur overnight, there is little reason not to believe that, given the same conditions that were present in the West twenty years before, the

Soviets cannot create a computer revolution of their own.

ENDNOTES

1 David A. Wellman, A Chip in the Curtain, (Washington, D.C.: National Defense University Press, 1989), p. 99.

2 Global Trends in Computer Technology and Their Impact on Export Control, Report to the American Academy of Sciences, (Washington, D.C.: National Academy Press, 1988), p. 100.

3 Webster's New World Dictionary of Computer Terms, (New York: Prentice Hall Press, 1987), p. 232.

4 Software, From the Time-Life Series, Understanding Computers, ed. Roberta Conlan (Alexandria: Time-Life Books, 1985), p. 19-21.

5 The Committee to Study International Developments in Computer Science and Technology in their report to the American National Academy of Sciences notes that software programs of over one million lines of code, and costing over $25 million are no longer uncommon. See, Global Trends in Computer Technology and Their Impact on Export Control, p. 84.

6 S. E. Goodman, "Software in the Soviet Union: Progress and Problems," Advances in Computers, vol. 18, (1979), p. 265.

7 Interview with Mr. Sasha Garin, conducted on 12 May 1987, at the United States Army Russian Institute, Garmish, West Germany. Mr. Garin, an instructor at the Russian Institute, had been a mathematician in Leningrad who was one of those 'drafted' as a computer scientist because of his background during the rush to expand the Soviet computer industry in the late sixties and early seventies.

8 Gary Taubes and Glenn Garelik, "Soviet Science: How Good Is It?," Discover, August 1986, p. 39. A very good survey of the strengths and weaknesses of Soviet Science. Also see Paul Cocks' Science Policy in the Soviet Union, Washington, D.C.: U.S. Government Printing Office, 1980.

9 Global Trends in Computer Technology and Their Impact on Export Control, p. 161.

10 "The Soviet Computer Industry: The Key to Gorbachev's Modernization Program," Presentation to the UK-US bilateral conference on Computers and Microelectronics, June 1988.

11 Just about every commentator in the field cites a shortage of hardware as one of the chief reasons for the problems in the development of software. Even when computers are present, the failure of Soviet computing authorities to impose some kind of standard on the computing field has left each Ministry with its own machines and operating systems that are not compatible with each other. According to an article in Izvestiya, this situation has not become any better under the USSR State Committee on Computing Technology and Informatics. (see A. Ivakhov, "Supreme Soviet Committees Hear Complaints About Computer Technology," Izvestiya, 15 August 1988, p. 2.) What is also interesting to note is that because of the growing number of western computers, primarily IBM clones, MS-DOS is becoming the de facto operating system standard in the Soviet Union.

12 Wellman, A Chip in the Curtain, p. 105. Closely related to the importance of openness is the fact that with availability also comes competition, which in turn serves to improve the quality of the software being provided. Conversely, in the Soviet case, the lack of competition and the limits on the software available has caused a seller's, rather than a buyer's market, with little incentive for Soviet software developers to be responsive to the needs of those who use their products. In theory, the movement to a market economy should rectify this situation. In practice, such a result has yet to be seen, with the possible exception of the software cooperatives mentioned later in this chapter

13 The case of Electronaya promyshlennost is a fascinating example of the results of a closed society turning in on itself. A journal designed to report the latest in electronic manufacturing technology, it is the 'in house' journal of Minelektronprom, a VPK Ministry, and is available to only a select few in what are presumably enterprises engaged in defense related industries. Upon asking a prominent former Soviet lawyer, Mr. Lev Yudovich, about this publication's existence, he indicated that yes, such a journal did exist, but its existence was not officially acknowledged. Whether openness will extend to journals like this during the period of reform remains to be seen.

14 Global Trends in Computer Technology and Their Impact on Export Control, p. 162.

15 Interview with Victor Yassman, held at Radio Liberty, 28 April 1987, Munich, West Germany. Mr. Yassman, an analyst at Radio Liberty and a key follower of Soviet computer development was himself a trained Soviet programmer, and was able to speak on questions relating to software in the Soviet Union based on first hand experience.

16 Interview with a Latvian computer science professor, conducted in New Windsor, New York on 24 April 1990. This individual, who requested that his name not be given out, was traveling in the United States under the sponsorship of various Latvian emigre groups in the United States and Canada. With regard to the question of programming languages, he indicated that there was no serious programmer who did anything in Cyrillic, and that of the languages used, 80% were based on English, 15% German and 5% French.

17 Global Trends in Computer Technology and Their Impact on Export Control, p. 165.

18 Wellman, A Chip in the Curtain, p. 104.

19 "The Soviet Computer Industry: The Key to Gorbachev's Modernization Program," UK-US bilateral conference.

20 Interview with Victoria Prescott, Analyst Defense Intelligence Agency, conducted in Washington D.C. on 18 July 1990. Ms. Prescott was in charge of monitoring visa application for Soviet scientists wishing to visit the United States. She indicated that several western software firms had offered to act as institutional sponsors for Soviet programmers, precisely on the grounds that they were interested in the unique approach that the Soviets brought to programming problems.

21 Interview with Victoria Prescott. Ms. Prescott also indicated that the software firms she dealt with considered Soviet software programs, particularly in the area of earthquake modeling, to be far in advance of anything that was being done in the West.

22 A. Ruvinskiy, "Prize-Winning Systems Specialist Deplores State of Software Development," Leninskoye znamya, 29 May 1988, p. 4--Abstracted in DailySnap, Soviet News Abstracts Publication, Foreign Technology Division, 7 July 1988, p. 1.

23 Interview with Col. John M. Carney, Military Advisor to the U.S. Delegate to CoCom, conducted at CoCom Headquarters in Paris on 18 February 1991. Col. Carney indicated that, in spite of the problems with policing CoCom policies, the mere fact that an item was placed on the control list immediately ensured compliance from up to 80% of the business community that might do business in that particular commodity. In this regard such measures became self-policing, since businesses were either afraid to sell, or simply did not want to have the stigma attached to them for selling restricted items to the East. Col. Carney indicated that just by reducing the volume of such sales, CoCom was serving its intended purpose.

24 The Toshiba/Konigsberg Vapenfabrik case has become so well known, that it needs only be mentioned here. In violation of CoCom restrictions, the Japanese manufacturer Toshiba in 1982 and 1983 sent eight milling devices that allowed the Soviets to reduce the noise given off by their submarines by milling the propellers of these submarines to far higher tolerances than the Soviets had been able to achieve on their own. The software that controlled these devices was made by the Kongigsberg Vapenfabrik firm of Norway, an enterprise owned by the Norwegian government. While significant in military terms, such transfers do relatively little in increasing overall computer capability A. because they are tied to a specific function or piece of equipment with limited utility for the rest of the economy, and B. in the compartmentalized nature of Soviet military related industry, the diffusion of such technologies to give them a wider impact is almost unheard of.

25 Even though the Soviet Union has been a signatory of the Paris Convention on the protection of industrial property since 1965, A. Ruvinskiy in his article "Prize-Winning Systems Specialist Deplores State of Software Development," quotes L. A. Yegoshin, an associate of the Institute of High-Energy Physics as complaining, "there are no copyright laws which apply to (software) program texts." If the Soviet Union does not even

guarantee the intellectual property of their own citizens in the area of software, it can hardly be expected to observe the rights of foreign software developers. In all fairness, it should be noted that the Soviet Union is not the only country that is having problems coming to grips with copyrights as they apply to software.

26 Wellman, A Chip in the Curtain, p. 103.

27 Interview with the Latvian computer science professor. During the course of the interview, the professor indicated that any time a piece of western software was obtained, copies were immediately made for all those who needed the program; manufacturer efforts to incorporate 'copy protection' codes did not seem to present a problem. While very apologetic and recognizing the need to eventually conform to western regulations concerning copyrights, the professor went on to say that he and his colleagues felt fully justified in what they were doing, as it was the only way that they could keep up with current computing trends in the rest of the world.

28 V. Andryushchenko, "The Reply: Help Computers To Speak," NTR: Problemy i resheniya, 14 July 1989, as cited in, JPRS-UST-89-011, 24 August 1989, p. 3.

29 Interview with the Latvian computer science professor. In what is if not a unique, then at least an extremely creative and instructive case of technology transfer in the area of software, the author was told by the professor that the way he and his colleagues obtained software was to read western trade journals, identify the software they wanted to obtain, send letters to their relatives in the West, and when these relatives came to visit have them bring literally suitcases filled with software packages. There were no problems with export controls, since western customs officials never checked outgoing luggage, and no Soviet customs official would ever prohibit such material from coming into the country. Once there, he went on to say, it was only a matter of days before the software was copied and sent out to all those in the Latvian republic who needed it.

30 Alex Beam, "Atari Bolsheviks," The Atlantic, March 1986, p. 29.

31 The concept of the need for consumer demand to help provide the impetus for software development, as well as computer development overall in the Soviet Union, came from Professor Philip Hanson of the Centre for Russian and East European Studies, University of Birmingham, during a discussion with the author held on 12 March 1991.

32 Global Trends in Computer Technology and Their Impact on Export Control, pp. 189-191.

33 Alan Cane, "Soviet Union buys 'intelligent' software," Financial Times, 20 March 1989, p. 10.

34 Ibid.

35 Quoting the report of the Committee to Study International Developments in Computer Science and Technology, "Software is of little use unless it can be adapted and supported." (Global Trends in Computer Technology and Their Impact on Export Control, p. 101.) Thus, the same concept applies to software as was discussed earlier in general terms about the effectiveness of technology transfers. Physical transfer of a piece of equipment, or in this case a program, does little unless it can be modified or otherwise adapted to meet the needs of the body receiving the technology. Only when this capability is demonstrated can technology transfers be considered as having the potential to make a true impact on the level of technological skill of the receiving group.

36 Mark Lewyn, "Microsoft is Becoming Fluent in Russian," Business Week, 23 April 1990, p. 120c.

37 To give an idea of the dominance of IBM, some sources estimate that as much as 70% of world computer market is made up of IBM compatibles. The established base of software available to support these machines is tremendous. See, "Tweaking Big Blue's beard," The Economist, 29 October 1989, pp. 99-100.

38 Lewyn, "Microsoft is Becoming Fluent in Russian," p. 120c.

39 Quoting the Committee to Study International Developments in Computer Science and Technology, "One on the strongest motivations (for the Soviet Union) for building hardware compatible with western hardware was the purchase or acquisition of western software." Global Trends in Computer Technology and Their Impact on Export Control, p. 164.

40 Lewyn, "Microsoft is Becoming Fluent in Russian," p. 120c.

41 One of the comments about the nature of Joint Ventures with the Soviet Union is that the majority of those signed to date have tended to be in the service sector, because they do not require a large outlay of investment capital. Software ventures occupy a unique position in this regard, in that while they are an essential part of a technical field, they do not require much in the way of capitalization and are thus appealing. For an in depth analysis of the nature Joint Ventures, see Jan Vanous, Editor, "Joint Ventures in the Soviet Union," PlanEcon Report, vol. V, nos. 10-11-12, 24 March 1989.

42 "Number of (Computer) JVs by Type," Diagram, prepared by the U.S. Foreign Science and Technology Center, 1990. (See Appendix H)

43 "Western Computer and Microelectric Joint Ventures with the USSR," British Government Document, August 1989.

44 Ibid. pp. A-4, A-6, A-7.

45 David Thomas and Louise Kehoe, "Soviets seek software joint ventures," Financial Times, 7 October 1988, p. 26.

46 A. Sychov, "A Soviet Program for Western Computers," Izvestiya, 26 March 1988, p. 3.

47 "Computer Tech Sought," Soviet Business & Trade, vol. XVI, no. 18 (1988), p. 2.

48 In addition to recent changes in the overall structure of the computing industry in the Soviet Union, specific reforms have been directed at the software sector. One of these called for the development of 'software packages' that could be used by a number of industries. Another aimed at providing 100 to 150

programmers specializing in different areas of software development, who would, in turn, assist industry software developers with specific projects. "The Soviet Computer Industry: The Key to Gorbachev's Modernization Program."

49 "A Study of Soviet Science," Central Intelligence Agency Report, December 1985.

50 Interview with Victoria Prescott.

51 Global Trends in Computer Technology and Their Impact on Export Control, pp. 88-90, p. 103.

52 For an interesting article providing a Soviet perspective on the question of intellectual property, see N. Lynnik, "The Conflict of Rules," NTR Tribuna, 23 March 1990, p. 2, summarized in, JPRS-UST-90-008, 23 July 1990, p.18. Among other items, Lynnik indicates that a draft of the Law on Invention Activity has been prepared and is currently being debated.

53 It is interesting to note that several Soviet scientists have complained about this practice, since it involves not only the copying of western software but their own efforts as well, for which they received no compensation. A. Yuskovets complains that because there are no copyright laws covering computer programs, "Certificates of authorship for such (program) texts, even the most original ones, accordingly, are not issued...." Prize-Winning Systems Specialist Deplores State of Software Development, p. 4.

54 In addition to the Draft Law on Invention activity (see endnote 52) these issues were apparently discussed in a conference that was held in Moscow 11-13 July 1990, attended by USSR and US Government representatives. As reported by Moscow Tass, 2321 GMT, 11 July 1990.

55 In just one example of such proposals, the Financial Times reported that a group of Soviet computer scientists were seeking a Joint Venture in with the United States to design and manufacture a 32-bit microprocessor, either in the US or USSR. "In return, they would give the their US partner access to their software skills" Thomas and Kehoe, "Soviets seek software joint ventures," Financial Times, 7 October 1988, p. 26.

56 See O. D. Baklanov, "Reports By Politburo Members and Candidate Members and CPSU Central Committee Secretaries," Pravda, 7 July 1990, p. 6. for an example of this conservative line of reasoning.

57 S. Pachikov, "All-Out Campaign for Computer-Technology Transfer with West Proposed," NTR: problemy i resheniya, no. 16, 16 August-5 September, pp. 6-7, abstracted in Daily Snap, Soviet News Abstracts Publication, 26 September 1988, p. 1.

58 V. Kovalenko, "Computers: Attaining World Standards," Sotsialisticheskaya Industeiya, 4 August 1987, p. 2.

59 It is somewhat ironic that this openness is considered by many to be an offshoot of the general movement towards glasnost in society. In fact, the argument can be made that openness was originally intended to help the economic sector by providing the free flow of accurate information and encouraging the reporting of problem areas. This type of glasnost, however, has now been overshadowed by the consequences of this policy for society as a whole.

60 See the story of the Latvian computer professor, endnote 29.

61 Global Trends in Computer Technology and Their Impact on Export Control, p. 84.

CHAPTER 7--INFORMATION TRANSFERS, TELECOMMUNICATIONS AND THE HUMAN ELEMENT

Introduction

Of the areas concerning technology transfer, both in general and specifically relating to the computer field, the one most difficult to describe and categorize, and therefore to control, is know-how. Hardware is relatively simple to define in terms of its existence or being; pieces of hardware, be they computers, their component parts or related peripherals, have size, shape, specific functions that they preform and ways in which they perform these functions. Software, even though it is less of a physical entity than hardware, still is comprised of specific elements, must be recorded, stored and transferred in some type of medium, and again performs given functions in a prescribed manner. But how does one define an idea? And even if one is able in some way to quantify the entity referred to as knowledge, how does one go about controlling it and limiting its transfer, if it is decided that such controls and limits on the transfer of knowledge are in one's better interests?

Mankind has struggled with the concept and nature of knowledge since prehistoric times. The spread of knowledge was a key element in the evolution of man; societies rose and fell over their ability not only to acquire, but to disseminate and assimilate knowledge and the technology that normally accompanies it. Knowledge has always been the mark by which societies have been measured, from the time of the ancient Greeks. More recently, not only knowledge, but know-how, the way that knowledge is put to use, has become a key element in determining the place a society occupies in the world order. During the Industrial Revolution, Britain not only led the world in manufacturing, but drawing on its strength in this area became the preeminent power of the era. In the nineteenth and early twentieth centuries, the United States with its great industrial capability rose to become the center of the democratic world after the Second World War, while today, Japan and the "Four Tigers" of Asia [1] have staked a claim to a major place in a world market dominated by the high technology goods in which they have shown remarkable strength. In all of these cases, while physical attributes (numbers of factories, output, etc.) were the eventual measures of a country's economic might, these attributes were the result of the ability of each country to apply, in practical terms, what knowledge and technology had to offer. Thus, perhaps the best way of defining know-how is to say that it is knowledge applied to the accomplishment of a given task, that is, the ability to convert theoretical concepts and put them to practical use. [2]

Part of the problem with defining know-how is that it is an entity that, in real terms, has little meaning until it is put into use. To help explain this phenomenon, an analogy to music may be helpful. While music can be created in the mind of the composer and recorded on paper, it does not truly become music until it is played, until it is put into a form that, while difficult to define, is recognizable to all who hear it. To do this requires individuals both with the required skills to sing or play the music, and who can add their own interpretations to that which is written, who can improvise, turning notation into something that can be enjoyed by all. In this process, the skills of the individual may vary, from the great opera singer to the amateur in a church choir, from the master of an instrument to a street musician. Still, what is essential here is that it requires man to operationalize the concept, to take an inanimate form and give it a life of its own. The same can be said of know-how, the ability to turn knowledge into something of use, to turn information into a product or a function that serves mankind in some form. Technology, in and of itself, is of little value unless there are humans who can put that technology to use.

Thus, a major factor in the transfer of technology is this human element. What is more, while information can be transferred in any number of means, via printed material, the electronic media, etc, the ability to turn this information into something useful depends on human beings. While knowledge can be imparted through various means, as has been shown some means tend to be more efficient than others, with those actually involving human contact normally being the most efficient. [3] One need only think in terms of trying to learn how to play a sport by reading a book to see the advantages of active participation. It takes practice and actual application of the information, using real materials and facilities, to truly gain proficiency in any area. Along the same lines, while the necessary information concerning a process can be transferred without direct personal contacts, there is no way to insure that the information being transmitted is correctly received and applied by the receiving body. Here again, even with the advances that have been made in technology, no substitute has been found yet for human contact, the interaction of two or more people, exchanging ideas and being able to question and receive direct feedback about their questions, which leads to understanding and mastery of a skill. While technology transfers can take many shapes and forms, a key element in determining the effectiveness of the transfer always seems to be the extent that human interaction is involved, i.e. the human factor. [4]

The Human Element in Transfers of Technology

When looking at technology transfers in the area of computers, the significance of these observations is readily borne out. One of the reasons already cited as hindering the development of the Soviet computer sector, as well as Soviet industry as a whole, has been the lack of interchange both between scientists within the country, and between Soviet specialists and their colleagues throughout the rest of the world. The Soviet record of assimilating technology that has not been accompanied by the human element has been chequered at best; at worst, the failure to have some kind of human involvement with either hardware or information transfers has resulted in the total inability to incorporate that technology, making such transfers of little or no value in spite of the cost and effort involved in the physical transfer process. Reverse engineering is probably the primary example of the problems involved. Obtaining a finished piece of machinery, taking it apart in order to determine both its physical dimensions and operation as well as the manufacturing process involved in its production, and then trying to duplicate both the process and the end product of this process works only for simple products. [5] In cases where the products and processes are complex, or the technologies involved are unfamiliar and even unknown, successes are few. And, even if the process can successfully be duplicated and the product reproduced, the time involved often makes the product and the technology obsolete before it can be duplicated on a broader and useful scale. The efforts involved in the creation of the Ryad series computers are a case in point. [6] By the time that the IBM 360 had been successfully copied it was no longer state of the art, and the East was left with a computing system that, while still capable, did little if anything to bring the Bloc up to world standards. As noted by one observer, "Reverse engineering a complex modern microprocessor has proved to be more difficult than the Soviets had originally anticipated." [7]

The extent of the importance of the human element can perhaps best be seen in a number of different examples, each representing a specific aspect of the problem, and each with different approaches to achieving a solution. In terms of manufacturing capability, the process of turning design information into a finished product has long bedeviled the Soviet Union. Earlier, turn key plants where entire manufacturing concerns were purchased and erected were long the most favored and sought after solution. Such operations overcame the problem of transferring information into production capability, especially if the agreements included provisions for the training of individuals to run these plants. But these did little to develop a related research infrastructure and the ability to expand upon and innovate, based upon the initial capability. [8] Further, western governments, also realizing the problems involved in transforming information into practical capability, tended to focus export controls on those areas that offered a way to overcome these problems, i.e. manufacturing capability. This was particularly the case in the area of micro-processors, where repeated Soviet attempts to obtain facilities to bolster the limited Soviet chip manufacturing capability were blocked. [9] Today, emphasis in this area has been shifted to Soviet involvement throughout the manufacturing cycle. This can be seen especially in the encouragement given Joint Ventures where

Soviet engineers and managers work with their foreign counterparts, learning not only the processes involved but the methods by which these processes are developed.[10] The end result, it is hoped, will be the transfer of knowledge relating to production capability; the goal, it can be argued, is to assimilate this know-how along with the ability to modify and develop the technologies involved, leading eventually to an independent capability in this area.

At the same time, Soviet and East European access to western manufacturing, research, and educational facilities, where know-how can be imparted to individuals and then taken back with them, is another area where the human aspect of technology transfer is readily apparent. Academic exchanges have long been considered an essential part of the development of ideas through the sharing of research and information; conferences, professional societies, and even the ability to go and visit colleagues doing research in a given field are all valued as ways to transmit information and share knowledge. Restricted in the past, not so much by the West as by the Soviets themselves, exchanges have not been an area of major concern in the West in terms of export control. Soviet fears of what might be lost, both in terms of the control of information and of people themselves, outweighed considerations of that which could be gained through such exchanges, and limited the number of Soviet academics with access to the West. Those scientists and researchers who were allowed to travel were those who were considered to be politically reliable, not those best qualified to take advantage of the opportunities that such travel presented.[11] Thus, the ability of individuals to learn from direct contact with others in their field, possibly the most effective way of transferring information, was specifically restricted. All this, however, began to change with the changing climate and relations between the two Blocs. Literally a flood of Soviet and East European scientists and researchers began coming to the West, representing at once a tremendous opportunity for gains in the exchange information, and a tremendous potential for loss of technology with little or no way of measuring what was being transferred.

Finally, just as direct contact between researchers has been restricted, so too has their ability to communicate via the growing number of means that advancements in technology have made available. Communication links, via telephone, satellite and computer data networks have revolutionized the ways in which information is distributed and transmitted. Not only is it now possible to interact with people around the globe in a matter of seconds, allowing for the interchange of ideas that before could only take place through personal contact, but scientists can access stores of information for research, expanding the realm of their own efforts and furthering the development of their own capabilities, without the need of physically being present. These stores, recorded in data bases that themselves are becoming increasingly more detailed and complex, are a direct result of the computer revolution that has allowed not only their creation, but the ability to make practical use of the materials contained within through the use of highly sophisticated search and analysis programs. While it was initially thought that the greatest value of computers was their ability to perform complex computations, data management and communications have recently shown themselves to be fields of equal, if not greater, significance to the scientific community. [12] All of these capabilities, however, revolve around the individual, increasing greatly his ability to access, manipulate and make use of information, and in the end increasing his knowledge, technical skills and know-how. Human access to these new resources, then, is another area of potential gain for the Soviet Union, and one where it has shown a keen interest in expanding that access. [13]

These three areas then, manufacturing know-how, personal contacts and access to information, help to define the human element of technology transfer, or modifying a term from the computer sector, the element of 'humanware'. Relating this to Soviet computer capabilities, hardware and software both play a significant role in determining the Soviet Union's place in the world with regard to computers; however, it is the training, skills and ability of its people in this area that will ultimately determine where this level will be. The Soviets themselves are well aware of this, as can be seen in their efforts to increase their contacts in this vital area. [14] What follows then, is an examination of these recent initiatives, with the goal both of determining the extent of these efforts and, if possible, their degree of success and the effect this success has had, or may have, on increasing Soviet computing capabilities.

The Human Element in Practice--Joint Ventures and Other Contacts

It should be noted here that personal contacts in computing actually consist of two distinct, though interrelated, subsets. The first of these relates to the manufacture of computers and their related peripherals, including software engineering. But computers, in and of themselves, are only tools and must be put to use to be truly effective. Thus the second and larger area where human contact plays a part in Soviet computing is in their use and integration within society. As important as it is for the Soviets to be able to manufacture and provide the essentials of a computer society, there must still be an impetus within society to adopt and use these computers, to have a true impact. Human contacts with the West help to provide both.

Using Joint Ventures as the vehicle most likely to bring Soviets in contact with westerners, it is possible, by turning to the record established by these ventures, to get some idea of the influence these have had on the Soviet citizens involved, or may have in the future. Initial liberalization of the rules concerning these ventures led to a large number of JVs being registered; however, the subsequent rate of these registrations has slowed with fading euphoria. [15] In a report on Joint Ventures published by the PlanEcon research foundation, a group specializing in East-West trade relations, it was noted that fears of economic instability in the Soviet Union, combined with the difficulties in recovering profits from investments made in the Soviet Union because of the lack of a convertible currency, has led to a slowing in the number of JVs being registered in 1990 after reaching a high point in 1989. [16] Still, new Joint Ventures continue to be registered, especially as noted earlier, in the service sector, reflecting the preference of western firms to enter into agreements that do not require large capital investments. Significantly, of the total registrations, "the largest single area of activity in JVs is personal computer production and programming, with primary emphasis on programming--208 (14.2%), followed by business consulting--149 (10.2%), [and] R&D and engineering consulting--129 (8.8%)...." [17] All of these combine personal contacts with some aspect of computing, and is a sign of what has been described as "a voracious appetite among Soviet citizens for computers...." [18]

In one respect, it can be argued that the net impact of these ventures to date has been small at best. Of the 1,542 Joint Ventures registered with the Ministry of Foreign Trade through 1989, only about 200 were considered operational, with total sales of goods and services in the first three quarters of 1990 amounting to 88 million rubles, a fairly meager sum. [19] Still, in spite of such figures, there is a greater value to such ventures, one that cannot be quantified. While the individual terms and makeup of these JVs vary, all entail interaction with westerners and western sources of information; indeed, one of the points brought up again and again in discussions with members of various Soviet delegations, is the desire of the Soviets to increase these contacts and to "learn western ways of doing business." [20] Among westerners doing business with the Soviet Union, common comments include praise for the willingness of Soviets to learn new ways and to bend over backwards to accommodate those westerners who are willing to take the risks involved in entering into ventures in the Soviet Union at this time. [21] For those who have dealt with Soviets in the past, this is a welcome break with previous traditions and behaviors, which is due in no small measure to the changes in attitudes brought about as a result of the reforms. For the Soviets themselves, it may be something of a shock, both in the realization that after these many years they now have access to the West as well as incentives to emulate western ways, but a shock they seem ready to overcome.

As for the number of actual manufacturing enterprises that have been established, where know-how and manufacturing skills have been transferred to the Soviet partners, this number, as reflected above, remains small and probably will remain so at least for the near future. Numerous problems serve to limit the enthusiasm of western investors for making large capital investments in the Soviet Union. First is the sheer difficulty of getting started and the scope of what often has to be done to begin production. As in the case of the former East Germany, western firms often find that Soviet enterprises are so outmoded that what is required is a total overhaul of the system.[22] This is especially the case in high technology areas such as computers, where the lag in Soviet capabilities behind those of the West is great, and is one of the key reasons why the Soviets turned to the West in the first place. Second is the often mentioned problem of currency convertibility. Even should a company decide that it wants to enter into a Joint Venture and is willing to wait the time it takes for the venture to become profitable, there has been little or no guarantee that the western partner will be able to get their profits out because the ruble, after much discussion, still cannot be readily converted so that investors can secure something tangible for their investment. Even the announcement in October of 1990, that beginning in January hard currency would be sold by the Government at public auction does little to aid this situation; since there is no fixed rate of exchange, profits still are not guaranteed, and inflation might quickly deflate the value of any investment in terms of the returns to be gained.[23] Finally, there is the problem created by the internal instability manifesting itself in the Soviet Union. The continuing decline in public order, increasing ethnic strife and conflicts over jurisdiction between the central government and local authorities hardly is a situation designed to bring confidence to a foreign investor looking for a safe and secure investment environment. From the summer of 1990, when the first elections of local governments on a relatively free basis took place, there have been conflicts over jurisdiction and sovereignty in various regions, with questions of exactly who has the right to make agreements with outside firms. As reflected in the comments of a western businessman just returning form a trip to the Soviet Union, "...it is not always clear who is in charge and has authority to make commitments. A great deal of confusion between new private organizations, established, All-Union ministries, and the republics have produced conflicting claims." [24]

What all of this means, in terms of the amount of technology being transferred to the Soviet Union in manufacturing know-how and those types of information passed between individuals through contact with the industrial process, is that at present it must be judged as minimal at best. While an effective way of transferring information, the limited scope of such operations prevents the quantity of material from being of any significance. The scope, in turn, will continue to be limited by those external factors that limit the willingness of western investors and firms from establishing manufacturing ties on a broader scale. In one of the 'chicken and the egg' situations that the Soviet Union finds itself in all too often, western investors will continue to be hesitant to make large scale investments in the Soviet Union until the situation improves, but the situation cannot improve without western investment. Western businessman in Moscow can hardly be encouraged about their prospects when they hear talk of Civil War and the breakup of the Union. From the point of technology transfer through joint manufacturing ventures, until the situation becomes one where western firms feel it is desirable to invest in this area in the Soviet Union, the number of enterprises structured along these lines will be small. As long as the number of enterprises remains small, the amount of technology and know-how being transferred through the personal contacts that come with such ventures will also be small.

Having said this, it must also be realized that the Soviets are aware of these attitudes as well as the fact that the situation in the Soviet Union will not improve without massive investment from the West, and accordingly have taken steps to allay western fears. At the international level, Soviet politicians from President Gorbachev down have continued to try to foster the aura of the beginning of a new era of improved East-West relations and modifying old behaviors and attitudes to reinforce this line of reasoning. [25] At lower levels, Soviet officials, realizing the apprehensions of western businessmen, are quick to point out that investors willing to take the chances involved will not only receive special considerations for their willingness to act now when the need is most urgent, but that in the long run they will be positioning themselves in an ideal situation when the Soviet economy begins to respond to the reforms, and as such will be in on the 'ground floor' of a period of tremendous economic growth. [26] At the same time, those firms who already have made investments in such ventures are likely to see them through, with many that were drawn up in 1987 and 1988 now beginning to produce. Recent moves also seem to indicate that the Soviet Union, at least in terms of foreign enterprises, may soon have a mechanism that will allow for the guaranteed conversion of rubles into hard currency. [27] All this, in and of itself, does not mean Joint Ventures in the short run, will be the miracle cure that some envisioned. However, with continued emphasis and willingness on the part of the Soviet Union to offer incentives to western businesses, plus some indication of a stable domestic situation, they do hold the possibility of being a major source of technology and know-how at some point in the future.

Academic Exchanges, Trade Fairs and Other Contacts

Perhaps there is no greater sign of the change in relations between East and West than the dramatic increase in the numbers of Soviet and Eastern Bloc visitors that has taken place in the last few years, as well as the reciprocal increase in the number of westerners, especially scientists, engineers and businessmen, visiting the East. In the former case, glasnost and perestroika have meant unprecedented opportunities for Soviet researchers and other specialists to travel abroad, meet with foreign colleagues, gain access to foreign information and even establish ties that allow them to maintain contacts once they have returned to the Soviet Union. The significance of these opportunities cannot be overemphasized; for years the only Soviet citizens allowed to travel to the West were those who were considered politically reliable, or who, in many cases, had been co-opted or were working for the security agencies in some manner. The average Soviet academic or industrial representative could only dream of such travel. Now, however, with the open encouragement of such travel and contacts, an increasing number of people in these areas are benefiting from such opportunities and the experience that can be gained. At the same time, openness on the part of the Soviet Union and the attempts to attract foreign capital and business have produced a steady stream of westerners to the Soviet Union, seeking out their counterparts in business and technical areas, exchanging ideas and exploring areas for future cooperation. What is significant here is the type of people engaging in such exchanges; westerners have always found it fairly easy to go to the Soviet Union, however those that went tended to represent non-technical fields. The situation was such that a standard joke in academic circles for years, describing those exchanges that took place, was that for every Soviet student who came to the West to study engineering, physics and computer science, another western student was allowed to go to the Soviet Union to study Russian language, literature, and art history. [28] In this respect, as others, the current situation represents a radical change from the past.

The extent of this increase can be seen in the visa figures for Soviet citizens coming to the United States for business and academic pursuits. [29] Maintained by the U.S. Office of Immigration, these figures document the dramatic climb in the numbers of visas issued to both Soviets and other members of the Eastern Bloc. In the B-1 visa category, issued to temporary visitors from the Soviet Union for business purposes, figures for the period 1980 to 1987 range between 1,169 (1984) and 2,602 (1987). In 1988, this figure jumped to 5,829, and in 1989 there were 12, 910 visitors, almost a five fold increase in a two year period. The same type of increase is reflected in the figures for pleasure and for the business/pleasure categories. While the term pleasure may at first seem to denote other than business purposes, the intent of such visits is often to gather information and establish contacts, since very few Soviets are in a position to take purely pleasure trips abroad. In terms of academic exchanges, while the numbers are not as impressive as those for business visas, the percentages reflect the same upward trend. In the J-1 category--applicants accepted to participate in exchange visitor programs sponsored by the United States Information Agency--the highest number prior to 1986 was 175 (1981); in 1986, 328 such visas were granted for the Soviet Union, in 1987--293, 1988--637, and 1989--1,030. While specific figures for other western countries such as Great Britain and Germany are not available, discussions with representatives that deal with visiting Soviets indicate the same phenomena in their countries.[30] (For detailed figures, see Appendix I)

Trade fairs, exhibitions, conferences and other business/industrial/scientific gatherings also are providing new opportunities for information exchange on the personal level. In terms of Soviet citizens traveling to the West, the doors have literally been opened, with almost anyone with the price of a ticket being allowed to leave to attend such events in the West. [31] Within the Soviet Union, the new opportunities for sales have brought western firms showing their latest wares. While there are no figures as to the total number of such exhibitions taking place, a listing provided by the American Department of Commerce for the period 1990/1991 runs to five pages. [32] Not only are the numbers impressive, but the nature of the material being shown would have been unheard of five years ago. From a list of exhibitions printed by the All Union Association Expocenter, there were exhibits dedicated to "Local Networks Based on PC and Computing Systems; CAD/CAM Systems, Automation of Biotechnical Processes in Medicine and Agriculture, and Spectroscopic Equipment for Scientific Purposes." [33] Nor are such exhibitions only for showing off the latest in equipment. TASS reported in 1990 that a meeting to discuss "problems of economic reforms and the policy of the coordinating committee for Export Controls...." was held between representatives from the United States and The Soviet Union during an exhibition of computer equipment and software, "World PC Forum," held in Moscow. [34]

While these figures and examples give an overall appreciation of the extent of these contacts, an anecdotal experience may shed some light as to impact that these types of contacts and exchanges can have. [35] As related earlier, the author had the opportunity to talk for several hours with a professor of computer science from the University of Riga in the spring of 1990. [36] This individual had been traveling in the United States for several weeks under the auspices of a Latvian emigre organization. Along with talking to gatherings of this organization, he stated that his purpose was to gather as much useful information for his department as he could, and establish academic and professional ties that he could draw upon once he returned to the Soviet Union. He was quite open about his work and the state of computing in the Soviet Union, and anxious to find information that would aid in solving problems that they faced. (He was also quite appreciative of the opportunity to travel in the West, and the fact that as little as two years before he would not have had such an opportunity.) In just one example of the type of information that he was able to obtain, one of the problems that he said the Soviet Union was having was tied to the fact that most of their modems were outdated, and transferred data at the slow rate of 1,200 baud, [37] which not only tied up scarce communications lines, but made these modems incompatible with those used in the rest of the world. Upon hearing this, an IBM programmer present showed him how, through a software modification, these modems could be made to transmit and receive at 2,400 baud. This solution was especially significant, since it allowed the Soviets to continue to use the outdated equipment that they already possessed, without the need for expensive replacements that they had little prospect of being able to afford.

Again, while the overall significance of these contacts is difficult to quantify in terms of the exact amount of information being transmitted, it should be apparent that the greater the number of contacts, the greater will be the amount of information transferred, knowingly or otherwise. It should also be remembered that the nature of these contacts in itself is inherently a most efficient means of technology transfer. [38] In the example above, the Soviet professor and the IBM programmer sat down together at a computer, and in a matter of minutes the latter was able to demonstrate a solution to a problem that had apparently been plaguing the Soviet Union for some time. The fact that they were able to communicate directly, with the former asking questions and receiving direct feedback, no doubt enhanced the process. The questions that the Soviet professor raised in this case were ones that would normally not even come up in western literature, since the problem did not exist in the West, and even if the solution had been written about in some western journal, it is questionable that reading the answer in a foreign language without the opportunity to discuss the solution and seeing it implemented would have had the same impact, or been assimilated as quickly. Further, this is but one example of the effectiveness of human contact as a means of transferring technology. The results of the rapid expansion of such contacts into the thousands or tens of thousands can only be imagined.

Telecommunications and Other Means of Information Transfer

Great as the importance is of face to face contact for effectively transferring information, technology itself has created other means for accomplishing this task, means that were unknown until a relatively short time ago. Embodied in the form of telecommunications, computer networks, data bases and other types of electronic interfaces, these means have revolutionized information transfers in the West and hold the potential to do the same in the East. In some respects, these means do have their limitations and are still inferior to what can be accomplished by direct contact. On the other hand, the ability to communicate almost instantaneously across the globe has overcome the barrier that distance imposes on such direct contact, and in terms of transferring large amounts of material or allowing access to stores of information that might not otherwise be available, technology may, in fact, offer advantages over trying to establish face to face coordination. Along with the computers that make such contacts possible, these mediums are another tool necessary for creating a modern technological society.

Of the devices mentioned above, probably the one that has done the most to revolutionize the ways that information is stored and transferred is computer networking. Tying together computers and the people using them throughout the world, and allowing direct communications and access to material stored at these locations, has given capabilities to individuals that have never before been present. With the only requirements being a computer, a modem and a functioning phone system, the West is criss-crossed with tens of thousands of computer nets, tying together academic institutions, industrial and research concerns, government offices and the like. Nor have the benefits of the ability to share information been lost on the Soviet Union. In just one example, a Soviet author in 1984 cited the need for a "collective of computers", adapting the rhetoric commonly used to promote united action for the benefit of socialist society to argue for the joining of Soviet computers to aid in solving problems too enormous for one individual or institution to deal with. [39]

While the values of these nets are recognized, the same problems that have plagued the Soviet computer industry in other areas have affected information transfers. "Computer networks represent one of the most sophisticated applications of computing, one that entails gluing together numerous pieces of technology. It is therefore not surprising that this is one of the weakest areas in the USSR." [40] Physical constraints, in terms of equipment and facilities, have limited the Soviet Union's ability to accomplish anything of substantive value. In addition to the limited number of computers available and problems with inter-operability caused by the variety of foreign and domestic models present, the Soviet phone system has proven to be too antiquated and unreliable to support even the most rudimentary of electronic networks. Perhaps the most ambitious and highly acclaimed effort to create a major computer network, ACADEMSET, was designed to link member institutions of the Academy of Sciences in a common research and information net spanning the length and breadth of the Soviet Union. [41] While much heralded, technical problems were such that even after several years of being discussed and worked on, "as of 1987, all centers were not yet able to communicate with each other." [42] Additional information since then indicates that the system still suffers problems, at the same time when literally thousands of similar networks are functioning in the West. [43] On a lesser scale, the Soviets seem to have had greater success with Local Area Networks (LANs), though again suffering severely in comparison with the West. [44]

Still, this less then auspicious first step should not be interpreted as meaning that the Soviets have given up on the idea of computer networking. In a major step towards improving the data transfer environment, the Soviet Union has aggressively sought to upgrade its telecommunications system by obtaining western equipment. One of their first cooperative ventures with a western firm in 1986 was a contract with Siemens to upgrade the Moscow phone system, which has been followed by subsequent agreements with the German electronics giant. [45] A similar agreement to provide digital telephone switching equipment was signed with Alcatel N. V. Owned in part by the ITT Corp., the Joint Venture, named LenBell, will provide both communication lines and switching equipment. [46] Following the example set in other JVs, it calls for production facilities to be set up on Soviet soil, with a portion of the production being returned to Alcatel for sale abroad; a parallel agreement calls for Alcatel and Soviet authorities to cooperate in developing a Soviet telecommunications industry. [47] In yet other examples of Joint Ventures in this area, International Message Switching Corporation of California signed an agreement in mid-1989 with the Ministry of Posts and Telecommunications to "help upgrade the Soviet Union's data transfer network..." supplying advanced high-speed telecommunications software and equipment as well as consultations services, [48] while the Spanish firm Telefonica has entered into an agreement to produce 500,000 telephones a year in the Soviet Union. [49]

Hardware, however, is only one aspect of the networking process. Even with the appropriate equipment, access must be available and willingly granted to a participant if it is to be of value. Thus, at the same time that the Soviet Union has been trying to upgrade the hardware that it needs to effectively network, it has been pursuing ventures that would tie it to existing nets and give Soviet institutions access to western information. As reflected in the National Academy of Science report on computer technology, "the director of the All Union Scientific Research Institute of Applied Automated Systems (VNIIPAS) seems to be actively encouraging the establishment of links and has said that the Soviets have access to a large number of western data bases." [50] In just two such examples of such efforts, the West German firm Taylorix has signed a letter of intent to establish a Joint Venture with the VNIIPAS to establish a network that would transmit data on a variety of topics to both Soviet and western customers. [51] The same Soviet Institute has also arranged a joint Soviet-American effort, SOVAM TELEPORT, offering "a wide range of telecommunications-information services" to include data banks, reference-information systems, telex, telefax and vidiotex networks. [52] Subscribers include the USSR Academy of Sciences, the Soviet Space Research Institute, Institute for Nuclear Physics (Novosibirsk), International Computer Club, the Institute for Automated Systems, and the USA and Canada Institute. [53] As part of its services, SOVAM TELEPORT has established a direct digital satellite hookup between the United States and the Soviet Union for business use. [54]

Even though the establishment of computer networking and related means of data transfer are high on the list of Soviet desires, they are not the only means of information transfer that have come about as a result of the reforms. In one of the most interesting, relating directly to the computer field, International Data Group Communications Inc. has brought out a Russian language edition of its popular publication, PC World. [55] Entitled PC World USSR, it is the second western publication that has appeared in translation in the Soviet Union, preceded by a Russian edition of the German fashion magazine, Burda Moden. Such publications have long been a source of popular information exchange in the West; the fact that this was high on the 'want' list in terms of western publications, and that the response to it has been overwhelmingly favorable, serves to underline the significance of such publications to the Soviet Union. Further, the value of such publications comes not only in terms of the articles in the magazine (the first edition ran articles on the history of the IBM PC and computer productivity in the United States), but from the advertisements carried in them. In an early test issue, Soviet editors rejected many advertisements for "lacking sufficient technical data", a fault corrected in the premiere issue. [56] Even though it can be argued that little technical data can be realistically transferred on the pages of a magazine ad, the mere act of exposing Soviet citizens to what is available in the West serves the purpose of expanding Soviet computing horizons, and has led in this particular case to a number of requests for information from those firms placing the ads. [57]

In summary, what can be seen from these examples is both a recognition of what can be gained in terms of information from the West through open sources and personal contacts, and an attempt to take advantages of these sources through establishment of the necessary infrastructure and information links. As in the West, the so-called information revolution has two components. The first of these is to access the tremendous amount of information that is being produced as a result of the advances made in science and technology. But second, to be of any use, this information must be assimilated by those who are capable of doing things with it; information in and of itself has little value, unless it can be put to use. In trying to establish ties with the West, as well as improving their own systems for accessing information, the Soviets have addressed the first of these two elements. In stressing personal contacts between East and West for people in the sciences and industry, they have tried to address the second. Their ability to make effective use of this information may still be in question, however they have demonstrated the desire to learn, and thus are taking steps in the right direction.

Information Transfers and the Computing Environment

While it can be seen through the efforts that the Soviets have engaged in that they value access to western sources of information, as well as the technologies that help to gain access to and use this information, the question still remains as to the impact that this information has had to date, or may be expected to have in the future. Again, this is far from an easy task; just as knowledge and information are not commodities that can be bundled up and counted the way that computers can be, the impact that a given piece of information will have, or for that matter the aggregate of many sources of information, is not something that can be easily measured. Still, based upon what has been seen, it should be possible first to draw some overall conclusions as to the value that the increased flow of information has had for the

Soviet Union in the field of computers today, and second to postulate what effect this increased flow may have for the future of Soviet computing.

There seems little question that the increased openness of the Soviet Union under Gorbachev, in terms of access to information, increased lines of communication and general easing of restrictions on contacts with the West, has altered Soviet society as a whole, and Soviet science and technical fields in particular. Long cut off from its western counterparts, Soviet science has progressed in many areas, but at great cost and without the benefit of the experience and knowledge that were being accumulated in the West at the same time. [58] In a few cases, such as software development, this 'splendid isolation' may, in fact, have had its advantages; however, in general the Soviets have suffered because of this isolation, being forced, as it were, to make the same mistakes involved in the learning process that had already been made in the West. [59] Being burdened with a less efficient system as well, in terms of resource allocation and general bureaucratic inertia, has led the Soviet Union to fall further behind the rest of the world as a result. This backwardness, in turn, only served to exacerbate the problem. Now, at least, the way appears to be clearing, if not for total openness and access to information from the West, then at least to greater access and interchange than there was before. This may not mean that the Soviet Union will catch up with the West, but at least there should be reason for the Soviets to hope that they will fall no further behind. [60]

The question arises, however, of whether this is really a true description of the situation, or if there is, in fact, more to the problem. For years the Soviet Union dedicated great efforts to gaining western information, both through legal and illicit means. The story has already been told of the massive efforts to obtain and translate every piece of western technical literature that was available to the Soviet Union. If information itself were the sole source of knowledge, then the Soviets should not be in the position that they find themselves today. The answer to this apparent contradiction goes back to the initial discussions of the nature of know-how and the transferring of knowledge. To be effective, information transfers must include in them not only information, but the ability to put that information to use, or know-how. This ability is not something that is readily transferable in figures or the written word; it must contain in it the human element, the ability of a human being to process information and put it into a form that makes this information useful to those who need it.

This leads us back to the human element in technology transfer, or 'humanware'. Humanware can be understood as consisting of that element of technology transfer that is not easily defined, however which can be identified in terms of the effectiveness of transfers involving contacts between people, as opposed to the simple transfer of machines or information. For years the Soviet Union and the Eastern Bloc have concentrated their efforts in the computer area on obtaining either technical data, or if possible actual computers and related peripherals. For years, in spite of successes in this area, it can be argued that they have been hindered in their efforts to make advances based on these acquisitions, in part at least because they have lacked this element, the element of human exposure that allows both the effective transfer of information and its implementation and use. While tremendous strides have been made in technology and the means by which information is transferred, man has been unable to improve on the single element that allows all of this information to be put to effective use--man himself. In terms of understanding design philosophies, manufacturing processes, information management and distribution, and countless other areas relating to computers and every other field of technological endeavor, man remains the most efficient means of transferring technology. By placing artificial limits on the ability of scientists, technicians, academicians and others in Soviet science and industry to interact with their western counterparts in the past, the Soviets have themselves placed the greatest obstacle in the path of their successfully obtaining and making use of the technologies that the West has to offer.

Having come to this realization, it must also be noted that this situation, which has hampered Soviet efforts at obtaining western technology, is rapidly changing. Under the reforms implemented by Gorbachev, and as reflected in the figures for visits by foreign academics, businessmen and the like, there has been a tremendous increase in the number of contacts between East and West, both in the sciences and business in general and in the computer field in particular. While some areas still suffer from certain deficiencies, such as the lack of telecommunication equipment, these are mechanical deficiencies that can be overcome with time. The greater problem in the transfer of technological information, that of the limiting of human contacts and associations, is being overcome by the general philosophical change in the thinking of the Soviet leadership that allows and actually encourages such contacts between East and West. While the significance of this change may not yet be fully apparent, due both to the limited number of early contacts and the the lag time between this change and when the fruits of these contacts may begin to appear, the increase in their number signals both the importance that the Soviet Union attaches to these contacts and the possibility down the road for tremendous amounts of material to be transferred, and transferred in a very efficient manner. Whether the West is ready to allow this to take place, and in fact if the West is even in a position to keep it from occurring, becomes the final question that must be examined.

Summary--The Significance for Export Controls

Little has been said about export controls in this section, for the simple reason that they have had very little to do with the items covered under this topic. While visa applications to western countries from the Soviet Union are screened, this has been mostly pro forma, to insure that known intelligence agents, terrorists or other undesirable agents are denied entry. [61] With a strong history of encouraging academic freedom, few prohibitions have been placed on Soviets specialists traveling in the West, aside from formally posted restricted areas. [62] Nor did there appear to be a reason for concern, since the numbers involved were extremely small. In terms of the hardware related to information transfer, CoCom restrictions did prohibit the transfer of some equipment required for upgrading communications, based on the claim that the same materials could be used to upgrade military command and control systems; however, recently the same relaxations that have allowed the shipment of formerly prohibited computer items have been applied to communications equipment as well. [63] The only area where export controls would seem to affect human transfers is in terms of restrictions on transferring manufacturing facilities for computer related technology, and even here, as reflected in many of the Joint Ventures that have been registered, assembly facilities that put together western supplied components are being established in the Soviet Union. [64]

What this means with regard to the overall effectiveness of technology transfers is still more difficult to ascertain. Many would argue that increased exchanges between East and West can only help the status or relations between the two, by increasing understanding and cooperation. [65] At the same time improvements, such as those in the Soviet phone system, achieved through purchases of western telecommunications material, or the allowing of access to western data bases which do not contain classified material, in and of themselves do not seem to do any harm. Yet returning to the comment made at the beginning of this study, that the whole often has characteristics that are different from its parts, so too must the overall impact of these individual cases be examined in aggregate for their true potential to be realized. Thus, having looked at the individual pieces, it is time to reassemble the puzzle.

ENDNOTES

1 The Four Tigers refer to South Korea, Taiwan, Hong Kong and Singapore, which are seen as representing a new and growing force in the world economy, especially in the area of advanced electronics. For an excellent book on Soviet relations with these and other countries in the region, see Gerald Segal, The Soviet Union and the Pacific, (London: Unwin Hyman, 1990).

2 The definition for know-how given by the Oxford Dictionary is "practical knowledge or skill". Used here, it refers to the ability to take the information and knowledge that had been acquired about computers and turn it into something that can be applied in such a way as to be of use to the Soviet economy. As with the explanation of what constitutes a successful technology transfer, know-how, to be of value, must be applied.

3 J. Fred Bucy, Chairman, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," Office of the Director of Defense Research and Engineering, 1976, p. 5-7.

4 Ibid. The Bucy Report stresses the effectiveness of 'active' over 'passive' transfer mechanisms, referring to the degree of human involvement. Despite the differences in terms, the underlying concept is the same.

5 Philip Hanson, Trade and Technology in Soviet-Western Relations, Studies in Soviet History and Society, ed. R.W. Davis (London: MacMillian Press Ltd., 1981), p. 200.

6 For a complete history of the development of the Ryad, see Richard Judy, "The Riad Computers of the Soviet Union and Eastern Europe, 1970-1985: A Survey and Analysis," Hudson Institute Report, 1986.

7 David A. Wellman, A Chip in the Bloc--Computer Technology in the Soviet Union, (Washington D.C.: National Defense University Press, 1989), p. 94.

8 The Soviet chemical industry, as mentioned earlier, is a prime example. See Ronald Amann, "The chemical industry: its level of

modernity and technical sophistication," The Technological Level of Soviet Industry, ed. Ronald Amann, Julian Cooper, and R.W. Davis, (London: Yale University Press, 1977), pp. 227-320.

9 For a summary of Soviet attempts in this area, see chapter eleven, "Univac--A Sputnik Shock For Moscow: The Eastern Electronics Industry" in Jay Tuck's, High-Tech Espionage, (New York: St. Martain's Press, 1986), pp. 131-152.

10 Soviet citizens involved in trade and industry that have talked with the author have emphasized that they value human exchanges and the opportunity to learn western production techniques as much as acquiring actual pieces of equipment.

11 During the discussions held at a NATO conference on Soviet Science, attended by the author in 24-26 September 1986, this practice was noted by several academics who had had dealings with the Soviets under such circumstances. Specifically, the charge was made and substantiated by several people that the Soviets practiced a variation of the 'bait and switch' tactic, where a given Soviet academic would be asked to a western conference because of his expertise in an area, but at the last second another, sometimes totally unknown representative would be sent in his place. While the aforementioned concern of the Soviets over letting their first class scientists out of direct control must have played a large part in these maneuvers, it must also be judged an overall loss both for the individuals involved and for the Soviet Union, in terms of the opportunities missed for true scholarly interchange and development.

12 Keith H. Hammond, Deidre A. Depke, and Richard Brandt, "Software: It's a New Game," Business Week, 4 June 1990, pp. 102-106.

13 During the same NATO conference referenced in endnote 11, it was noted that, in answer to an electronic questionaire distributed on a European academic computer net, more than forty responses were received from countries in Eastern Europe which no one previously thought had access to the network. The result was that Western European users learned quickly to be careful about what they put on their computers networks. It also demonstrated the interest that the East had in tying in to established western nets, even for perfectly legitimate uses.

14 Global Trends in Computer Technology and Their Impact on Export Control, Report to the National Academy of Sciences, (Washington D.C.: National Academy Press, 1988), pp. 180.

15 Jan Vanous, Editor, "PlanEcon Report," vol. VI, no. 17, 1990, p. 2.

16 Ibid.

17 Ibid.

18 Mark Meredith, "Soviet Union's painful road to capitalism," The Daily Telegraph, 25 February 1991, p. 29.

19 Jan Vanous, Editor, "PlanEcon Report," vol. VI, no. 17, 1990, p. 2.

20 Comment made to the author by a Soviet delegate to the Forum for U.S. Soviet Dialogue, held on 8-14 July 1990, at West Point, N.Y. Along with acquiring western production techniques, the Soviet Union is now attaching great importance to learning western business practices and management techniques as well. For an interesting description of a program that has been designed to meet this desire, see Paul D. Staudohr, "Welcome to Business 101, Comrades," Personnel Journal, December 1990, pp. 36-43.

21 Another comment made to the author during the Forum for U.S. Soviet Dialogue which has been made to other westerners doing business in the Soviet Union. The substance of the reasoning seems to be, that while the Soviets realize that there is a certain degree of risk involved in investing in the Soviet Union at this time, they will look with favor on anyone willing to take that risk now when foreign inputs are needed most, and that such risk taking will be rewarded with special considerations both now and in the future. It is interesting to note that while the Soviets seem to understand risk in these terms, as noted earlier they have very little conception of economic advantage as applied to investments. Political risk, in this sense, is far better understood than economic risk.

22 While credited as industrially being in better shape then the Soviet Union, recent stories about the attempts to modernize industry in what was formerly East German must surely have a sobering effect on anyone who is even mildly knowledgeable on the state of Soviet industry.

23 Figures from the first three auctions held in 1991 set exchange rates varying from 18 to 31 rubles to the dollar, with the number of rubles far exceeding the supply of hard currency offered at these rates. While a mechanism that may eventually allow foreign partners in Joint Ventures to change ruble profits into hard currency, this can hardly be seen as an encouraging sign for western firms with large ruble holdings. From the notes of Professor B.P. Pockney, based on information in Ekonomika i zhizn, 11 March 1991, pp. 16-17.

24 Quoted from a private letter to the author by Dr. Eric Novotny Vice President for International Marketing and Business Development, Communications Satellite Corporation (COMSAT). He goes on to comment that, "...as the saying goes, in chaos there is supposed to be profit."

25 Though Soviet politicians continue to pursue this line, events relating to the war in the Middle East and the intervention by Soviet military forces in the Baltic republics in early 1991 have led western politicians to take a more cautious view of such pronouncements.

26 Relating to the line of reasoning put forward in endnote 21 above, the author was told by a former official of the Soviet Ministry of Trade that while he realized that there were risks involved, he viewed the current situation as being ideal for any western firm to invest in the Soviet Union, since the present problems would be worked out, and eventually the economic potential of the Soviet Union, both in terms of resources and markets, would offer tremendous opportunities for anyone with the foresight to get in on the 'ground floor' of this development.

27 Recently there have been indications that some mechanism will be created to allow Joint Ventures to convert profits into hard currency, even if the ruble remains a non-convertible currency for the near future. Whether this is in response to the disappointing results of the initial currency auctions, or the

realization that if foreign investment is to be seriously pursued this issue must be resolved, is open to speculation.

28 Not only student exchanges, but faculty exchanges have increased as a result of the new relations between East and West. In a letter to the author from a faculty member of the University of Wisconsin, a member of Slavic Linguistics Department indicated that there is a continuous stream of Soviet academics looking for exchange positions, and who once they arrive, "are very reluctant to return." This raises another issue that, while outside of the realm of this study, is of great significance to the Soviet Union and its attempts at reform. With greater access to the West, more Soviet scientists and academics are traveling outside of the Soviet Union in hopes of finding a position so that they do not have to return. While a sensitive topic, the problem of a potential 'Brain Drain' has been acknowledged by some Soviet officials, as well as being noted in the West, and may become a very real concern if recently proposed changes to Soviet laws on passports and emigration are enacted. See, Gina Kolata, "Soviet Scientists Flock to U.S., Acting as Tonic for Colleges, " New York Times, 15 August 1990, pp. A-1, C-14.

29 The information on visa requests was provided by Ms. Victoria Prescott, Defense Intelligence Agency, during an interview conducted in Washington D.C on 18 July 1990.

30 A telephonic interview with Mrs. Anna Forey, Regional Officer for the Soviet Union, The British Council, conducted on 22 March 1991, confirmed the general trends reflected in the American figures, specifically the tremendous rise in interest and numbers for Soviets academics wishing to visit Great Britain in the last several years. While she thought that no centralized figures were kept for such visits in the United Kingdom, she indicated that both the data kept by the British Council, as well as other organizations that she worked with bringing Soviet citizens to the United Kingdom, bore this out.

31 The case of the Latvian Computer Professor is good example. He first came to the attention of the author through a friend who met this individual at a 'MacWorld' Macintosh computer Trade Fair held in San Francisco, which traditionally highlights the latest in products and technologies for this particular computer.

32 The list described was part of a packet prepared for businessmen interested in dealing with the Soviet Union by the United States Department of Commerce and provided to the author by that Department in August 1990.

33 "International Exhibitions in the USSR," Foreign Trade, June 1990, front inside cover.

34 Georgiy Meizerov, TASS Correspondent, "Foreign Experts Attend Meeting on Reforms," TASS news release, 11 July 1990.

35 While the use of anecdotal information may be questioned in some academic circles, its use in the case of the Soviet Union has achieved a certain degree of acceptance as a way of supplementing what is often scarce or partial data. In this case, the example is offered to show the ways in which personal contacts and exchanges of this type can be of tremendous benefit to the Soviet specialists involved, and in turn to the Soviet Union overall.

36 Interview conducted with a Latvian computer science professor conducted in New Windsor, NY on 24 April 1990.

37 A baud is defined as, "a unit of measurement that denotes the number of discrete signal elements, such as bits, that can be transmitted per second: for example, a device that transmits 300 bits per second can also said to transmit at 300 baud." Webster's NewWorld Dictionary of Computer Terms, (New York: Prentice Hall Press, 1983), p.20.

38 Bucy, "An Analysis of Export Control of U.S. Technology - A DOD Perspective," pp. 4-8.

39 R. Tavast, "One Computer Is Good...," Sovetskaya Estoniya, 2 October 1984, p. 2, translated in JPRS-UST-004, 2 May 1985, p. 87.

40 Global Trends in Computer Technology and Their Impact on Export Control, p. 180.

41 It should be noted here that there are probably Soviet military computer networks that have equal or possibly better capabilities

of those in the civilian sector, however such information is classified, and as such outside the scope of this work.

42 Global Trends in Computer Technology and Their Impact on Export Control, p. 183.

43 The Latvian professor of computer science reported that a demonstration of a computer net connecting his University with Academy of Sciences facilities in Moscow was attempted sometime in 1989; the system was on line for about two hours, during which time several test messages were transmitted, and the net was then shut down. Almost a year later, nothing more had been heard by him about the system.

44 Global Trends in Computer Technology and Their Impact on Export Control, p. 183.

45 "Siemens announces JV in digital telecommunications switches," Financial Times, 22 June 1990, p. 28.

46 Roger Woolnough, "Alcatel rings up Soviet switch deal," Electronic Engineering Times, 2 July 1990, p. 18.

47 Ibid.

48 "Communications JVs," Soviet Business & Trade, vol. XVII, no. 11, 29 June 1989, p. 2.

49 Susanne Sternthal, "Ailing Soviet Phone System Is Trying to Ring in the New," Insight, 6 August 1990, pp. 40-41.

50 Global Trends in Computer Technology and Their Impact on Export Control, p. 185.

51 Communications JV's" Soviet Business & Trade, vol. XVII, no. 7, 29 April 1989, p. 2.

52 O. Smirnov, "Telecommunications Across the Ocean," Sotsialisticheskaya industriya, no. 214, 17 September 1989, p. 3.

53 Ibid.

54 "Communications JV's," Soviet Business & Trade, vol. XVI, no. 18, 9 October 1988, p. 1.

55 "Russian-Language Computer Magazine," Foreign Press Notes, 22 July 1988, p. 2, citing a report in Moscow News, no. 26, 3-10 July 1988, p. 7.

56 Gary Stix, "Do you wanna buy an ad,comrade?," The Institute, February 1989,. p. 3.

57 Ibid.

58 Gary Taubes and Glen Garelik, "Soviet Science: How Good Is It?," Discovery, August 1986, p. 42.

59 Alex Beam, "Russia Gropes For A Way To Enter The High-Tech Age," Business Week, 11 November 1985, p. 98.

60 It should be noted that there are two elements at work here. Access to information and technology embodied in material should, provided that the receiving group is capable in some form of integrating it, raise up the level of that group if only in that particular area. As in the case of the Soviet chemical industry, the importation of chemical plants allowed a jump in the level of technology, at least to the level represented by the equipment it received. However the ability to develop and generate new technologies based on what is received is a separate, though related issue. Thus freer access to western technology will probably allow the Soviet Union not to fall any further behind the West, as long as it has access. However to close the 'technology gap' requires more than mere copying, as the past history of computer development in the Soviet Union has shown.

61 It also must be added that each country has different entry requirements, screening procedures, and degrees of enforcement. The result is that there is no way of effectively telling how many Soviet citizens are in the West or what they are doing.

62 In what was a major battle over academic freedom involving Eastern Bloc personnel in the late 1970s and early 1980s, the University of Illinois was asked to restrict access to their supercomputer, Illiac IV, (at the time one of the most powerful computers in the United States) for security reasons. After a

heated debate, the University declared that it would not issue a blanket restriction since this would infringe upon academic freedom, but would instead require researchers from Eastern Bloc nations to show that their research was non-defense related before allowing them to use the machine. While eventually resolved in this case, it points to a larger issue in that academic circles in the West tend to jealously guard the right of freedom in academic pursuit, and protest anything they view as undue government interference. This, in turn, causes additional problems in terms of monitoring exactly what is being done by Soviet and other foreign academics in the West.

63 Interview with Colonel John Carney, Military Advisor to the U.S. Delegation to CoCom, conducted at CoCom Headquarters, Paris, on 18 February 1991. Colonel Carney indicated that the CoCom position on transfers of telecommunications was that upgrading of local area systems was now looked on favorably, but would continue to be banned where it was felt that these upgrades increased country-wide capabilities that might be used for military command and control networks.

64 "Western Computer and Microelectronic Joint Ventures with the USSR," British Government Document, August 1989.

65 This philosophy is reflected in the charter of groups such as the Forum for U.S.-Soviet Dialogue. The Forum has organized meetings between Soviet and American citizens in all walks of life over the past 18 years on the belief that such exchanges increase understanding and cooperation between East and West.

CHAPTER 8--AN ANALYSIS OF TECHNOLOGY TRANSFER IN THE CASE OF SOVIET COMPUTERS

A Summary of the Parts

As should be apparent by now, the issues surrounding technology transfer, its methods, impact and the ways that have been employed to monitor and control such transfers, represent a complex set of variables whose relationship is not always clear, but whose aggregate impact can be immense. Using the scientific method, an analyst wishing to untangle and define these relationships might try to isolate these factors, and in a controlled environment vary one or more of them while keeping the rest constant, in order to determine the effect that each has upon the other and the part that each plays in making up the whole. Unfortunately, in real life such luxuries as a controlled experimental environment are seldom available to the researcher. Instead, he must do his best to break out pieces of the puzzle, examine each as to its nature, and then return them to the whole with, hopefully, a better understanding of how each piece relates to the other pieces and how they affect the overall nature of the phenomena being examined.

Thus, having looked at individual pieces of the puzzle in the case of Soviet computers, it is necessary to step back and see how these pieces fit together. While hardware, software and information exchanges have each been examined individually, it should already be apparent that each of these areas is dependent to a great degree on the nature of the others, and that in some instances they contain elements that are common to all three. In one sense this makes the task more complex, but at the same time it should come as no surprise since very few things in real life are simple and allow themselves to be readily broken down for the benefit of the analyst. Technology transfer is a phenomenon whose parameters are shaped by real world considerations and constraints and it would be unrealistic to try to draw any serious conclusions about the nature of the whole solely by examining the parts. Therefore, the last step in this analysis is to reassemble the parts, to see how the changes in the approach towards the transfer of technology in the areas of hardware, software, and information technology may affect Soviet computer development as a whole.

Having said this, however, it still might be appropriate to begin with a review of the nature of each of these elements, in order not only to summarize the characteristics of each that have already been determined, but to gain a better idea of how each relates to the other. The results of this review will, in turn, lead to the discussion of the overall effect on the state of Soviet computer development and what this may mean for western efforts in the area of export control. If the changes brought about by the reforms increase the effectiveness of technology transfers in this area, and if the western goal continues to be to maintain a lead in these technologies, then it follows that the measures employed by the current export control regimes will have to be modified to meet these changing circumstances.

Hardware

The most tangible of the three elements of technology transfer in the computer area is hardware, in that it is a physical entity, something that can be seen, touched and dealt with in terms that are easily comprehended by the average individual. It is also the element that has received the majority of the attention from the export control regimes, in part because it represents the embodiment of computer technology but also because, unlike software and information flow in general, it has been far easier to deal with. In some respects, the emphasis on hardware seems well justified; the evolution of the early computer industry in both the East and the West was measured in the capability of machines, with the desire always being for computers that were bigger (in terms of capacity), smaller (in terms of size), faster and more capable. Those not possessing such machines could not maintain themselves on the cutting edge of the field, therefore controls that prevented access to such machines seemed to make sense if the goal was to maintain a technological lead. At the same time, from a Soviet perspective, the drive to catch up caused them to focus attempts at obtaining the latest hardware. What resulted was a classic cat and mouse game, with the West trying to impose restrictions on hardware transfers and the Soviet Union trying to overcome them.

While the successes and failures of each side in this effort can be argued, it is generally accepted that the Soviet Union has never been able to catch up with the West through its efforts to obtain and incorporate western computer hardware. Some would even go so far as to say that this, in itself, shows the effectiveness of western controls on hardware transfers, and that in fact the West's goal of limiting Soviet computer development has been achieved. [1] Based on this examination, however, this argument seems overstated. In spite of export controls, the Soviet Union has been able to obtain a significant amount of computer hardware over the years, both through legal and illicit means. [2] The fact that the Soviets were able to duplicate an entire set of IBM computers in their Ryad series, as well as make copies of numerous other pieces of western equipment, points to their achievements in this field. [3] The fact that in spite of these successes, the Soviet Union is little better off for its efforts than when it started, and has never achieved the goal of catching up with the West, leads to the conclusion that it requires more than access to hardware to develop and maintain a state-of-the-art computer capability.

The possible reasons for the Soviet failure in this area are many and varied. Part of the answer can be attributed to bureaucratic problems and the fragmented nature of the Soviet computer industry. Part of the answer rests in the failure to successfully incorporate the technology which they were able to obtain into their existing industrial system. Part of the answer lies in the inefficiencies of the system itself, the inability to learn from what was obtained as well as expand upon and improve domestic capability based on transferred technology. Finally, part of the answer can be tied to the inability to translate advances in research into manufacturing capability, always a weak point in Soviet industry. All this led to the failure to mass produce computers and their peripherals with adequate quality and reliability to put them into widespread use, thus hindering further development and innovation, as well as limiting the growth of a Soviet computer culture similar to the one that has spurred computer development in the West. Whatever the reasons one may choose to attach, the fact remains that the Soviet Union has failed to take full advantage of the hardware which has been obtained from the West, as reflected in the failure to close the 'technology gap' in computers. [4]

What this has to say about the effectiveness of export controls may be open to interpretation, however, it seems at least plausible to argue that the Soviet failure to catch up with the West has not been the result of western export controls on computer hardware, as much as the Soviet Union's own inability to use western technology to close the gap. All too many examples exist where even when the Soviet Union has had access to western technology, it has either been unable to make use of it or, as in the case of Toshiba, the utility that has been achieved from western inputs has been limited and has not contributed greatly to overall Soviet computing capabilities. While it might be stretching a point, it can even be argued that export controls have not been necessary, simply because even if the Soviets had been able to import everything that they wanted, they would not have been able to make use of this material in improving their capabilities. [5] More realistically, it seems reasonable to state that the Soviet Union's own weaknesses in the computer area have been a far greater limiting factor in their development than the lack of access to up-to-date western technology brought about by export controls from the West.

Applying what has been observed above to the policies of reform and their results, it is significant to note that while Soviet interest in obtaining western computer hardware has not changed, their approach to obtaining this hardware has, thus increasing the impact it may have on Soviet computing overall. [6] Earlier Soviet practices centered around obtaining models of western computers and reverse engineering them for Soviet domestic production, a slow process that suffered both because of the difficulties involved as well as the failings in Soviet manufacturing capabilities. Now, with the general change in Soviet attitudes and the corresponding response from the West in terms of loosening export restrictions, [7] the Soviet Union has access to a ready supply of relatively inexpensive western computers. [8] While this does little for improving the top end of Soviet computer capabilities where western imports are still restricted, it does foster a wider availability of computers within the Soviet Union, including those for use in education, business and scientific research. Further, Joint Ventures for production of western computers on Soviet soil stand to upgrade the Soviet Union's domestic computer industry by introducing western production methods and quality standards. While still in its embryonic stage, the potential for increasing the number and type of computers available in the Soviet Union cannot be dismissed. [9] If, as one source states, "the cornerstone of Gorbachev's technology program is a plan to 'computerize' the economy," [10] then these steps to obtain a sufficient supply of computer hardware must be viewed as a key element in this entire process.

Software

As has been shown, software exhibits a different set of characteristics relating to technology transfer, as well as a different set of problems concerning its monitoring and control. Part information in terms of the material that it conveys, part physical entity because some means is necessary to store and transmit the information it entails, and part intellectual property because its creation and development is so clearly tied to the individual efforts of the programmer, software is difficult to quantify simply because of the various aspects that comprise its nature. It is also this elusive nature that has caused problems with its control. In something of a parody of the person who hopes that by ignoring his problems they will somehow go away, export control regimes have tended to shy away from trying to create specific measures for controlling software transfers simply because of the difficulty involved in enforcing such controls. [11]

As has also been shown, software is a critical element in computer development; without it, all the sophisticated hardware in the world is next to useless. However it is not a unitary entity, in that without the proper hardware to run the software, it is just as useless as hardware without software. Each alone is helpless without the other; the two must act to complement one another and must be present for any computer system to work. This has led to the argument that since the efforts to control the transfer of hardware have been so successful, there is no real need to worry about monitoring software transfers. The logic here follows the path that if both hardware and software are needed for computers to operate effectively, then prohibiting one element lessens or even eliminates the need to attempt to control the other, and since software is inherently more difficult to control, then why not concentrate all one's efforts on controlling hardware? [12]

While this sort of reasoning is appealing in terms of simplifying the lives of those charged with controlling the transfer of technology, it is also spurious in that it rests on what may prove to be a false assumption, that western efforts at controlling the flow of computer hardware have been and will continue to be successful. This type of reasoning could also lead to serious problems as Soviet access to western hardware increases due to the lessening of export restrictions. [13] In the past, Soviet software development has suffered from many of the same problems that have plagued hardware development, including a lack of machines, lack of coordination among the official organizations responsible for computers in the Soviet Union, lack of commercial motivation and a lack of interaction, both with domestic developers and foreign. This last point has become particularly significant, as Soviet programmers have increasingly been expected to develop software for computers based on foreign designs and using foreign based languages. Now, however, many of these circumstances appear to be changing under the reforms, and with these changes the utility and appeal of using western software is increasing. The question that western specialists are left to deal with is still one of how to control the transfer of software, especially in the wake of these new demands?

From the Soviet perspective, software development serves as an interesting showcase not only of the weaknesses of the Soviet system, but of some of its strengths. As has already been noted, the Soviet Union has devoted tremendous resources to software development, and in some cases has been rewarded by a number of successes. [14] In other cases, the relative isolation of Eastern Bloc software developers has led to the development of approaches to writing software that are now prized in the West, as well as cases where software solutions have been devised to overcome hardware deficiencies. [15] As access to the West increases, there is the possibility that these talents will disappear, however, it is just as viable to argue that access to the West will allow the best of both worlds, and that programmers will still maintain the unique skills that come from their particular upbringing, but with access to new and more powerful computers they will be able to create new hybrids in the area of software. Wider access to computers throughout the economy will also increase the demand for domestic software, further assisting the development of programming skills. Finally, ties to western sources, as in the case of hardware, will allow the Soviet Union to follow the latest in software developments and access new programs without the traditional lag time that was often brought about by the lack of direct access in the past.

Thus, the prospects for advances in Soviet software development seem good. In one respect, reform in the software field may not result in a substantial jump in Soviet capabilities, simply because they already have demonstrated at least the basis for a strong domestic software industry. On the other hand, these skills will only increase as greater integration with the West is achieved. To argue that Soviet software and those individuals who create that software are inferior to those in the West reflects the erroneous perception that people with access to inferior technology are somehow themselves inferior. Given the increased access to western systems and techniques, there is every reason to believe that while Soviet programmers in the past have been at a disadvantage, overcoming this disadvantage will only be a matter of time. In the words of one Soviet mathematician, "Our brains are no worse than yours...We just don't have any equipment to work with." [16] Given access to sufficient computers, Soviet software could be every bit as effective as its western counterpart.

Information Transfers and the Human Element

Returning to the original discussions about the nature of technology transfers, historically such transfers have been brought about by the interaction of people and their ideas. While technology can be codified in documents, described in writing and visually represented in drawings, it is still most effectively conveyed by human interchange. Technology itself has greatly aided the process of exchanging documentation; with telecommunication, fax and data links, information can be transferred in quantities and at speeds never before imagined. What technology has been unable to do, however, is overcome or replace the need for an individual to comprehend the technological processes involved, something that is essential before they can be recreated and then improved upon or otherwise adapted for a particular use. To do this requires the interaction of individuals, and it is here that the Soviet Union traditionally has suffered its greatest problems in the transfer of technology.

What is ironic about this situation with regard to export control, is that the Soviet Union's problems in this area have come about not so much through western restrictions, as through Soviet policies themselves. From the 1920's and Stalin's program of developing 'socialism in one country' onward, the Soviet Union has been wary of contacts with the outside world and has limited these contacts out of fear of what might be given to the West, what the West might find out about Soviet weaknesses, and even what the results might be of Soviet citizens being exposed to the realities of life outside the Soviet Union rather than the pictures of such life that the Soviet government wished to convey. While the rationales for such prohibitions on contacts carry a certain validity from the Soviet point of view, what was not understood at the time was the disadvantage that these policies placed the Soviet Union at, especially in the areas of science and technology. While autarky might appear to be desirable in terms of limiting foreign dependency, it also led to weakness in terms of keeping up with the rest of the world, especially in areas where rapid changes were taking place. When the Soviet government realized that it was falling behind in the area of advanced technology, it tried to take advantage of what was available in the West in terms of written material, documents and even representative examples of the products of technology, while still maintaining the limits on human interchange between the two systems. The scale of these efforts at obtaining information from the West and then trying to reproduce the processes and products reflected in this information, stand as testimony to the seriousness of these attempts. Yet these efforts either failed or had only limited success, as can be seen in the overall result that the Soviet Union has continually fallen behind the West in areas were it has sought to catch up by copying or adapting western technology.

Based on what has been seen, it can be argued that one of the primary reasons for this is the failure to recognize the importance of the human element in technology transfer. As long as the Soviet Union has continued to limit and prohibit contacts between Soviet citizens and their counterparts in the West, they have never been able to effectively take advantage of and incorporate all that the West had to offer in terms of advanced technology. This failure can also be tied to the limits placed on the interchange of ideas within the Soviet academic and scientific community itself. A product of over seventy years of a society where the ability to exchange information and ideas was severely constrained, not only was contact with the West limited, but communication within Soviet society as well. Even in the case of defense related industries, where the best scientists and engineers were traditionally placed, rigid compartmentalization prohibited those ideas that were developed from receiving the widespread dissemination that would have allowed them to have a far greater impact on society as a whole. The failure in the past to recognize the importance of human contact and the exchange of ideas, in effect, preordained failure in attempts at increasing Soviet capabilities across the wide spectrum of the Soviet economy. In the words of one commentator, "Perhaps the biggest factor preventing the USSR from competing scientifically with the West is the lack of a free flow of ideas." [17]

Applied to the case of Soviet computers, it can be seen where the failure to allow for this human element in these transfers has hindered the attempts to effectively utilize foreign technology in the past. In spite of Soviet efforts to obtain and benefit from western computer technology from the mid-sixties onward, they have continued to fall behind. It has been argued that this has been due, in fact, to the lack of knowledge and skill in putting the information that has been gained into use, as much as limitations on access to foreign material caused by export controls. Part of the problem comes form the nature of the Soviet system and those weaknesses that have already been discussed. Part of the problem, however, is that once information was obtained, it still had to be 'digested', i.e. put into a comprehensible form before it could be put to use, leading to delays in the application of this information. One of the ways that this time lag can be overcome is through integration into the process of information development and transfer itself, that is, rather than standing on the outside and merely observing what is going on, becoming an active participant. As long as the Soviet Union remained on the receiving end of the technological development process, waiting for the end results and then trying to apply them in the field of computers as well as other areas, it could not possibly hope to keep up with the West. At the same time, the decision to divert resources from computer development in the fifties stopped the growth of the infrastructure needed to continue development in this field domestically, while the decision to borrow from the West rather than go back and develop such an infrastructure in the sixties and seventies only compounded the problem. The answer to this dilemma is that of integration. Once Soviet computer specialists are allowed to integrate with the West, they will not only be able to take better advantage of western developments, but they will become part of that developmental process, be able to develop their own skills, and finally with sufficient material support and experience, will be able to generate technology on their own. In this respect, it is precisely the opportunity to achieve this type of integration that may be the greatest accomplishment, to date, of the current economic reforms.

A Question of Integration

Having looked at each of these areas of computer technology in terms of the economic reforms, it is also possible to summarize the relationship of each to the question of export control. With regard to hardware, export controls in the past have probably been fairly effective in keeping the most capable and latest computer hardware from reaching the Soviet Union, however based on the Soviets' poor track record for using the hardware which they did obtain, it is doubtful that even if they did have access to this latest technology, it would have made a substantial difference in their level of computer development. The same can be said about software; high end sophisticated programs probably have been protected by export controls, while the sheer difficulty in monitoring lower end software packages, even if on the control list, allowed the Soviet Union access to a substantial amount of material. Again, however, this led to little or no substantive increase in Soviet capabilities. The Soviet inability to gain from western inputs in these first two categories revolves around the third area, that of information transfer and human inputs, where the reluctance to allow contacts between Soviet specialists and those of the West were as responsible for the problems in this area as any restrictions imposed by export controls. It is this last category that is at once the most significant and the most ironic, for while well intended, western export controls have probably been of secondary importance in limiting the effectiveness of technology transfers when compared to the Soviet reluctance to allow integration of their specialists with the West, which might have resolved many of the problems they faced while allowing them to more effectively take advantage of western hardware and software.

The policies prohibiting such integration, however, are changing. Whether the Soviet Union consciously recognized the need for such integration through reasoned thought, or has come to this realization through mere happenstance, the change in Soviet policies in this area cannot be questioned. As has been seen, one of the key elements in Gorbachev's overall drive for restructuring is the increased use of western technology and integration with the West, to act as the bridge over which his technology starved nation can pass into the 21st century. This, in turn, has led to a lessening of the former restrictions and a significant increase in Soviet contacts with the West. While it is impossible to quantify all of these contacts in terms of what they achieve, at the same time it would be difficult to argue that these contacts will not result in a significant increase in the amount of information that is transferred to the Soviet Union via a medium that will increase in the ability of the Soviets to make better use of this information. As has been seen in the past, information alone has not provided the solution to the problems that the Soviets face, either in the specific area of computers or in the broader realm of science and technology. By incorporating the human factor into their efforts in this area, the Soviets have provided a key element that has been missing in the past, one that is essential to making technology transfers truly effective. Combined with other changes designed to overcome what have been traditional problems with the Soviet economy, the results, in time, could lead to a significant increase in the Soviet ability to make use of foreign technology and thus increase their overall level of economic development.

While at first deceptively simple in its appearance and formulation, the significance of this change should not be underestimated. In spite of some twenty years of effort at obtaining and incorporating western technology as a means of bolstering their own computer field, the Soviet record in this area has been lackluster at best. At the same time, countries such as Japan, Taiwan, South Korea and even India and Pakistan have developed thriving computer industries, partly because of their domestic economic structure, but more importantly because of their ability to interact with the rest of the technically developed world. One would be hard pressed to argue that these countries have any inherent advantage in native intelligence or skills, or that their efforts have been any more pronounced then those of the Soviet Union in the field of computers. The features that stands out as different, however, are that their industries were able to integrate with the more technologically developed countries in this area, their students were able to study in western universities, and their businessmen were able to establish contacts and contracts in the West. Once these ties were established, in was then a matter of keeping up with the current technological developments abroad, while developing an independent infrastructure at home, that eventually allowed them to begin to make technological advances and innovations on their own. Combined with other factors, including low labor costs, external investment, and government intervention to protect these fledgling efforts until they had developed sufficiently to be able to compete in the world market, some of these countries were able to advance to the point that they now challenge, and in some cases have surpassed, the West, just as predicted in Kurth's model for colonial development. [18] All this can be attributed, in large measure, to the free exchange of information and the interaction of people dealing in these areas, as well as the market system that fostered this development through competition and incentives. Previously, neither of these conditions existed in the Soviet Union; now, however, both are actively being pursued. [19]

The significance of the other elements called for by the reforms cannot to be overlooked either, as they are complimentary and designed to assist in bringing about the same goals. Not only do Joint Ventures encourage integration, but in real terms they may help in overcoming the material shortages, in terms of hardware, that have plagued computer development. Education programs, once sufficient computers are available to support them, could begin to produce a generation of computer literate students ready to carry their skills into the work force. Efforts at decentralization, breaking up of ministerial control and encouraging of initiative from below, all will contribute to an environment in which individual efforts can bear fruit, where earlier none was present. Finally, the policies of reform in the Soviet Union have not only set about to change the way that the Soviets deal with the rest of the world in the areas of science, trade and technology. They have brought about a revolution at home, a revolution that, given time, may change those very elements of the economic and social structure that have for so long hindered the effective incorporation of technology into Soviet society. One need only look at the stories of new information services, cooperatives and even political offices bristling with computers and other electronic technology to know that in spite of all the obstacles in their path, the Soviets are making rapid strides to enter into the information revolution. [20]

While there are some who would argue that the Soviet Union is so far behind in the area of computers that it will never be able to catch up with the West, such arguments may well prove to be a serious underestimation of Soviet capabilities, with potentially adverse consequences should the Soviet Union turn away from the away from the path of seeking better relations with the West. If countries such as South Korea and India can become major actors in the world computing arena in a matter of twenty years, there is no reason to believe that the Soviets cannot as well. While traditional logic would argue that it will take the Soviets a fairly substantial amount of time to make up all of the ground they have already lost, technology itself may help to cut the time that is needed to recover from their early problems. What is more, the inability or unwillingness of westerners to realize what is taking place and the potential that changes in Soviet policy in this area may hold, represents a type of intransigence that can be likened to that shown by the Soviets in former times. Just as the race goes to those who are swift, so the lead not only in the computer field but in technology in general will go to those who have the fewest preconceived notions about what is possible and what is not, to those who are wiling to explore without reservations or biases, and to those who are willing to allow that things formerly not considered possible, can, in fact, take place.

Assembling The Whole--The Need For An Infrastructure [21]

To understand why technology transfer, as seen during the Gorbachev era, may eventually play a significant part in improving

Soviet computing where it has not done so before, one must return to the earlier discussions of the failings of the computer establishment as a whole, in order to see how the current initiatives address these failings. While there are many weaknesses in the Soviet computer industry, the underlying one, that to some degree takes into account all the others, is the failure to establish a computer infrastructure capable of sustaining independent development in this area. It should be remembered that through the second generation of computer development, the Soviets did have the beginnings of such an infrastructure and were able to keep up with, and in some areas were even able to surpass, the West in their early efforts. While it is true that in comparison with today's standards these efforts were small and unsophisticated, they nonetheless did represent the cutting edge of computer technology at the time, and the Soviet Union through its own initiative was able to do very well. It was only with the diversion of resources to other areas that this development was curtailed, and with it the development and maintenance of the research and development facilities, academic programs, manufacturing concerns and trained specialists that would be needed for further growth. [22] When priority was returned to the computer sector in the sixties, there were literally not enough people and materials to carry out the work that needed to be done. Further, when the decision was made to concentrate on obtaining and integrating western computer technology, what infrastructure there was, was assigned to this task, leaving little time or resources for developing domestic efforts. [23] The failure to effectively make use of western technology, reflected in the failure to integrate, reproduce, innovate from and improve upon imported technology, compounded the problems the Soviet Union faced, causing it to fall even further behind the West. This failure was made manifest as technological advances in the West, suffering none of these problems and enjoying an ever expanding computer infrastructure of its own, blossomed exponentially.

While the Soviet Union has repeatedly sought to advance its own level of development by the use of western technology, these efforts were hampered by the ways in which technology was obtained as much as by western attempts at blocking these efforts. In seeking western hardware and then copying and integrating this hardware into their own system, the Soviets encountered several problems. One, in fact, was the difficulty in obtaining the hardware that they desired, though this was not always due to export controls. [24] Once they obtained this hardware, however, they had to determine how it was manufactured, duplicate the process, and finally integrate what were essentially foreign designs with Soviet systems that were built along different lines. Another problem was that by placing restrictions on Soviet scientists and manufactures that prevented them from interacting with their western counterparts, Soviet authorities were hindering the very contacts that not only might have eased the assimilation process with regard to hardware, but would have allowed the transfer of the principles that went into the hardware's design and operation. In sum, the Soviet computer community suffered from two major failings; first they were never permitted to develop the infrastructure that would have allowed them to create and evolve their own designs and systems, and second, when they were told to borrow from the West, they were never given the opportunity to develop the contacts necessary to fully understand and assimilate the western systems. The situation is analogous to the earlier mentioned pattern of colonial development, where a developing country is given a technologically advanced product by a developed nation. The former may be able to learn how to use this product, but until an indigenous infrastructure is developed that can build, supply and support this product, the developing country will never be independent of its supplier, and the technology that went into the creation of the product cannot be considered to have been effectively transferred from one to the other.

While the failure to create a computer infrastructure has long been recognized in the Soviet Union, [25] it is only with the current reforms that conditions have been created which, given time, may allow a computer infrastructure to develop. The major difference between current efforts at overcoming the problems that the Soviet Union face and earlier attempts, comes down to the shift in Soviet philosophy that seeks not only Western technology in terms of hardware and software, but to increase the human contacts that go along with and assist these transfers. As has been shown, this can take many forms, either in terms of Joint Ventures, scientific meetings and exchanges, increased educational opportunities or any other of a number of vehicles that take advantage of and emphasize human interaction between East and West. Since human contact is one of the most effective ways of transferring technology so that it is successfully assimilated, increasing such contacts will only increase the benefit that is achieved from such transfers. [26] Not only is the encouragement of such contacts in stark contrast to previous

Soviet policies, but the scale on which such interchanges are being proposed has never been seen before in relations with the Soviet Union. [27] The long term consequence of this change may well be that this greater access and integration will allow the Soviets to assimilate the technology needed to establish an infrastructure of their own in the computer field, an infrastructure that, once established, will be able to develop technology on its own, giving the Soviet Union a computing capability no longer dependent upon inputs from the West.

Building An Infrastructure--How It Could Be Accomplished

The nature of the process by which a computing infrastructure would come about is complex, and could take years, possibly even decades to achieve. [28] Still, in terms of developing an infrastructure, the process would be shorter than if the Soviet Union tried to accomplish this entirely on its own. If one goes back to the arguments of Lebedev and others in the sixties, building an independent infrastructure in this manner was called for along with developing domestic computers without western inputs, thus insuring Soviet independence from the West. [29] At the time, the counter argument was that to do so would take too long, be too expensive both in terms of cost and resources, and would ignore much that had already been done in this field in the West. Western inputs, the counter argument ran, could be of use in closing the gap between Soviet and western computing. The same argument can be made today, and in fact is even more relevant, given the tremendous advances that have been made in western technology and the chronic shortages of computers in the East. The previous failure of the Soviets to effectively establish an infrastructure using western inputs can be attributed in no small measure to the failure to involve humans actively in the transfer process, and instead concentrating almost exclusively on hardware and technical documentation, which did little to establish the type of knowledge and know-how needed to effectively assimilate western technology. The combination of greater access to hardware at home, greater contacts abroad and freer information flow both at home and from abroad, may allow this attempt to succeed.

Just how such an infrastructure could be developed in the present context is open to a certain amount of conjecture, simply because it would be an evolutionary process, without specific milestones. However several elements can be identified which, by their presence, may be seen as essential in establishing the preconditions for such an infrastructure. The first of these is access to large numbers of computers and amounts of software, necessary for the development of a cadre of trained and qualified computer personnel. One of the conditions that spurred the development of computers in the West was the 'computer culture' that evolved because of easy access to computers. [30] The widespread availability of computers in schools, businesses and industry, and the resulting number of people who are computer literate, have had a tremendous impact on the ease with which new ideas, equipment and applications are developed and accepted in the West. The Soviets are no less capable than their western counterparts, however the limited access they have had to computers has slowed the development of a similar culture in their country, and thus slowed the overall course of computer development. [31] Now, however, the lifting of import restrictions and potential for improving domestic computer production facilities through Joint Ventures and other associations, should mean a substantial increase in the numbers of computers available in the Soviet Union during the next several years. Availability, in turn, will lead to increasing familiarity and acceptance, and eventually to the ability to modify and develop both hardware and software independent of western inputs. In short, the broader the use and acceptance of computers in the

Soviet Union, the broader the basis for an independent computing infrastructure.

Manufacturing procedures as well as modern efficient computer production facilities are an area which stands to gain by the new openness and increasing ties to the West. Long the Achilles heel of Soviet industry, not only in computers but in most areas of high technology, the primary failure of Soviet manufacturing has not been that it could not produce limited numbers of high technology products, but that it could not produce and distribute goods in mass with an acceptable level of reliability. [32] Even production in the military related sector, or "A" economy, while meeting reliability standards, suffered to a degree from those problems endemic to Soviet industry, which were overcome only by methods and procedures that flew in the face of western concepts of efficiency. [33] The problems with shifting production of these military plants to the civilian sector, or conversion as this process is known, has done much to show the true nature of what was thought to be the one efficient part of the Soviet economy. [34] Yet in this area Joint Ventures, combining western know-how and technology with Soviet raw materials and labor, have shown that Soviet industry can be as productive and efficient as western concerns. In the past several years, stories have begun to appear on how, aided by western investment and technical assistance, various Soviet manufacturing firms are showing improvements in their ability to produce. [35] In the area of computers, as has been seen, a number of agreements have been reached providing for western assistance in establishing computer production facilities on Soviet soil. The beginning of the shift to an economy based on market principles, plus adoption of western procedures, can only help in this area. Given the proper incentives, there is little reason to believe that eventually, Soviet industry is not fully capable of producing adequate goods in sufficient quantities to meet domestic demands. In the area of computers, this would go a long way towards eliminating the shortages in hardware that have always been a limiting factor, as well as establishing the manufacturing base that would be an essential part of a computer infrastructure. [36]

The establishment of a pool of scientists and technicians that would allow the Soviet Union to staff and support an independent computer infrastructure, along with sufficient research institutions and manufacturing facilities, is a function of the degree to which human integration and interaction exists in these areas. If the Soviet Union is to take full advantage of what the

West has to offer, then it must be willing to let its personnel be trained in western ways and assimilate western concepts of management, design, and development that are associated with the computer revolution. In the past, this has not been the case, with the result that whatever western material was obtained, it was seldom effectively put to use, and the lessons to be learned from it often went to waste. Now, however, with the open encouragement of integration, in terms of academic, scientific and industrial exchanges, the Soviets stand to develop a cadre of personnel that not only will be able to more effectively use that which is received from the West, but may eventually be able to apply this expertise in creating technologies of their own. Human interaction again could prove its worth.

All these elements combined could provide the Soviet Union with solutions to the problems that it faces in terms of the ability to incorporate and generate technology, both in the area of computers and in the broader spectrum of its scientific and industrial communities. Greater access to western computers and computer related hardware and software provide a short term solution to many of the problems that have plagued the Soviet computer industry from its inception. Joint Ventures, co-production facilities and increased interaction with the West and the computing infrastructure that already exists there, offers the possibility of a longer term solution, either by becoming intertwined with these western institutions, or by paralleling them and duplicating their functions. Through such a process, the Soviets stand to gain the infrastructure that they have always lacked in this area, and which, in turn, has always hindered their development. The key element in all this is the human one, for only through human interaction on a broad scale can this come about; only through human interaction can the necessary technologies and know-how be effectively transferred. Only once an effective computer infrastructure is established, once the computers and the trained people are present in sufficient numbers, will the Soviets be able to achieve their long sought after goal of being able keep up with the West in this area. In what may be the ultimate irony of Soviet computer development, integration with the West may be the only path by which the Soviet Union can achieve the the infrastructure needed to allow the country to eventually achieve an independent computing capability. [37]

In summary, the process outlined above hinges on the question of integration. The failure of the Soviet Union in the past to integrate with the West, not only in the field of computers but in all areas of technology and science, has been one of the reasons for its failure to keep up with the West in these fields. The realization of what has been lost because of this has brought about a reversal in previous Soviet policies, and a drive not only to gain from the West that which it has to offer, but to integrate generally with the West, so that the benefits from integration can be institutionalized and the Soviet Union will no longer be subject to falling behind due either to self-imposed restrictions, or restrictions imposed from without. This desire to integrate has led the Soviets to modify not only their actions in the international political arena, but the ways in which they traditionally have have done business, bringing new respect for western norms such as in the area of copyrights and licensing agreements, that previously were shunned or ignored. In doing this, the Soviets have had to pay a certain price, but it is a price they seem willing to absorb in return for the advantages that they feel they will receive. The question, from the western perspective, becomes one of whether it is in the West's best interests to encourage this trend, or even just to stand by and tacitly let it take place, or whether the potential costs to the West outweigh that which may be gained.

The Implications For Export Controls--The Need For A New Approach

All this leads back to the question of export controls, their utility, and even their viability under the present circumstances. The rate at which change has occurred in the Soviet Union and Eastern Europe in the past five years has gone beyond what anyone could possibly have imagined in 1985. In the broad area of East-West relations and the world order in general, a shift has occurred that has brought into question many of the underlying beliefs and guidelines that governed relationships between nations and political alliances for over forty years. At the domestic level in the Soviet Union, the policies of Mikhail Gorbachev, while neither fully implemented and still questioned as to their ability to correct the problems brought about by seventy years of economic and political mismanagement, have started the Soviet Union along a road from which it will be difficult at best, if not impossible, to return to previous policies. These changes, as reflected in the changes that have been outlined in the area of technology and those pertaining specifically to Soviet computing, have brought the Soviet Union into a new situation with regards to its relationships with the

West, with the Soviets in many cases showing remarkable flexibility and quickness in their willingness to exploit the opportunities that are becoming available to them. Less flexible, however, has been the western response, especially in those areas where old ideas, and the policies based on those ideas, are firmly entrenched. This is particularly true in the case of export controls, and it forms the basis of a dilemma facing western nations and their policy makers.

The traditional approach toward export control and limiting the flow of technology from West to East has been one of denial. Through the CoCom list and the efforts of the member nations, the transfer of technology was monitored, with those items or areas that were determined to be sensitive or of military value prohibited from export to the East. These restrictions, while sometimes questioned as to their effectiveness, were generally viable with regard to computers for two reasons. First, while individual items of computer hardware, carrying with them selected technologies, might slip through, the restrictions did prevent a large scale transfer of equipment and technologies which were needed by the East to develop their computing capabilities on a broad basis. The element of scale here is essential, since it was only with the development of a widely based infrastructure that the Soviets could hope to duplicate the type of 'computer culture' that led the computer/information revolution in the West. [38] Second, while western efforts limiting the transfer of technology embodied in individual pieces of computer hardware may not always have been effective, this has not really mattered since Soviet efforts at incorporating western technologies through hardware have themselves been less than efficient. By focusing on small numbers of hardware items, the Soviets have gone after western technology in a form that has proven to be one of the least efficient means of transferring technology. Even when western computers were obtained, the process of reverse engineering, duplicating the manufacturing processes involved and then adapting the final products to fit their system, was time consuming at best; at worst, it proved next to impossible to gain anything in these efforts that would allow the Soviets and their allies to close the gap in computing between East and West. The picture that comes to mind from this situation is that of two boxers who are trying to hit each other while blindfolded--neither has been effective because of the inherent inefficiencies in their efforts, with the result that no one was hurt.

This situation, however, is rapidly changing. As has been seen, the new policies being put forward as part of Gorbachev's economic reforms have altered not only the direction and emphasis of the Soviet efforts at obtaining western technology, but the scope of these efforts. By encouraging the acquisition of western computer hardware and manufacturing capabilities on a broad scale, rather than going after a few prototypes, the Soviets stand to overcome the chronic shortages of equipment that have always hindered their development. Overcoming this shortage, in turn, is key to speeding up the process of general integration of computers in society, leading to greater use and greater demands for the services that computers can provide. By such measures, not only in the area of computer technology but in all areas where computers play a part in modern life, the Soviet government is consciously or unconsciously helping the transfer of information in a manner that will assist the country in integrating computers and developing the computing infrastructure that it has always lacked. At the same time, from a western perspective, not only is there political incentive in the West for trying to assist the reform efforts of the Soviet government, but there is a tremendous push from business interests to continue this process, with an eye towards new markets and the profits they represent. A consequence of all of this, however, is that in the rush to take advantage of these new opportunities, old guidelines and procedures are being overwhelmed and ignored, with the very real possibility that in the process more will be given up, in terms of technology, than might be desirable.

For their part, western regulators have tried to keep up with the changes taking place. However, pressures from both the business community and political circles to loosen CoCom restrictions have risen steadily as opportunities for profit combine with a perception of the reduced Soviet threat to argue against maintaining old limits based on security concerns. In an early, yet significant concession to these pressures in the computer field, the United States in July 1989 announced the dropping of restrictions on the export of personal computers using 32 bit architecture. [39] Comprising a great number of what had previously been considered fairly sophisticated machines, including among others the Apple Macintosh and IBM OS-2 systems, this was seen as a major signal in the shift of western attitudes on these issues. [40] This was quickly followed by the announcement that a comprehensive review of the entire CoCom list would take place, with emphasis on streamlining procedures and cutting down on the number of monitored items, effectively opening up a number of formerly restricted areas of technology for export to the Soviet Union and Eastern Bloc.

While well meaning in its intent, the results of this process and the attempts to keep up with the changes taking place have been haphazard at best and have generally lagged behind the reality of the situation. [41] Critics have noted that the effort to come up with new guidelines on export controls may be an effort in futility, since virtually no one believes in the threat posed by the Soviet Union any more, and even if they did the opportunities for gain appear to far outweigh the potential costs involved. [42] Because of the number of these opportunities, any system of control would soon be overwhelmed by the sheer volume of materials being transferred. It was hard enough to keep track of contacts and contracts when initiatives were small; now the limited enforcement mechanisms find themselves inundated. [43] Further, to a large degree the old regime of export controls worked through self-restraint and enforcement on the part of the members. Now, however, those restraints have been all but swept aside in the rush to cut the best deal with this new market before someone else can do the same.

What this means from a western perspective, is that current export control regimes no longer represent an effective way of controlling the flow of technology from West to East. This may seem perfectly acceptable as long as one believes that the Soviet Union no longer represents a threat to the West, however one need only look to the tremendous changes that have taken place in the past five years to see that the totally unexpected can, and often does occur in international politics. While few would argue that a return to the cold war world order seems imminent, at the same time the reestablishment of some type of strict authoritarian regime in the Soviet Union willing to use the country's still substantial military capabilities, cannot be ruled out. [44] At the same time, as noted earlier, some conservative elements within the Soviet hierarchy have been open in their condemnation of present reform policies, especially the move toward better relations with the West. While possibly not a major factor in the current situation, the presence of such sentiments could play a role in the future course that the Soviet Union follows. [45]

At the same time, what can be seen as a result of this situation, where the current export controls have been outstripped by the new initiatives, is the potential for a massive transfer of information and technology. While the argument has been made by some that this is not significant because of the traditionally poor track record on the part of the Soviets in making use of western inputs, the counter-argument can be made that the current situation permits transfers of a different type, that both the amount and nature of these transfers have changed, reflecting the changing circumstances in the Soviet Union and the realization of the nature of the problems they have had with such transfers in the past. Not only will these changes allow for a more effective use of foreign technology, but in larger terms they go a long way towards addressing the major weaknesses that have always plagued Soviet computing. While, in the short term, Soviet computing will assuredly continue to lag behind that of the West, to believe that the Soviets are incapable of duplicating the type of computer revolution that has taken place in the West not only ignores what has been seen in other countries such as South Korea, but shows a certain arrogance that is not only unfounded but could have serious consequences should political reforms in the Soviet Union falter, while economic reforms succeed. There is no reason to believe that given sufficient inputs, in terms of hardware, information and technical assistance, a viable computing community cannot develop in the Soviet Union. Not only that, but should at some future point the Soviet Union or elements therein decide to return to earlier antagonistic ways, reinstating previous forms of export controls could hardly be expected to recoup what has already been lost. Once the genie is out of the bottle, it is difficult if not impossible to put him back in; once the Soviet Union has developed an independent computing capability based on a domestic infrastructure able to generate its own technology, there will be little need to continue turning to the West. [46]

What all this argues for is a degree of prudence in the West's current policies. Since no one can predict the political future of the Soviet Union, it would seem wise to be cautious in what is given to the Soviets lest, as was the case earlier in this century with the materials that were sent to Japan in the 1920s and 1930s, these materials becomes the basis of a very real threat to those who supplied them. At the same time, however, this is not to say that all aid and assistance to the Soviet Union should be halted till a clearer picture of what the future may bring comes into focus. In truth, not only would this probably be impossible to enforce, but it might bring about the very consequences that the West hopes to avoid, in terms of a return to the previous cold war era and all of the uncertainties that that type of a world involved. Instead, what seems to be called for is a new approach in export controls, one that recognizes the changes in the world situation in general, and in the Soviet approach toward technology transfer in particular. If the current situation is a result of restructuring in the Soviet Union, then what may be needed is restructuring of the West's ideas about export control, to meet the new challenges that are being posed.

ENDNOTES

1 For an example of this type of reasoning, see the comments of David Wigg, Deputy Assistant Secretary of Defense for Policy Analysis, as reported by Bill Gretz in, "Embargo urged to win Cold War," Washington Times, 14 September 1989, p. 5.

2 The American Central Intelligence Agency maintains that the Soviet Union acquired more than 2,500 pieces of western microelectronic manufacturing equipment between the early 1970s and early 1980s alone. "See Soviet Acquisition of Militarily Sensitive Technologies," Report of the Central Intelligence Agency, December 1987, p. 25.

3 For a listing of many of the pieces of Eastern Bloc computer equipment and the western material from which they were derived, see Jay Tuck, High-Tech Espionage, (New York: St. Martin's Press, 1986) pp. 141-142.

4 As discussed earlier, the exact measure of how wide this gap is, is imprecise at best and varies depending upon the specific piece of technology, as well as the individual doing the analysis. Most estimates currently fall between six and 12 years.

5 A joke told among people dealing with export control to the Soviet Union that, as with all satire, has an element of truth about it that makes it all the more devastating, runs along the lines that the worst thing that the West could to to the Soviet Union would be to give them all of the latest western high technology electronics that they want, and then watch as, in the process of trying to make use of it, the Soviet system becomes so overburdened by the effort that it collapses, something analogous to a computer systems overload for the entire society.

6 In figures reported by the PlanEcon organization for 1989 and 1990 the continuing rise in imports in this area is clearly reflected. Table 5, p. 17 shows percentage increases in all categories of 1990 imports over 1989 in the area of Electrical computers and office machines. Sub-category increases include 25.3% for Digital electronic-calculating boards/components, 135.1% for Digital electronic computers, 39.9% for External storage devices, and 85.6% for Input/output devices. Table 8,

p. 25 shows the amounts purchased in rubles in each of these categories by quarter through 3rd. quarter 1990, with all three quarters in 1990 running in excess of 1 Billion rubles imported in this area. See Jan Vanous, Editor, PlanEcon Report, vol. VI, no. 48-49, 18 January 1991, pp. 17, 25.

7 David Silverberg, "Export Reauthorization Bill Would Liberalize Controls," Defense News, 30 April 1990, p. 27.

8 Stephen Budianski, "Chips for the Soviet Bloc?," U.S.News & World Report, 9 October 1989, p. 28.

9 Susanne Sternthal, "Soviets Search for Computer Power," Insight, 6 November 1989, pp. 42-43.

10 Alex Beam, "Russia Gropes for a Way to Enter the High-Tech Age," Business Week, 11 November 1985, p. 99.

11 Interview with Colonel John Carney, Military Advisor to the U.S. Delegate to CoCom, conducted at CoCom headquarters in Paris on 18 February, 1991. While personally believing in the need to maintain controls over some areas of software, Col. Carney said that the difficulty in trying to monitor software transfers had led many people to favor not even making the effort.

12 Ibid. Again, not a personal belief of Col. Carney's, but one that he has encountered in his work with others at CoCom.

13 In its report to the American National Academy of Sciences, the Committee to Study International Developments in Computer Science and Technology recommended a three tier approach to software control, with strict limits on militarily sensitive software, little or no control on commercially available software, but control on software development tools that might be used, especially in the development of the first category. This represents another way of trying deal with the difficulty of controlling software, i.e. by restricting the elements that go into its development or use. See, Global Trends in Computer Technology and Their Impact on Export Control, Report to the National Academy of Sciences, (Washington, D.C., National Academy Press, 1988), pp. 103-104.

14 The author's discussions with several specialists in the area

have indicated that while the general level of Soviet software is behind that of the West, just as in technology in general, there are areas where the Soviet Union has shown a surprising capability, and may in fact lead the West in terms of specific programs. The area most often mentioned are those programs dealing with earthquake prediction.

15 In what turned into a fascinating discussion at a reception in the American embassy in Budapest in 1986, the author was told by a Canadian trade official that because of CoCom restrictions on the import of upper level computers, the Hungarian government had opted for a low technology fix and had imported tremendous numbers of relatively simple Comadore 64's which did not violate export controls and which were "literally running the Hungarian economy." Not only were they readily available, but through software modifications, Hungarian programmers had managed to get these computers to emulate some of the operations normally performed by much more powerful IBMs. Those familiar with Eastern Bloc industry will recognize the pattern here, that if a high technology solution to a problem cannot be achieved, then a less sophisticated, but comparably effective low-tech solution will be sought. This same procedure is reflected in the earlier mentioned case of adapting older fax machines to higher rates of transmission, and indicates the possibility of getting around limits placed on the export of the most powerful pieces of hardware through modifying software programs.

16 Beam, "Russia Gropes for a Way to Enter the High-Tech Age," p. 99.

17 Gary Taubes and Glen Garelik, "Soviet Science: How Good Is It?," Discover, August 1986, p. 42.

18 A classic case in this regard is the story of microprocessor production. Originally the domain of the United States, the proportion of 'chips' made in America has declined in the face of stiff competition from Japan, including "dumping (by Japan) to drive out U.S. competition." While few today would call Japan a developing country, the pattern remains valid, as the Japanese have taken a technology devised in the West, copied it, improved on the manufacturing procedures involved, and then been able to capture a growing portion of the market through outperforming

the originators of the technology. See Jeff Shear, "A High-tech Reply to Chip Invasion," Insight, 15 May 1989, pp. 42-44.

19 It should be noted that while these countries all possess market economies, few have what would be considered open and democratic political regimes. This point is particularly telling when one is looking at possible ways in which the Soviet Union might develop. While exact parallels could probably never be drawn, Soviet conservatives have made the point that South Korea (which for most of its existence has had a strict authoritarian regime) might be an acceptable model for Soviet development. Interview with Col. Alksnis, BBC Money Program, aired on 10 March, 1991.

20 For an interesting article on the rise of the fax machine as a means of communication as well as spreading political literature and information of a less than flattering nature to the current Soviet regime, see Jonathan Steele, "Samifax replaces samizdat as the medium of dissidence," The Guardian, 25 March 1991, p. 19. This is just one example of the growing electronic culture in the Soviet Union that, in spite of all the problems involved, is springing up like blades of grass through a broken concrete walkway.

21 Infrastructure, in this sense, refers not only to the material, facilities and skilled personnel required for the manufacture of computers and their related peripherals, but enough reliable computers to conduct research, train personnel, and adapt computers to the particular needs of the economy. Again, the human element is key. The wider the use of computers, the more people trained to employ them, the faster the integration of computers will be in Soviet society and the greater the impact they will have.

22 Seymour Goodman, "Soviet Computing and Technology Transfer: An Overview," World Politics, vol. XXXI, no. 4 (1979), pp. 539-540.

23 Telephone discussion with Dr. Michael Grigson, British Ministry of Defense, 27 March 1991. Dr. Grigson emphasised that even once the Soviet Union began emphasizing computer development in the sixties, most of the people who could have begun to form an independent infrastructure for Soviet computing

were instead assigned the task of trying to duplicate western computer designs, taking them away from domestic research that might ultimately have given the Soviet Union the independent capability that it sought.

24 While much is made of export controls as causing problems for the Soviet Union in their attempts to gain western hardware, it should be noted that there are other constraints as well. A primary one is cost. Even when certain types of computers and computer related equipment were not restricted from import in the past several years, the Soviet Union still practiced the philosophy of obtaining only a few examples of a piece of equipment and then trying to duplicate it. In theory this allowed the Soviets to save on expenditures of scarce hard currency resources; in practice, as has been seen, it probably cost substantially more in terms of slowing their rate of development.

25 It should be remembered that both Lebedev in the sixties and Velikov in the eighties argued for the need to maintain an independent capability in computing, and sought to build the infrastructure that would provide such a capability.

26 Other conditions will also help this process--the lessening of controls on exports and greater availability of hardware will free up R&D elements to concentrate on projects other than reverse engineering. Familiarity with western manufacturing practices will increase the reliability and efficiency of Soviet manufacturing. Greater access to information will decrease the need to duplicate efforts developing the same types of material. Still all of these, to a certain degree, are dependent on, or can have their efficiency increased through, such contacts with the West.

27 Reference is made here to the tremendous increase in contacts reflected in the data provided by the Defense Intelligence Agency, as well as numerous articles, conversations, and pieces of anecdotal information.

28 The element of the time for this process to take effect needs to be emphasized. Professor Phillip Hanson has pointed out very correctly that Joint Ventures have not proved to be the source of technology that the Soviets might have hoped for, along with

giving an excellent analysis of why this has been the case. From the Soviet point of view, there has been disappointment that Joint Ventures do not seem to be the panacea for the ills of the Soviet Economy they might have hoped for. But this is not necessarily because Joint Ventures are ineffective means of transferring technology, as much as that the Soviet Union has had inflated expectations of what could be accomplished in the amount of time these ventures have been in effect, as well as the type of ventures (primarily in the service sector) that have been formed to date. See Phillip Hanson, "Joint Ventures: Transfer of Technology and Know-How," Paper delivered to the European Conference on Joint Ventures, Moscow, 9-16 December 1990.

29 Alex Beam, "Atari Bolsheviks," The Atlantic, March 1986, p. 29.

30 The concept of the 'computer culture' is key. One of the reasons for the rapid spread and development of computers in the West, as noted earlier, was the presence of this cult ranging from the Steven Jobs and Steve Wozniaks who created the first Apple computer in a garage, to tens and even hundreds of thousands of users whose sole accomplishment may have been nothing more then through their efforts, gaining acceptance for computers in society. This concept has not been lost on the Soviets. For some interesting views on this topic, see A. Tertychnyy, "A Formula for Overtaking," Rabochaya Gazeta, 12 September 1986, p. 2, as extracted in JPRS-UCC-87-015, pp. 10-13.

31 Ibid. In this article, which outlines the Soviet Union's policy toward personal computers, it is noted that in the West, "computers began to rise at an explosive rate: in 1981 the total number of them (Personal Computers) in the USA was one million, in two years--seven million, and already by 1984--twelve million units." The availability of these computers is cited by the author of the article as one reason for the rapid growth of computer use and development in the West.

32 In the words of one western specialist with experience in Soviet computing, Edson d. de Castro the Chairman of Data General Corporation, "They don't have the ability to [manufacture advanced computers] on a broad scale. But they can do just about anything once...." Lawrence Edleman, "Computer lag irks Edelman," Boston Globe, 29 December 1989, p. 63.

33 In a story told to the author by a Soviet citizen, quality control at a factory producing microprocessors for use in military equipment was insured by a military officer (Voinpred--literally military representative) who checked each processor as it came off the line with a testing kit. If it met the necessary standards, (about one in ten), it was accepted; if, on the other hand, it was found in some way to be defective, it was then turned over for use in civilian products.

34 Cited early on as one way of improving the economy in the Soviet Union, conversion of military production facilities to civilian was supposed to bring better standards to civilian goods. In fact, conversion has had more than its share of problems, and in many cases has proven that rather than being more efficient than the civilian sector, industries in the military sector suffer many of the same problems as do their civilian counterparts. Among other sources, see James Wallace and Nicholas Daniloff, "Developing high tech in a low-tech system," U.S. News & World Report, 12 May 1986, pp. 24-25, and Julian Cooper, "Nuclear Milking Machines and Perestroika," Detente, no. 14, 1989, pp. 11-13, 27.

35 One of the earliest examples of the way this process could work is the experience of the German firm, Salamandar shoes. Opening a production facility in Leningrad under terms of a Joint Venture, Salamandar brought in German equipment and management to operate a factory using Soviet labor and materials. It was insisted that the material provided by the Soviets meet German specifications, and that workers performed according to German standards, in return for which they were paid three to five times what a normal Soviet worker would receive. Under these conditions, it was reported that the factory was operating very successfully, and that Soviets were now being trained to fill managerial positions. For a more recent example of a Soviet electronics firm, and its efforts to adapt to western ways, see Steven Greenhouse, "A Rare Success Story in Moscow," The New York Times, 11 December 1990, pp. D-1, D-5.

36 Professor Hanson in his paper for the European Conference on Joint Ventures points out that at present there is little to suggest that Joint Ventures in the Soviet Union are "serving as vehicles for Soviet assimilation of foreign technology" (p. 16)

While not disputing these findings, it must remembered that the process described with regard to computers, may take decades to accomplish. The <u>potential</u> of Joint Ventures and other arrangements that have proven effective in transferring technology in the past to change the Soviet economy is the basis for this argument. Though current conditions are not such that they seem to be fostering such ventures, these conditions may change. While forecasting that Joint Ventures will play an increasing role in transferring technology in the future may seem like speculation, successful policy formulation involves projecting all possible scenarios, and devising policies to deal with these scenarios, should they come to pass. See Hanson, "Joint Ventures: Transfer of Technology and Know-How," pp. 16-17.

37 A large part of the ability of the Soviet Union to create such an infrastructure will depend upon whether it can secure sufficient capital to achieve this goal, either through increases in exports in other areas or through attracting foreign investment. Several points should be made here. First, while a fairly sophisticated area of technology, computers and related items are not necessarily expensive, and are relatively inexpensive when compared with other fields, such as the development of infrastructure needed to exploit mineral resources in Siberia. Second, computers are an enabling technology that can be applied to all areas of Soviet industry and the economy, thus investments here can be justified as having greater potential for improving overall economic performance, as opposed to money devoted to specific sectors of the economy. Finally, as has already been shown in the figures for imports in computer related fields in the period from 1985 to the present, the decision already seems to have been made to spend whatever it costs, even at the expense of other areas of the economy, in order to acquire a computing capability. As investment capital becomes available, whatever its source, it seems reasonable to expect that computers and other high technology electronics will claim more than their share of such funds. Further, Soviet actions in the first half of 1991 seem to have reaffirmed the Soviet desire to obtain western capital for just such purposes.

38 While a topic beyond the scope of this study, the possible consequences of such an information revolution in the Soviet Union have been the source of much discussion, both in the West

and in the Soviet Union. This is a fascinating topic, and the evolution of this process in the Soviet Union will have a major effect on the nature of the Soviet computer industry, Soviet science and industry, and eventually on Soviet society itself.

39 "Glasnost for U.S. Computer Sales," Chicago Tribune, 21 July 1989, p. 18.

40 Richard H.P. Sia, "Defense vs trade conflict intensifies," Baltimore Sun, 20 July 1989, p. 8.

41 "High stakes in high technology," Cleveland Plain Dealer, 28 August 1989, p. 6b.

42 Paul Magnusson, et. al., "High-Tech Exports: Is the Dam Breaking?" Business Week, 4 June 1990, pp. 128-129.

43 Ibid.

44 While not discussed at length in this study, the role of the military in the reforms cannot be ignored. Initially, the Soviet military appeared to be won over by the argument that reform was necessary because it would lead to improved technological capability for Soviet industry, even if it meant temporary cuts in defense expenditures to support the reform. Recently, however, as defense cuts have continued without achieving any noticeable improvements in industry, senior officers have begun to question the reforms, and have been cited as a key element in the conservative backlash that is appearing in the Soviet Union.

45 While predicting political events in the Soviet Union is hazardous at best, a number of western observers, noting the shift away from formerly liberal policies, have labeled the current relationship between the Soviet Union and the West, if not a state of cold war, then one of 'cold peace'. A major premise of this study is that such shifts should not come as any great surprise, and that while the West should assist in the reform effort, western leaders should also have thought about what actions will have to be taken if the Soviet Union, for whatever reasons, turns from policies that are acceptable to the West, and once again becomes a threat to western security.

46 A key element in this scenario is the continued transition from the current command economy to some form of market mechanism. Just as the old economic order was responsible to a large degree for the conditions that led to the difficulties in assimilating western technology, the transition to a different system is essential if there is to be any substantial improvement in the process of technology assimilation. Among other things, a market economy would improve efficiency, allow for consumer feedback, attract foreign investment and provide the general conditions which might foster sustained growth and advancement, not only in the area of computers, but in the economy overall. After apparent hesitation, the Soviet leadership as of this writing appears to have re-committed itself to this type of economic transformation. Whether it will maintain this commitment, remains to be seen.

CONCLUSIONS--SOME THOUGHTS FOR THE FUTURE

As with any scholarly endeavor, there are often as not just as many new questions that are raised from a study as there are old questions answered. This paper has attempted to shed new light on the nature of technology transfer, both to better understand the processes involved and through this understanding to act as a guide for policy makers who must decide on the appropriate ways of controlling the flow of technology where issues of national security are involved. To do this, the history and state of computing in the Soviet Union have been used as a case study for examining both the impact of technology transfer upon a nation seeking to develop its capabilities through the use and integration of foreign technology, and the effectiveness of efforts to limit these attempts. While it is realized that some of the material examined may be unique to the computer area, both because of the nature of the technology and the the systems involved, general conclusions may still be drawn from these observations and applied to other cases and circumstances. And even if some conclusions are area specific, the importance of computers in the life of a modern industrial society is such as to have warranted the examination. Finally, if the mere act of bringing these issues to light generates further discussion and examination, then the ultimate goal of expanding knowledge in this area will have been achieved.

In drawing conclusions from what has been seen in the case of technology transfer and the Soviet computer industry, it first seems appropriate to restate the findings, so as to be sure that what is proposed, in fact, follows from that which has been observed. As a subset of the general competition between East and West, computing has been an area of particular importance, both in and of itself and in terms of what computers can contribute to the industrial and economic development of a nation. Early computer development (through second generation) in the West and the East reflected relatively equal emphasis on this area and fairly equal accomplishments. However, since that time the gap between the two sides has widened to the point that, from the 1960s onward, the leadership of the Soviet Union has been forced to admit the disparities that exist in this area and to take active measures to try to overcome their country's deficiencies, including an all out campaign to take advantage of western computer technology. In spite of resolute efforts, however, the Soviet Union has been unable to catch up with the

West. The reasons for this failure are many, ranging from the inherent weaknesses of the Soviet economic system in general, to western efforts at limiting such transfers, primarily through the export control regime administered by CoCom. While no one reason can account entirely for the Soviet failure, this study has argued that a central reason, which has largely been overlooked, is that the ways by which the Soviet Union tried to transfer and incorporate western technology were themselves inherently inefficient. Therefore, this effort, if not doomed from the start, was severely handicapped by conditions of the Soviets' own making, and not through western efforts as is commonly supposed.

The significance of these findings might be far less if the situation described above still existed today. However with the coming to power of Mikhail Gorbachev, and his program of restructuring the Soviet economy to overcome the problems endemic to that system, came a change in the Soviet approach to obtaining and incorporating western technology. Further, the significance of this change has not been fully appreciated by decision makers in the West because of the failure to be cognizant of the ways in which technologies are most effectively transferred. While Soviet acquisition initiatives, besides increasing in number, have taken new and wholly unprecedented forms, western responses to these initiatives have been slow and/or inappropriate. Not only has the amount of computer hardware being imported by the Soviet Union increased significantly in the past five years, encouraged by a loosening of export restrictions in the West, but the number of Soviet scientists and businessmen traveling in the West has seen a dramatic rise. At the same time as well, the Soviet Union has launched a major program emphasizing Joint Ventures and other forms of mutual cooperation, which will help to bring both western technical know-how and managerial expertise into the country. The extent of this emphasis can be seen in the comment of one western observer, who noted that "Joint Venture is as common an English phrase to Soviet business leaders as blue jeans is to their teenage children." [1]

The reason these changes are so significant in the area of computers is that, in addition to addressing the short term problems of a lack of hardware and software, these measures address what may be the key element as to why Soviet attempts to incorporate western technology have failed in the past; the failure to recognize the importance of human interaction in the successful transfer of technology. As a result of these changes, the combination of increased numbers of computers, increased access to western computer know-how, and the growth of a 'computer culture' similar to that in the West may eventually give the Soviet Union something it has never had before, a strong computing infrastructure, one able to generate computer related technologies on its own. The reasons for the lack of western response to these changes are just as numerous as the reasons for the previous Soviet failures at successfully assimilating technology, and include everything from bureaucratic inertia, to political optimism over the changes taking place in the East, to pressures from the business community to allow businesses to take advantage of the new opportunities presenting themselves in terms of trade with the Soviet Union. Whatever the reasons though, the result may be that the West, by its actions or lack thereof, could be sacrificing the technological advantage that it has enjoyed over the past forty years, and which it has claimed has been one of the cornerstones of its security.

The Western Debate

Critics of this view, who support either an end to export controls altogether or at least their radical reduction, argue along two separate, though related tracks. The first group maintains that this situation is not as serious as it might at first appear, simply because no matter what new technologies the Soviet Union receives, it has proved incapable of effectively using them in the past, and will continue to do so in the future. While the Soviet Union's record for successful integration of western technology has certainly been less than spectacular, this type of argument contains an element of complacency about the West's technological superiority, as if the Soviets are incapable of creating and working with advanced technology in any field. Such, however, is not the case, as Soviet achievements in certain areas where they have chosen to focus their efforts have shown. [2] The fact that they have not been able to do this in all areas speaks of the failings of their system to support such efforts in a number of sectors simultaneously, and not the inability of Soviet scientists to master any given technology. Indeed, the economic reforms were created to address these failings and are designed to change the very mechanisms that lie at the basis of these problems. Further, the record of the development of several of the countries in the Far East should serve to banish such western complacency about the ability of countries that, while economically not as developed as the West, still possess a basic industrial foundation which can support rapid advances given the proper conditions.

Starting from a position far less advantageous than that of the Soviet Union, countries such as Taiwan and South Korea in the past thirty years have managed achievements that have astounded the rest of the world. They were able to accomplish these feats through a combination of foreign technology and investment, government policies that on one hand encouraged human integration, while on the other protected fledgling domestic industries until they could compete with those abroad, and market economies that gave incentives for development, expansion and efficiency. [3] It would be unreasonable to assume that given the same types of conditions and incentives, the Soviet Union could not be able to emulate this type of development, especially given support from the West.

This leads to the second argument that is heard with regard to the current situation, that even if all of the above is true and the Soviet Union can reap a major benefit from the reforms, this situation is not to be feared, as the Soviet Union that is emerging under Gorbachev is not the same one that has traditionally been an adversary of the West, and that there is no longer the need to fear Soviet intentions as the cold war is truly over. Heard especially from business concerns who stand to profit from the new relations, as well as certain sectors of western governments who see the current situation as an opportunity to end the hostile atmosphere that has governed East-West relations for the past forty years, these elements would abandon or greatly reduce export controls on the assumption that the current process is irreversible and therefore there is no longer a need to fear the results if the Soviet Union should begin to close the technology gap, since by the time this occurs it will be a different type of Soviet Union. While this assessment is appealing, as a minimum it may be overly optimistic, if for no other reason than it seems to count on five years of less than successful political and economic reform overcoming more than seventy (and some might even argue more than 300) years of authoritarian rule, combined with a deep rooted distrust of the West. The resurgence of conservative elements in the Soviet Union's body politic serves as a sobering reminder that many in the Soviet Union are dissatisfied not only with the conditions that the reforms have brought about, but with the general philosophical beliefs on which the reforms are based. [4] Only time will tell the effect that these elements will have on the eventual shape and nature of the Soviet Union, however it would seem more than a remote possibility that the cooperative future that many predict as the result of the Gorbachev reforms may, in fact, revert to one of strained relations between the Soviet Union and the West. Until a clearer picture of the future begins to unfold, at least some degree of caution on the part of western policies towards the Soviet Union would seem to be prudent.

Unfortunately, there are just as many elements in the West who are ready to ignore the events that have taken place in East and would prefer to maintain pre-1985 policies, including strong export controls, in the belief that if the reforms succeed, then policies can be changed, and if they do not and the Soviet Union returns to some variant of its past policies, nothing will have been lost in the process. Such reasoning is dangerous on two accounts. First, the refusal to acknowledge the changing situation in the relations between East and West flies in the face of reality, and only bolsters the arguments of those who say that the old export control policies are out of date and do not reflect the current situation. [5] Second, failing to respond to Soviet initiatives may well condemn the reforms to failure. In this instance, the argument that nothing should be changed because the reforms may fail becomes something of a self-fulfilling prophecy, since almost everyone concedes that the reforms can only succeed with large scale intervention and assistance from the West. What is missing from this debate is a middle ground, one that recognizes both the need to respond positively to the current situation, but in such a way that should events take such a turn that the two sides again become adversaries, the West will have no need to regret that which has been given to the Soviet Union in the interim.

The Need for a New Approach to Export Control

All this points to the need for a new approach to the employment of export controls; one that seeks to limit the transfer of key technological skills as opposed to individual pieces of equipment. This approach would incorporate an appreciation for the ways that technologies are most effectively transferred with a realistic appraisal of what export controls can be expected to achieve, and what they cannot, given the current circumstances. Based on this knowledge, reasonable goals could be set for such a regime along with measures to achieve these goals, ones likely to be complied with out of the mutual interests of the participants rather than any enforcement mechanism. While this may seem like the basis on which any rational export control regime should be founded, it can be argued that, in fact, the current system no longer conforms to these criteria. The present system has sought to limit technology transfers by controlling items that were thought to have a military significance, but which, in reality, did little in raising the overall level of the Soviet Union's technological skill. In the area of computing, this led to the current regimes being directed against transfers of individual items of hardware (an inefficient means of transferring technology) and software (which is almost impossible to monitor and control), while virtually ignoring personal contacts and information transfer systems. That these approaches were, in fact, appropriate as long as the Soviet Union concentrated on obtaining technology through hardware and software is readily conceded. However, as has been shown, the Soviet approach since 1985 has changed; thus, the export regime must change as well, if it is to remain a viable entity.

As a first step in considering any change in export controls, the question must be asked, what exactly is it that export controls hope to accomplish? The goal of prohibiting the transfer of technologies that might have military application, which has been an underlying tenant of the current export control regime, has always been difficult to quantify especially in terms of dual use technologies, [6] appears anachronistic given the changing relations between the East and the West, and is probably unrealistic given both the political and economic pressures involved. The goal of maintaining a given lead time, that is to insure that the West maintains a technological advantage in certain areas, is less definable but may be more realistic. By recognizing the western strength in the development of new technologies, such an approach would not be afraid to let older technologies be transferred as a way of encouraging general Soviet economic development. The focus of such a regime would be an economic strategy designed to limit the ability of the Soviet Union to make rapid leaps in technical capabilities that could pose a potential threat either to the security of the West. The way to avoid such a situation would be to control and influence the development of the element that could provide the ability to achieve such accomplishments, the industrial-technical infrastructure.

This is not to argue that export controls should attempt to limit the economic development of the Soviet Union overall. At the same time, however, it recognizes the fact that left unchecked, Soviet initiatives in the area of technology transfer will eventually result in a greatly expanded capability for this infrastructure first, to make use of western technology and second, to generate technologies of its own. Politically, there are valid reasons for responding to the initiatives and requests for technical assistance that have come from the Soviet Union; already, cases have been seen where the Soviet Union has broken with past policies and behaviors in the international arena, as part of the process of 'New Thinking'. [7] Economically, the opportunities for expanded trade and markets presented by the opening of the Soviet Union to the West provides possibilities not only for western industries, but for western scientists and other professionals as well. Both give the opportunity for integration on a wider scale and with this integration a more stable base for continued peaceful relations between nations. This integration in itself becomes a security measure of sorts, since countries that have strong economic and social ties are less likely to wish each other harm. Integration would also allow a more accurate understanding and evaluation of each others capabilities and intentions. Revisionist historians have long maintained that the cold war was the result of mutual misunderstandings between the blocs, reinforced by the aura of secrecy surrounding the Soviet Union. [8] This secrecy and the surprises that it brought, as with the launching of sputnik, contributed to western fears and the tension that existed between East and West, fears that might have been reduced had the West been privy to a more accurate assessment of the Soviet Union's true capabilities at the time.

Thus the key to the new approach to export control would be to focus on the development of the Soviet infrastructure in various key sectors, such as computers, monitor this development, and through export controls and other measures attempt to influence this development so that it does not present a threat to western security.

Summarizing the underlying premises of this type of approach, the overriding concern would be the maintenance of a technological edge over the Soviet Union. This would not necessarily mean stopping Soviet scientific-technical development, but channeling that development and taking steps to insure that the rate of development did not outstrip that of the West. While this may seem a fairly straight forward matter, given the terrible state of the Soviet economy, it must be remembered that it is not the overall state of economic development that is of concern to the West in terms of security, as much as the developments in certain key areas that might prove militarily threatening under a given set of circumstances. To avoid this, such a regime should concentrate on influencing the development of the infrastructure that could create such a situation. [9] This, in turn, could be done through a combination of controls on technologies critical to such an infrastructure, such as manufacturing, and economic incentives to participate in the world division of labor. Integration, here, plays a critical role. Through failure to integrate earlier in its history, the Soviet Union has found itself in the position that it occupies today. Through integration, it hopes to extract itself from that position. Because integration is essential, the West should be able to set the terms of that integration so that it does not present a threat to the West and may, in fact, increase the security of all.

Certain elements of this approach can be found in the discussions taking place with regard to the revisions of the current CoCom lists. The problem is that these revisions still focus on hardware, and ignore the other areas that, as have been shown, are essential for successful technology transfer. Further, the CoCom reforms are concerned with individual items or technologies rather than an overall objective. What is called for is a 'holistic approach', one that combines a package of measures that work together to achieve the desired result. It does the West little good to continue to restrict the transfer of individual items, while in the longer term allowing the Soviet Union to increase its technical skills to the point that the Soviets can create equivalent items without turning to the West. Lebedev and his supporters fully understood the nature of dependence when they argued for an independent infrastructure that did not depend upon western inputs for its advances. On the other hand, if guarantees of access to a reasonable level of related technologies can be combined with security guarantees that would cause the Soviet Union to voluntarily curb its efforts at creating such a domestic infrastructure, the West will have achieved its goal of securing its technological advantage, at least until such time as the need for such an advantage is no longer felt.

A Model Regime for Computing

While the purpose of this study is not to propose new policies but to show their need, and through demonstrating this need spur further examination of these issues, it might be worthwhile to put forward the elements of such a regime in the case of Soviet computing as a starting point for future discussion. The goal of the regime, as indicated above, would be to preserve the technological advantage enjoyed by the West, not necessarily by hindering the general level of computer development and use in the Soviet Union, but by monitoring that development, and through controls on certain key elements ensuring that development does not pose a risk to western security.[10] To achieve this goal, based on what has been observed in the course of this examination, the following elements might be considered:

<u>Encourage Integration with the West</u>--While this might at first appear to be at odds with the traditional purposes of export controls, given that such integration effectively transfers technology, it should be remembered that the ultimate objective of this effort is to maintain ones security; if this can be achieved through integration, then the purpose of the regime will be accomplished. Integration, in terms of hardware and software, would tie the Soviet Union to western systems and make it less likely to pursue designs of its own. Integration, in terms of personnel, would foster professional ties as well as allow the West a means of informally monitoring Soviet developments.

<u>Identify and Maintain Control of 'Critical Nodes'</u> [11]--Critical nodes, as used here, apply to critical elements without which a system rapidly looses its ability to function. Supplies of certain materials (such as high grade silicon), capabilities (such a microprocessor manufacture), [12] or access to certain facilities all could be key elements in developing an independent computing capability. CoCom already monitors several of these areas, however they would have to be re-examined in terms of their

importance to the overall development of a computer infrastructure. At the same time, guaranteeing the supply of finished products at a cost comparable to the cost of domestic production, would offer the Soviet Union incentives to forgo such developments as well as encourage integration.

Temporarily Embargo 'State of the Art' Technologies [13] --As has been noted, earlier regimes prohibited the transfer of specific pieces of equipment that were thought to have military significance. An alternative approach might be to prohibit the transfer of any piece of equipment during a specified time period after it is first made commercially available, but then release all controls after that time period has passed. Along with guaranteeing a lead time for security reasons, commercially such an approach would be appealing since all manufacturers would be treated the same, and would have the chance to compete for sales on an equal footing after the embargo period. From the Soviet perspective, the knowledge that any given piece of hardware would be available to them after the embargo period might dissuade them from attempting to develop or acquire such technologies on their own.

Insist on Observance of International Laws Governing Copyrights and Intellectual Property--Restrictions on software would be removed in return for guarantees that software developers would receive due compensation for their work. The royalties received would be used to support further development, thus maintaining western strengths in this area. Soviet compliance would be encouraged by the desire for mutual respect and protection for their own products.

Closely Monitor Human and Other Information Exchanges--This should not be construed as limiting such interchanges, which would go against the goal of integration, however better monitoring of the people coming to the West and what they are doing would give a better idea of what technologies are being transferred by such means, and could be used to identify efforts at obtaining information or capabilities with direct bearing on security issues.

How this regime would apply to the various aspects of computer technology would depend to a degree on the technologies themselves. In terms of hardware, restrictions would be lifted on most computers, with all but the most powerful and most advanced being allowed for export. This would not only provide the Soviet Union with the machines needed to make up for their current shortages, but it would answer the calls for an end to restrictions on western firms doing business in this area. At the same time, a blanket embargo might be placed on all newly manufactured technologies for a period of time, after which all restrictions on the transfer of this equipment would be lifted. [14] Firm controls would also be placed on any transfers of elements involved in the manufacturing of computers or computer components, especially microprocessors. As has already been seen, these types of technologies are high on the 'wish list' of Joint Ventures, and could eventually give the Soviet Union a degree of independence in the computer field. While certain elements in the Soviet Union might chafe at what they see as an overt attempt to foster dependence, as long as the Soviet Union was guaranteed access to finished computers at reasonable cost, in contrast to the cost of developing an independent manufacturing capability, this might prove to be a more than acceptable trade off.

In terms of software, restrictions on all but special purpose software would be lifted, giving the Soviet Union access to the software that they need to take advantage of the influx of western computers, with strict adherence to international patent and copyright laws required as a condition for the lifting of other restrictions. Compliance would come about again, because the Soviet Union would have more to gain than it would be willing to lose through non-compliance. From the western perspective, controls on the transfer of software are almost impossible to enforce; therefore, it stands to reason to cease futile efforts at control as long as legal rights are observed. Those areas where software controls would remain might include CAD/CAM and software programs relating to the design and manufacture of computers and other high technology equipment, reinforcing the effort to limit the development of an independent manufacturing capability in this area. The royalties from user fees should, in turn, go back to spur further software development. Integration of Soviet and western programmers would be encouraged, both for its inherent benefits to all concerned and as a way of monitoring Soviet software development. While increasing access to western software and programming may result in the transfer of the latest software technology to the Soviet Union, at the same time, Soviet programmers have skills that could be of value in the West. The trade-off of lifting controls in return for greater access and integration in the software field may well be as beneficial for the West as for the Soviet Union.

Finally, as has been emphasized, possibly the greatest change in the area of technology transfer to come about as a result of Soviet reforms has not had anything to do with the economic restructuring directly, but is a result of the change in attitude towards human contacts with the West. A basic tenet of this paper has been that such contacts are the most efficient means of transferring technology, and therefore the increase in contacts between East and West represents a tremendous potential increase in the effectiveness that can be gotten from western technology. At the same time, however, if there is a hope for improving the relations between the West and the Soviet Union, it is that through such increased contacts, mutual understandings will be reached between the peoples of both sides, forming the basis for cooperation and better relations in the future. While the line between benefit and cost is difficult to draw, it can be argued that efforts to monitor the contacts taking place could be reinforced without necessarily restricting the number of these contacts. At present, the efforts being made to keep track of Soviet visitors are minimal at best, aside from screening of visa applications and the monitoring of known or suspected intelligence agents. Yet these people may represent the greatest flow of technology leaving the West. By more closely monitoring the nature of these growing contacts between the two, agencies charged with regulating export controls could evaluate the impact of such transfers as well as identify attempts to obtain those technologies and capabilities that the West feels there is still a need to control, specifically in the areas of manufacturing and production. The same type of care should be taken with access to computer networks, data bases and other types of information exchange. The goal here would not necessarily be to restrict the flow of all technology, but to identify the sources and content of the technology being transferred, so as to be able to better judge its significance and whether further restrictions in a given area need be applied. [15]

The Implications of this Type of Approach

The results of this type of policy would first be to limit the development of a computing infrastructure within the Soviet Union by restraining certain key elements in this infrastructure. As has been shown, the lack of such an infrastructure is at the heart of most of the problems that the Soviet Union faces with regard to computers. The difference now would be that recognition of this fact would be used by the West as a control mechanism. Development in other areas, including the widening use of computers within society, would still be encouraged through liberal export policies that would provide all of the lower end computers and peripherals the country could absorb, without losing the ability to restrict the import of extremely powerful machines with military applications or the general import of machines, should a change in political conditions warrant such an action. Controls on manufacturing capabilities would also continue, as least in the immediate future. As has been seen, such capabilities are a key element in any infrastructure and their absence in the past has severely limited Soviet development. However, by guaranteeing that computers will be available at a cost comparable to that of domestic manufacture, restrictions on the transfer of manufacturing technology might be accepted. Integration would also be encouraged through the use of common machines as well as common sources of supply. Finally, identifying and more closely monitoring the growing number of human contacts, as well as other sources of information provided by computer networks and data links, while not overtly interfering with the process of exchange would give the West the ability to close or restrict such access if the need should ever be felt. Thus, by policies designed to control the development of a computer infrastructure, as opposed to controlling individual pieces of equipment, western dominance in this area would be preserved.

It can be argued that such a policy is designed to place the Soviet Union in a permanent state of dependence on the West, a dependence that the Soviets have always feared and would be loathe to accept. The counter to this argument is that, in fact, this policy is designed to foster integration between East and West to the benefit of the former, while answering the security concerns that are still held by the latter. From the Soviet perspective, the cost involved in trying to achieve an independent capability in computing, especially given their past record, might more than ameliorate the conditions imposed by the West. Further, if in fact one of the goals of the current Soviet regime is to improve relations, so that all can live together in one 'common world home', then the fear of dependence on the West for certain elements in this area should also be lessened. Finally, it should be recognized that even following such a policy, eventually the Soviet Union may be able to achieve an independent capability in the area of computers. As exposure both to western computing techniques and to computing in general within Soviet society grows, the type of computer culture that has fostered the information revolution in the West will come into being in the Soviet Union as well. If there is one lesson that history teaches, it is that man, no matter what conditions he finds himself in, will continue to strive to progress. However, by modifying the course of this development to lengthen the time involved, the West also gives time for other reforms to take effect, reforms that may lessen the concern for the day when the Soviets do achieve an independent capability in this area.

The implications of this type of approach, both for the Soviet Union in particular and the world in general, are many and varied. For the Soviet Union, this type of approach should not be seen as a further attempt to limit its development by an adversary as has been the case in the past, but as a way to aid Soviet development by allowing, to the widest possible degree, the transfer of technology. By providing a viable means of monitoring and controlling those transfers that pose a security concern for the West, restrictions in other areas would no longer be needed. From a western perspective, not only would security concerns be addressed, but also political and business concerns as well, concerns that see the welfare of both the West and the East aided by improved political and economic relations, without the burden of a series of cumbersome export regulations whose appropriateness and effectiveness have come into question. There are lessons to be learned, as well, which can be applied to the transfer of technology from North to South. The rise of the third world as a new center of industrial and political importance has brought with it concerns among the industrial nations about the transfer of sensitive technologies to these regions, regions where these technologies may fall into the hands of those whose intention is to bring harm to others. The recent cases of western industrialists aiding the development of manufacturing capabilities for chemical weapons in Libya, as well as being the source of Iraq's nuclear potential, point to the need to re-look export control policies in these areas as well. At the same time, it should be remembered that what have been identified as the efficient ways of transferring technology need not necessarily be viewed solely with an eye toward restricting these means. In cases where the goal is to aid in the development of an area, these lessons can be used to identify the most effective ways of transferring technology, so that these methods and means can be targeted to ensure the greatest success possible.

In conclusion, it should be emphasized that any examination of export controls and the policies that implement these controls must be based on the ways that technologies are most efficiently transferred, if they are to be effective. While this may seem obvious, as has been seen this has not always been the case in the past, nor unless there is recognition of this fact, is there any guarantee that this will be the case in the future. The rapid and radical changes taking place in the Soviet Union, however, present an excellent opportunity not only to revise past practices in the light of these changes, but to respond positively to a process that may ultimately benefit the world overall. Re-looking export controls is but one element of this process, but it is an element of tremendous significance, and cannot be ignored. The questions involved are difficult ones and the implementation of any policy will be far from easy, however the potential benefits to be gained, make it well worth the effort involved.

ENDNOTES

1 Harvet S. Caras, "Sizing Up the Soviet System," PJ--Personnel Journal, vol. 69, no. 12 (1990), p. 40.

2 As cited in the report to the American National Academy of Sciences, "Some areas where Soviet research may be ahead of the West are in frost-resistent fiber cables, radiation-hard fibers, and laser sources for fiber-optic transmissions." With the attention being given to the current economic problems in the Soviet Union, it is all too easy to forget that the USSR still maintains the third largest economy in the world (behind the United States and Japan), and has devoted tremendous amounts of resources to its research and development sector, which can be very good. Global Trends in Computer Technology and Their Impact on Export Control, (Washington, D.C.: National Academy Press, 1988) p. 181.

3 In his opening remarks to the Tech Transfer Society conference held at Dayton Ohio on 26 June 1990, Dr. Philip Roberts commented, "I have bad news and good news to report today. The bad news is that forty percent of the graduate students in the sciences and engineering in the United States are citizens of Asian countries. The good news is, that upon completion of their studies, fifty percent of those decide to remain in the United States." While an approximation designed for shock value, the figures that he states are not very much different from those of other sources, and point to the tremendous number of students from the Far East who attend western universities for their training, and then return home, carrying with them the skills that have helped to propel this region of the world to a meteoric climb in terms of high technology.

4 While the current political spectrum in the Soviet Union runs the gambit from radical reformers to radical reactionaries, the conservative faction in late 1990 and early 1991 has shown a resurgence of strength as well as the ability to influence policy. While not all conservatives decry all the reforms, there are at least some elements whose beliefs parallel those of the Slavophiles, that is, they show a severe distrust of the West and have been quick to condemn any policy that is seen as fostering better relations for any reason. To this must be added the fact that seventy plus years of viewing the West as an enemy by the

whole of Soviet Society cannot be totally forgotten in a matter of half a decade.

5 The Soviets themselves are quick to join this debate on their own behalf. "Soviet specialists hold the view that today when obvious positive changes are taking place on the world arena and confrontation is giving way to the policy of talks on the most complicated problems, the very existence of CoCom is becoming an anachronism." Aleksandr Baraulin, "Prospects of Technology Exchange in Soviet Cooperation with Asian Countries," Foreign Trade, June 1990, p. 19.

6 Dual use technologies are defined as those technologies that can be used for either peaceful or military purposes, with most computer equipment falling into this category. Not surprisingly, decisions on such items normally are a matter of interpretation, with interpretations, in turn, normally coinciding with the interests of those doing the interpreting. With the decrease in the perceived threat posed by the Soviet Union has come an increase in the calls for more liberal policies with regard to these technologies.

7 'New Thinking' as originally formulated by President Gorbachev, was to be the new and realistic approach taken by the Soviet Union in its relations with the rest of the world. In practice, it has resulted in a modification of what have been traditional patterns of behavior by the Soviet Union in the world arena, in return for pledges of support and aid from western governments for Soviet reform policies. The Soviet withdrawal form Afghanistan, restraint shown in the Middle East, and support for agreements such as in Angola, all have been positive results of the 'New Thinking' process.

8 Stephen Cohn's, Rethinking the Soviet Experience, Oxford: Oxford University Press, 1985, is an excellent example of this type of argument. Known as revisionist historians (not to be mistaken for the revisionists condemned by Lenin), this group argues that the cold war was the result of mutual misunderstandings between the Blocs as much as through any ill intent on the part of either side. While this line of reasoning has more than its share of detractors, there are enough examples where each side has overreacted to what it perceived to be the intentions of the other, to support the idea that a better

understanding of the other side's views, as well as an accurate assessment of its capabilities and intentions, can only help in such situations.

9 The concept here would be to encourage evolutionary, rather than revolutionary change in the Soviet computing field. Those familiar Soviet scientific development will verify that in the past the Soviet Union has been known for its ability to make rapid leaps or 'Skachoks' in certain fields, primarily because of its emphasis on theoretical rather than experimental development. It is exactly this type of leap in capability that is of particular concern in security related matters, where sudden surprises are seldom welcome. Rather than trying to stop all development, the goal here would be to allow evolutionary development through selective release of materials and equipment that would satisfy the Soviet Union's needs and not force them into pursuing independent efforts, where a skachok might occur.

10 Monitoring, as envisioned here, would be informal in nature, based on reports brought back from western academics and businessmen during the course of their normal dealings with the Soviets. One of the biggest changes that has come about as a result of the new openness in the Soviet Union is that western observers are gaining access to areas and information that were never available before. While a concerted effort might be made to hide a particular project, in general, integration would probably allow a fairly accurate picture of Soviet capabilities and interests to be developed.

11 The concept of critical nodes is not a new one to either management or social science theory. By identifying certain key elements in a process or system, an element of control is established, for by restricting this element, the system or process itself is either restricted, or in extreme cases can be brought to a halt.

12 An example in the case of computers might be the 88383 microprocessor currently used in the latest generation of MS-DOS machines that make up a substantial portion of the world's computing capability. Only one company in the world, Intel, makes this particular chip, and while it is probable that it could be duplicated in time, the short term restriction of the availability of this microprocessor would have serious

consequences for any nation with a computing population. Thus control over distribution of this particular item becomes a 'critical node' that could be used as a potential means controlling development.

13 While similar in terms of the theory behind its employment, such an embargo should not be confused with the use of sanctions, as recently seen in the case of Iraq. In this case, the restrictions of goods was designed to force a given action or concession; the embargo would not be punitive in nature. Instead, it should be viewed as a safeguard in this process, that in the short term provides security without necessarily disrupting or otherwise adversely affecting the system overall, and in the long run allows a greater amount of technology to be transferred.

14 Delayed release of given technologies offers some interesting possibilities in terms of export control. Rather than focusing on certain items, as in the case of critical nodes, entire categories of technologies or their related products would be prohibited from release for export for a specified period of time, after which all controls would be lifted. The benefits of this type of approach include a built in lead time (that period during which the product is not available for export), simplified policing (no trade is allowed on a given product for the given period of time), and preservation of economic equity (after the designated period, anyone is allowed to compete for sales on an equal footing). At the same time, because availability is guaranteed after the specified period, there is less incentive on the part of those to whom these restrictions apply to take the steps necessary to develop a domestic source.

15 Monitoring could serve several functions. First, having a better idea of exactly what visiting scholars are working on, could not only serve to identify possible violations to western guidelines, but might serve to identify those people and areas where western researchers and scientists could benefit from the nature of this work. Second, the mere fact that more attention is being paid to this area might serve to limit those actions that go against existing restrictions and guidelines. Finally, an accurate idea of the work being conducted in the Soviet Union would help to identify the existing level of its capabilities, and thus serve as a guide to future actions designed to modify the export regime, should they be needed.

APPENDIX A

EFFECTIVENESS OF TECHNOLOGY TRANSFER ACCORDING TO INDUSTRY AND TRANSFER MECHANISM

TRANSFER EFFECTIVENESS	INSTRUMENTATION	SEMICONDUCTOR	JET ENGINE	AIRFRAME	TRANSFER MECHANISM	
HIGHLY EFFECTIVE (TIGHT CONTROL)	H	H	H	H	TURNKEY FACTORIES	ACTIVE
	H	H	H	H	LICENSES WITH EXTENSIVE TEACHING EFFORT	
	H	H	H	H	JOINT VENTURES	
	H	H	H	H	TECHNICAL EXCHANGE WITH ONGOING CONTACT	
	H	H	H	H	TRAINING IN HIGH-TECHNOLOGY AREAS	← DONOR ACTIVITY
	MH	H	M	M	PROCESSING EQUIPMENT (WITH KNOW-HOW)	
EFFECTIVE	M	H	MH	MH	ENGINEERING DOCUMENTS & TECHNICAL DATA	
	M	H	MH	MH	CONSULTING	
	M	MH	M	M	LICENSES (WITH KNOW-HOW)	
MODERATELY EFFECTIVE	L	L	M	M	PROPOSALS (DOCUMENTED)	
	L	MH	L	L	PROCESSING EQUIPMENT (W/O KNOW-HOW)	
	L	LM	L	L	COMMERCIAL VISITS	
LOW EFFECTIVENESS (DECONTROL)	L	L	L	L	LICENSES (W/O KNOW-HOW)	
	L	L	L	L	SALE OF PRODUCTS (W/O MAINTENANCE & OPERATIONS DATA)	
	L	L	L	L	PROPOSALS (UNDOCUMENTED)	
	L	L	L	L	COMMERCIAL LITERATURE	PASSIVE
	L	L	L	L	TRADE EXHIBITS	

L = Low Effectiveness

LM = Low to Medium Effectiveness

M = Medium Effectiveness

MH = Medium to High Effectiveness

H = Highly Effective

Source: "AN ANALYSIS OF EXPORT CONTROL OF U.S. Technology - A DOD PERSPECTIVE" p. 6.

APPENDIX B

QUARTERLY NUMBER OF NEW JOINT VENTURES IN THE SOVIET UNION AND THE VALUE OF INVESTMENT BY FOREIGN PARTNERS

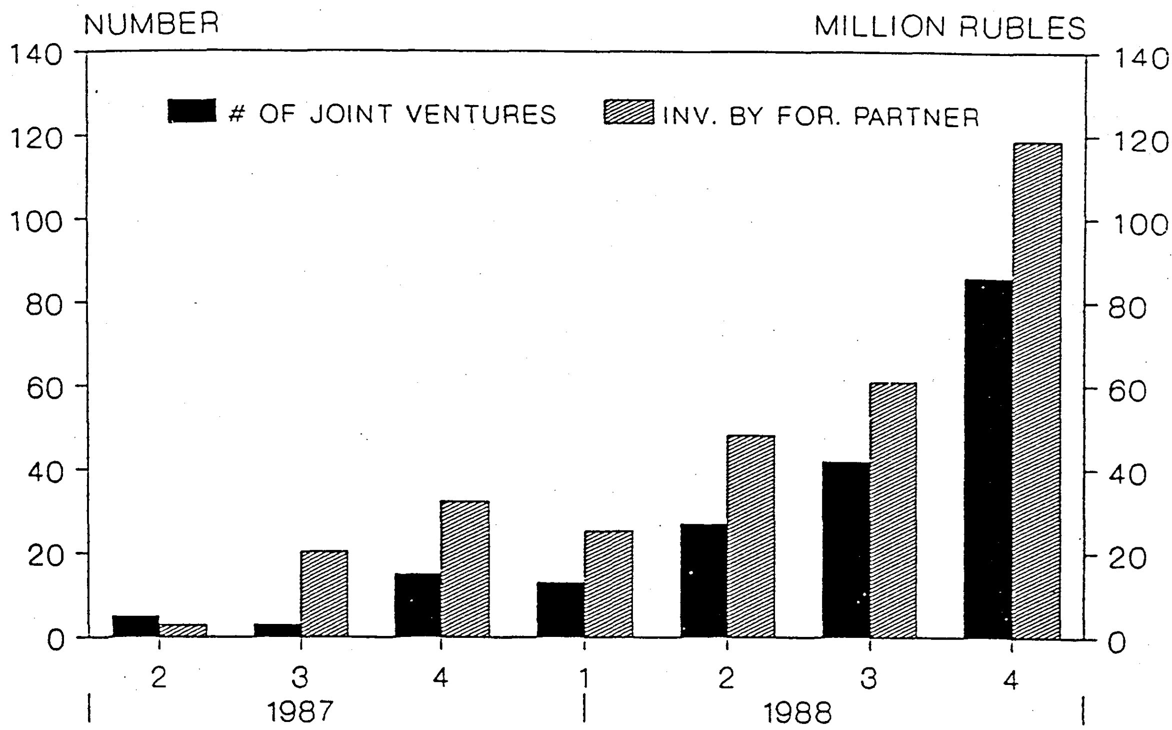

TABLE 3 -- REGISTRATION OF SOVIET JOINT VENTURES AS OF MID-JANUARY 1989, BY QUARTER

	Frequency		Capitalization			Ave. share of foreign partner in capital in percent	Value of foreign investment		
Registration Period	Number	Share in percent	In million rubles	Share in percent	Average size in mil. R.		In million rubles	Share in percent	Average size in mil. R.
Total	205	100.00	873.052	100.00	4.259	38.37	335.003	100.00	1.634
1987-Q2	5	2.44	6.150	.70	1.230	47.02	2.892	.86	.578
1987-Q3	3	1.46	59.089	6.77	19.696	34.50	20.387	6.09	6.796
1987-Q4	15	7.32	94.031	10.77	6.269	34.34	32.293	9.64	2.153
1988-Q1	13	6.34	67.548	7.74	5.196	37.35	25.228	7.53	1.941
1988-Q2	27	13.17	118.951	13.62	4.406	40.54	48.220	14.39	1.786
1988-Q3	42	20.49	151.765	17.38	3.613	40.17	60.963	18.20	1.452
1988-Q4	86	41.95	307.389	35.21	3.574	38.63	118.737	35.44	1.381
January 1989	14	6.83	68.130	7.80	4.866	38.58	26.283	7.85	1.877

Source: <u>PlanEcon Report</u>, vol. V, nos 10-11-12, 24 March 1989, p. 6.

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APPENDIX D

СОВЕТСКО-БОЛГАРО-ФИНСКОЕ
СОВМЕСТНОЕ ПРЕДПРИЯТИЕ
НОВЫЕ ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ

119517, Москва, ул.Нежинская, 13
тел. 442-57-92
телекс 411080 STYLE
телефакс 9430072

SOVIET-BULGARIAN-FINNISH
JOINT VENTURE
NEW INFORMATION TECHNOLOGIES

13, Nezhinskaya st., Moscow, 119517
tel. 442-57-92
telex 411080 STYLE
telefax 9430072

__________ N __________
На N ________ от __________

Novintech Soviet-Bulgarian-Finnish Joint Venture proposes to your firm mutually advantageous cooperation in the field of information technologies

Letterhead from the Computer Joint Venture "Novintech"

Source: New Information Technologies

APPENDIX E

US-USSR Trade: 1978-1989

(Millions of Dollars)

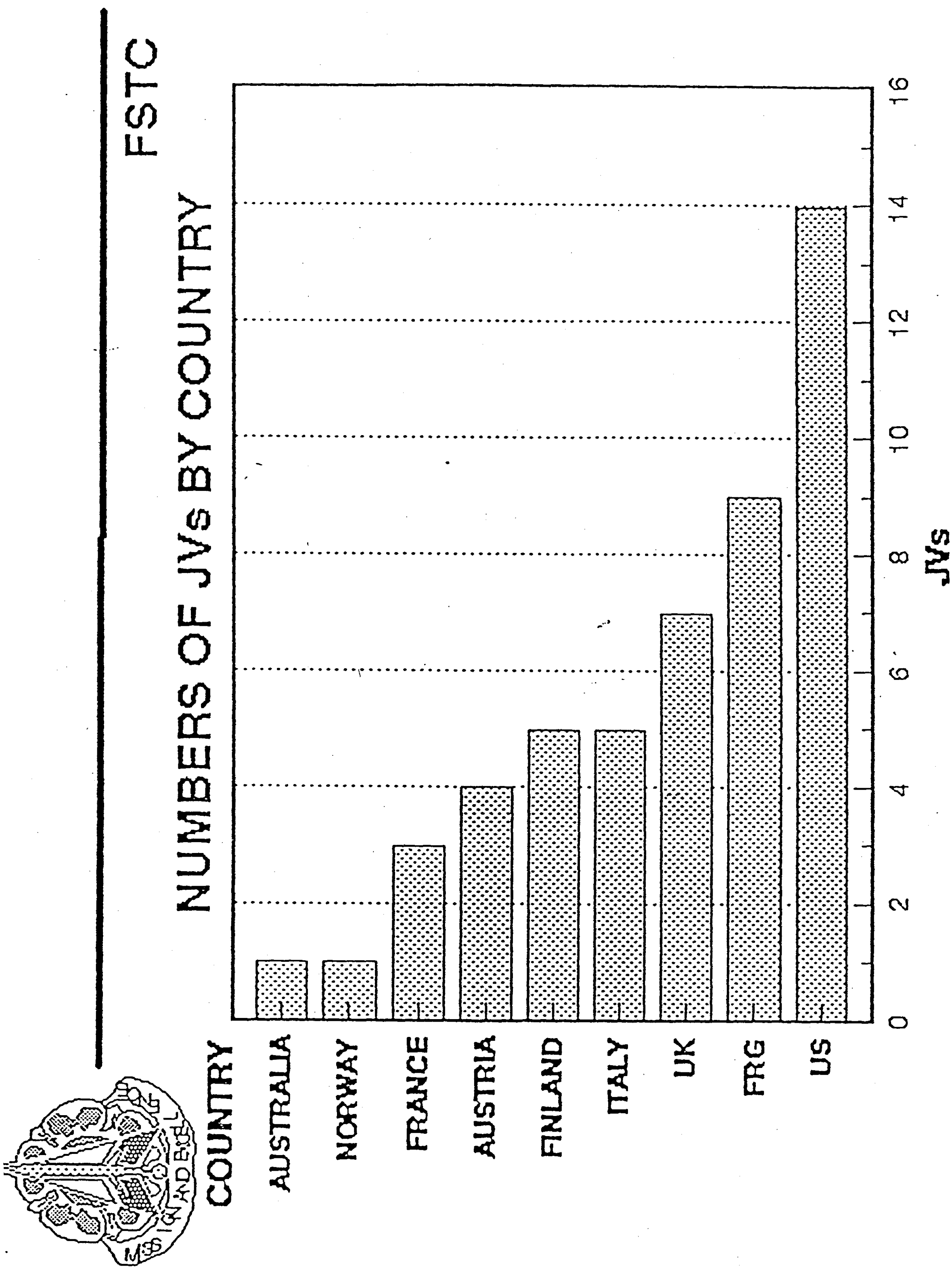
US Exports (F.a.s)

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Total	2,252	3,607	1,513	2,340	2,593	2,003	3,284	2,423	1,248	1,480	2,768	4,271
Agric	1,687	2,855	1,047	1,665	1,855	1,457	2,817	1,864	648	923	2,162	3,437
Non Agric	565	742	466	675	737	546	467	559	600	557	606	835
US Imports for Consumption (c.i.f.)*												
Total	530	873	463	387	248	367	602	443	605	470	649	703
Agric	13	15	10	12	11	11	11	9	16	22	20	21
Non-Agric	517	858	452	375	237	356	591	434	589	448	269	682

*Customs value for 1978-1979

Source: U.S. Census Bureau, U.S. Department of Commerce

MATERIAL REDACTED AT REQUEST OF UNIVERSITY



Computer Joint Ventures with the Soviet Union, by Country, for 1989

Source: U.S. Foreign Science and Technology Center

MATERIAL REDACTED AT REQUEST OF UNIVERSITY

Non-Immigrant Visas Issued to Applicants from the Soviet Union Under the SPLEX BUSVIS, and Private Visitors Provisions Fiscal Years 1980–1989

Visa Class	Definition	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
B–1	Temporary visitors for business	1,728	1,634	1660	2,070	1,169	1,190	1,774	2,602	5,829	12,910
B–2	Temporary visitor for pleasure	4,077	2,342	2,570	2,350	1,743	2,154	2,999	5,479	21,512	37,828
B-1/B-2	Temporary visitor for pleasure and pleasure	13	37	70	48	49	62	148	146	251	349
TOTAL B		5,818	4,013	4,300	4,468	2,961	3,406	4,921	8,227	27,592	51,087
F–1	An applicant seeking entry temporarily and solely for the purpose of pursuing a full course of study at an institution approved by INS on behalf of the Attorney General	–	2	5	12	6	8	5	4	9	56
F-2	Spouse or child accompanying an F–1	–	3	1	2	4	4	3	4	2	5
TOTAL F		0	6	5	6	14	10	8	8	11	61
H-1	A temporary worker who is of distinguished merit and ability	–	40	39	11	10	14	538	728	1,126	2,256
H–2*	Applicant to perform temporary services or labor, if unemployed persons capable of performing such service or labour cannot be found in this country	–	0	0	0	0	1	0	1	9	–
H–2A*	Temporary worker performing agricultural services unavailable in the US										4
H–2B*	Temporary worker performing other services unavailable in the US										87
H–3	Applicant coming as a trainee	–	1	0	0	0	0	1	0	–	–
H–4	Accompanying spouse and/or child	–	0	3	2	0	5	7	5	6	41
TOTAL H		52	41	42	13	10	20	546	734	1,141	2,388

* For 1989 petition filed prior to June 1,1987

Continued

Soviet Visa Applications to the United States, by Type, 1980 to 1989

Source: U.S. Defense Intelligence Agency

Continued

Non-Immigrant Visas Issued to Applicants from the Soviet Union Under the SPLEX BUSVIS, and Private Visitors Provisions Fiscal Years 1980–1989

Visa Class	Definition	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
I	Representative of foreign press, radio, film or other information media	177	37	36	32	34	16	153	111	226	348
J–1	An applicant who has been accepted to participate in an exchange visitor program designed by USIA	–	175	145	128	93	104	328	293	637	1.030
J–2	Accompanying spouse or child	–	5	38	32	5	62	10	14	14	64
TOTAL J		**234**	**180**	**183**	**160**	**98**	**166**	**338**	**307**	**651**	**1,094**
L–1	Intra-company transferee	–	21	23	30	9	14	65	49	63	75
L–2	Accompanying spouse or child	–	25	33	17	22	21	95	52	75	91
TOTAL L		**144**	**46**	**56**	**47**	**31**	**35**	**160**	**101**	**138**	**166**

Note: A small number of the above total were issued by third country posts to Soviet nationals who, although they continued to retain their Soviet passports, no longer reside in the Soviet Union e.g., Soviet national married to third country nationals

Soviet Visa Applications to the United States, by Type, 1980 to 1989

Source: U.S. Defense Intelligence Agency

Computer Advertisement in Izvestiya, "IBM for Rubles"

Source: Izvestiya, 14 February 1991, p. 8

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