The Heritage Foundation Backgrounder

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THE STRATEGIC DIMENSION OF THE U. S. COMPUTER EXPORTS TO THE U.S.S.R.

I. Introduction

The ongoing controversy, in the U.S. government and in the media and industry, over the sale of one of the largest and most advanced computer systems in the world to the Soviet Union focuses upon one of the most sensitive aspects of U.S. - Soviet commercial relations: the transfer of one of the most critical technologies and its products, both of which are of paramount importance in effective military systems and sophisticated intelligence operations.

The Cyber 76 is a "super-computer" developed by the Control Data Corporation of Minneapolis, Minnesota. It is a scientific marvel, processing up to 40 million operations per second and estimated to be at least 40 times faster than the best Soviet computer and some 12 to 15 years ahead of the best indigenous computer system in the U.S.S.R. and its satellite countries.

The Cyber 76 serves as the "brain center" of the Pentagon, of the U. S. Air Force, of the super-secret National Security Agency, of the ERDA (Energy Research and Development Administration), and of the National Aeronautics and Space Administration (NASA). What, then, can those officials of the State Department and the Commerce Department who favor the export be thinking when granting permission for sale of Cyber 76 to a state openly attempting to achieve military and technological superiority - and eventual control - over the U.S.?

Those in favor of the deal insist that the Cyber 76 will be used by the Soviet communists only to process weather forecasting data. They do concede, however, that the computer has a critical strategic capacity as well.

Proponents of the export also argue that there will be a system of controls designed to make sure that the Soviet Union does not divert Cyber 76 to military purposes. One such control would be the on-site monitoring by one or two Control Data technicians. CDC, however, so far has sold about 50 large computer systems to the Soviet bloc, and only in one instance does the system have on-site inspection.

The majority of computer experts - inside and outside the government - have expressed skepticism, however. A typical statement comes from Ray Chapman, director of the International Security Agency, ERDA, who remarked, "Because of the similarity between the meteorological and weapons modeling programs in calculational characteristics, it is not enough to just monitor the actual programs while they are going through the machine. It is necessary to look at the input and output data."

When confronted with Mr. Chapman's statement, the CDC representatives said that they will try to spot-check the memory and input and output data from the machine for possible Soviet violations. They admit, however, that the checks have to be only sporadic, because there would be a mountain of tapes requiring enormous storage facilities which were not available at CDC.

Congressman Robert Dornan directed a question to CDC's director for public relations as to what the CDC intends to do if the company discovers that the Soviets are cheating for this the CDC representative had no answer whatsoever.

Congressman Sam Stratton made an inquiry with the Pentagon regarding safeguards. He was informed that there are no adequate safeguards for Cyber 76 or any other advanced computer system.

The computer experts contend that Cyber 76 will provide the Soviet military with critical strategic capabilities which they presently lack. For example, the Soviets, with application of Cyber 76, stand to improve their SAM's effectiveness and as a result could neutralize our entire B-52 bomber force. Also, Cyber 76 could assist them to vastly improve their nuclear strategic force capabilities as well as to penetrate our military and intelligence computer networks.

Last fall, then, Secretary of State Henry Kissinger intervened in favor of export to the Soviet Union of Control Data's Cyber 73 computer system. He overruled the objections by the Pentagon and ERDA. He also overruled the Pentagon's and ERDA's objections to sale of two CDC Cyber 172 computer systems to Red China.

The objections by the Pentagon and ERDA were on the ground that both computer systems, the Cyber 73 and Cyber 172, were suitable for nuclear weapons calculations, for anti-submarine warfare, for large phased-array radar to track enemy ICBM's and for other military applications.

Today, the Department of Defense deploys close to 6,000 of the so-called general purpose computers. The same type of computers, however, could be used in a wide variety of civil applications from sciences to R&D in industry, to crime control and physchiatry.

Obviously, the national security implications of this trade are enormous. Concern in the United States had led the Defense Department's Science Board task force under the chairmanship of J. Fred Bucy of Texas Instruments to recommend restrictions on the transfer of strategic technologies - in which the U. S. enjoys a clear lead over the U. S. S. R. - to the communist superpowers and their satellites.

Six high-technology trade associations, however, vehemently disagreed with the position of the Defense task force. Their spokesman, Peter F. McCluskey, president of the Computer and Business Equipment Manufactureres' Association, has demanded that the U. S. Congress relax export controls for strategic goods and eliminate the Pentagon's role as one of the participants in the export control process. Mr. McCluskey argued, in his testimony before the House Committee on International Relations, "In civilian government such as ours, the control and administration must reside apart from the military."

Control Data's chairman and chief executive officer, William Norris, puts it more bluntly: "Our biggest problem isn't the Soviets, it's the damn Defense Department!"

The aforementioned discussion makes it abundantly clear that we have a serious issue facing the executive and legislative branches of our government. The issue is dominated by deep disputes among concerned parties, and at the heart of the problem is the question of how computers relate to the vital national security interests of the United States.

The purpose of this discourse is to shed light upon the problem by providing some grasp of computer technology, of its role in technological competition between the United States and the Soviet Union, and of its impact on the strategic balance between the two superpowers.

II. Technological Competition

With respect to national defense, the term "technological competition" refers to the efforts of competing politico-economic systems to maintain, or to achieve, superiority in high-technology areas that are important in effective military systems. The history of such a competition between the United States and the U.S.S.R. dates back to 1943 when the Soviet Union began its effort to develop an atomic bomb. The unexpected orbiting of the "Sputnik" earth satellite by the Soviets in 1957 shocked the United States and for the first time focused a broad public attention on the Soviet scientific and technological capabilities and objectives. This event also resulted in a rapid development of our own space science.

The competition between the United States and Soviet Union continued in all phases of manned and unmanned space programs and in the development of strategic weapon systems. In this era of unprecedented change, our technological strength is the key to our long-range survival as a nation.

In his statement before the Committee on Appropriations of the U.S. House of Representatives, Dr. Malcolm R. Currie, then Director of Defense Research and Engineering, stated:

> American security, like the American economy, stands on a foundation of technological superiority. We need superiority in defense technology. First, because the openness of our society tells our adversaries what we are planning in military technology while their secrecy forces us to provide for many possibilities. Second, in military operations we traditionally depend on superior quality to compensate for inferior numbers. Third, in order to interpret vital but fragmentary technical intelligence information, we must have extensive prior experience in the area.[1]

The United States continues to hold a technological lead over the Soviet Union in most critical areas vital to our national security. But that lead has been diminishing. In some very important areas, it is gone; the Soviets are ahead (e.g., directed-energy weapons based on laser beams or other charged particle beams - see Heritage Foundation Backgrounder #13).

Moreover, the technology balance is dynamic. In examining the current technology balance and its dynamics, the qualified analysts agree that the U.S.S.R. has a very large and determined effort and that the Soviets are inexorably increasing their level of technology relative to ours and are, in fact, seizing the initiative in important areas (e.g., already mentioned laser beam weapons, surface-effect vehicles, and anti-personnel pressure weapons).

The technological development is molding future Soviet strategy. From all indications, the future Soviet strategy will be world dominance, with technology as one of the key drivers.[2] A crucial element in our strategy of deterrence is the maintenance of a margin of military advantage through possession of a number of sophisticated technologies.

III. The Revolution in Warfare: The Computer Impact

There is considerable confusion today about the strategic importance of computers. Many analysts point out that numerous other technologies are revolutionizing warfare, such as giros, lasers, avionics, nucleonics,

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[1] The Department of Defense Program of Research, Development, Test, and Evaluation, FY 1975, 93rd Congress, Second Session, April 29, 1974 (U.S. Government Printing Office - 1974)

[2] For a useful discussion of the subject see Hearings before the Committee on Armed Services, U.S. Senate, 94th Congress, Second Session, on S. 2965, Parts 4, 6, and 11, U.S. Government Printing Office (Washington: 1976).

metallurgy and propulsion. This is true, yet in one way or another all emerging technologies, including computer technologies themselves, are dependent on computers. For example, the world's most advanced computer systems (e.g., ILLIAC IV, CDC STAR-100, Texas Instrument's ASC and Goodyear's STARAN IV) were built with the help of several large computer systems.

In short, today's emerging technologies are as dependent on computers as the technologies of the first industrial revolution were dependent on energy. Computers multiply man's brainpower with the same force that the first industrial revolution multiplied man's muscle power. Furthermore, computers, lasers, and nucleonics are inter-related.

Computers are as important and intrusive as the mathematics and the data processing systems required to conceive, build, and operate complex new machines and to create new materials. They are indispensable for the recording and interpretation of entire classes of observations. They make it possible to handle and quickly recall large numbers of information bits. They are part of communications and are needed for operations analysis. They assume production and distribution jobs and perform a nearly limitless number of other vital tasks.

Without computers modern weapons systems could not be built, integrated, tested, deployed, kept combat-ready and operated. In fact, weapons such as missiles, aircraft, tanks, high-performance satellite-based surveillance systems, ABM defense systems, and submarines incorporate computers as part of their armament. Avionics are intrinsically computer-linked, as is missile accuracy. Helicopters used against tanks are provided with computers and computer links to obtain the real time information needed for effective battlefield interaction.

In brief, there are no modern weapon systems that are not vitally dependent upon high-speed computers. A number of strategic missions are centered on high-performance computers; e.g., early warning systems, anti-ballistic missiles defense, command control-communications (C-3), anti-submarine warfare, space operations, and several branches of intelligence.

Computers are not just swift calculating machines. They are entire systems which include, in addition to the computers themselves, internal and external memory stores, testing and correction mechanisms, and peripheral equipment such as display units, input-output links, communications, and "software," i.e., the programming language and other aids that assist computer users to avail themselves of the machine. Big operational structures--for instance, a missile force or the meteorological and hydrological services--require several large general-purpose computers and special computers feeding the general-purpose machines, plus field computers on board mobile units such as ships, airplanes, missiles, and space vehicles. For these systems superior computer technology may also permit the achievement of superior military capabilities.

For example, in the Apollo program a fairly large computer was carried in the Saturn booster; one computer was housed in the command spacecraft, and two computers were attached to the lunar module. The launch site had a large computer installation, the vast tracking system contained many smaller and several large computers, and mission control had still another large installation. The Earth Resources Technology (ERTS) program would be useless without computers to handle and "enhance" the inputs from the diverse sensors carried on the satellite.

To summarize, computer technology permeates all phases of the development, production, operation, and support of modern military systems. Six dimensions can be nonexhaustively distinguished and illustrated.

1. Research and Development. Computers permit a major saving in time and resources. This is evident in the design of aircraft, missiles, and new warheads. Prototyping and laboratory study can be partially displaced, with the presumed result that a better device is achieved, although the temptation to over-engineer is rarely resisted.

2. Production. Computer-aided design and production processes and quality control improves the product, minimize waste, and lead to systems less apt to malfunction in an operational environment. The effect is to increase effectiveness by having more units operational.

3. Support and Maintenance. Electronic data processing again enhances effectiveness by providing a higher percentage of machines in an operationally ready state at any time, preceding both commitment to operations and recommitment after sortie recovery, at least for aircraft.

4. Onboard Computers. These devices permit one machine to do each of several missions better than a mix of simpler, mission-specialized machines. On board computers may permit targeting not otherwise possible, such as the redirection in flight of a missile to a target acquired during that flight. Certainly such computers lead to improvements in CEP (the missile accuracy).

5. Tactical Fragging. Effectiveness increases when the time of the cycle--target acquisition, designation, force commitment, ordnance loading, routing, communications, recovery--is decreased while its precision is increased. That is, forces not committed on a timely basis are in effect temporarily useless.

6. Command, Control, Communications (Strategic Fragging). It is evident that if a C^3 system deploys sensor systems which in real time can perform damage assessment, determine

residual enemy force posture, provide empty-hole information, perform boost-phase and midcourse tracking to determine own forces at risk, evaluate the evolving enemy main battle plan, exercise fingertip control over own forces, and reoptimize plans, then strategic force effectiveness increases because of more effective applications and less waste of combat capital.

IV. Computer Technology

The term "computer technology" is often used to mean only the hardware aspects of digital computers. In this report computer technology will be more broadly defined to encompass analog computers[1] (still widely used in the Soviet Union) and digital computer software. Including the latter accentuates the evident fact that any computer, no matter how capable, is of little use without equally capable software. Indeed, it is now recognized that in most large-scale computer applications, software design and production are far more difficult and expensive than hardware development and procurement. For example, IBM spends more on R & D effort in software than the entire computer industry does on development of hardware.

In this comparative analysis of computer technology in the United States and in the Soviet Union, reference will be made to various types of computer systems and architectures, computer and component generations, and computer characteristics. This section will define and briefly describe these terms.

There are several dimensions for classifying computers. On the basis of the environment in which they are designed to operate, there are:

* Commercial computers--manufactured for use in benign environments which are established to satisfy the computer's requirements for floor space, temperature, humidity, floor stability, and the like.

* Military computers--manufactured to be used in environments that are only partially controllable and consequently may be adverse to commercial computers. These systems may have to operate under a wide range of climatic conditions, in moving vehicles, unattended, and may be exposed to damaging nuclear radiation.

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[1]An analog computer is a computer that operates with numbers represented by directly measurable quantities (as voltage, resistance, or rotations).

[2]Kosy, D. W., Air Force Command and Control Information Processing in the 1980's: Trends in Software Technology, The Rand Corporation, R-1012-PR, June 1974

Both commercial and military computers may be further categorized as general-purpose computers, which are designed to handle a wide variety of computational tasks reasonably efficiently, and special-purpose computers, which are designed to optimize the computation of a specific class of tasks. Many militarized computers are special-purpose digital or analog computers.

The performance of a computer system, especially its processing speed, is a function of the architecture of the computer system and its hardware. One criterion for architectural classification of computers is the degree of parallelism in computation, expressed in terms of the number of concurrent instruction streams and data streams that the system can handle. Although there is a continuous evolution of architectural concepts, several architectures are sufficiently well established and widely used to warrant their description. Table 1 on page 22 lists these architectures and representative U.S. computers.

The ability to design and manufacture mini- and microcomputer systems represents an important milestone in the advancement of computer technology and warrants making a distinction in the subsequent analyses between "conventional" computers and mini- and microcomputers. The modifier "conventional" (e.g., conventional computer, conventional uniprocessor) will be used whenever the intention to exclude mini- and microcomputers is not clear from the context of the discussion.

Computer hardware and computer systems are often discussed in terms of components generations and computer generations. The former refers to the hardware used (components and their packaging), and the latter denotes both the architectural and software aspects of computer systems. On page 23 Table 2 illustrates one set of definitions of component and computer generations. As in any classification system, there are exceptions. Thus, the well-known CDC 6600 and Cyber 76 computers use second-generation software technology to implement third-generation architectures and software capabilities.

Finally, while the above classification dimensions set a framework for comparisons of computer technology in the United States and the Soviet Union, it is also useful to indicate more specific quantifiable computer system characteristics. The following are important descriptors of computer hardware characteristics:

Processing speed. The raw (maximum possible) computing speed in terms of instructions processed per second for a particular mixture of short and long instructions. Processing speed is a function of component speeds, the algorithms or instructions used in the mix, and the processor and memory architectures. Usually expressed in terms of MIPS (millions of instructions per second).

Data processing rate. The product of the processor word length in bits and the processor cycle time (usually the time for short instructions).

Expressed in bits per second, this measure removes the variations due to different word lengths, but hides the precision of the results.

Random-access (and mass) memory size in terms of bits, bytes, or words, the maximum data transfer rate of the memory device, and the access time of a request to the memory device to obtain a word or a block of words. These characteristics depend on the type of memory device and its architectural features.

Viability. Aspects of viability are: reliability (in probabilistic terms of mean time between failures, MTBF); availability when needed; maintainability when applicable; and ruggedness when subjected to substantial environmental variations or hazards.

Physical attributes. The size, weight, power consumption, and cooling requirements of the computer system.

For the input-output peripherals, the principal descriptor is the maximum data rate, terms of bits per second, that they can produce or accept.

Software characteristics are more difficult to quantify. They depend on the system's architecture (available instructions and other capabilities that are implemented in hardware or firmware, e.g., using microprogrammable control units), users' capabilities that are provided (e.g., resource sharing, interactive terminals, security), and applications that are to be supported (e.g., real time input from other systems or data collection devices). It is also important to note that it is the software efficiency that determines what fraction of the potential hardware speed of a processor will actually be achieved, and that the lack of software reliability is a major reason why systems seldom meet their planned operational capability dates.[1]

One very crude but common descriptor which reflects the general level of computer applications in a country is the total number of installed and operational computers.[2]

V. U.S. and Soviet Computer Technologies

American Computer Technology - Computer technology in the United States made substantial advances into the fourth generation--nearly all new

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[1]Cyber 76 and its software are a very good example of a computer with given capacity to process 10 to 12 MIPS, and in fact with special software, the processing speed can reach 40 MIPS.

[2]Such totals are useful for assessing the computing capability a country possesses only if one takes into account the difference in performance characteristics or the efficiency of their use.

conventional, uni- and multiprocessors can support resource sharing by multiple users from remote terminals, provide hardware features for implementing virtual memory and virtual processor operating systems[1], use microprogramming techniques, and use advanced semiconductor integrated circuits and memory units.

The minicomputers of the late 1960's have become minicomputer systems with complete sets of terminals, auxiliary storage in the form of magnetic tape cassettes and "floppy" disks (inexpensive, phonograph-record-like storage units), and software that includes compilers and operating systems. The cost has decreased steadily while performance has improved. For example, minicomputer kits may be bought for $300 and hand-held scientific "slide-rule" calculators for $90.

Microprocessor chips are being manufactured in vast quantities for inclusion into other types of systems; stand-alone microcomputers are also emerging.

The very large capacity computers whose design was begun in the late 1960's (e.g., ILLIAC IV, CDC STAR-100) are now in operation and have been joined by others that are commercially marketed (e.g., Texas Instruments' ASC and Goodyear's STARAN IV). The DARPA[2] computer network has expanded to include over 40 disparate computer systems (including the ILLIAC IV) that are connected by landline, radio, and satellite communications links. Several other computer networks have been established and are being expanded.

By 1976 the United States already operated about 150,00 general-purpose computers (80% of which are third- and fourth-generation systems).

Soviet Computer Technology - By contrast, the U.S.S.R. is believed to have had by 1976 about 16,000 computers (80% of which are first- and second-generation machines), virtually all of which were allocated to the military and arms industry, and to some extent to scientific institutions. Of course, without a substantial capability Soviet equipment could not have reached the moon, Venus, and Mars; and the Soviets could not have developed a MIRV capability. But there are strong indications that a large number of Soviet computers are obsolete and obsolescent; Soviet computer memory devices are inferior; peripheral equipment is poor; software is inadequate; time-sharing is poorly organized; and parallelism and multiprocessors are in developing stages.

Computer technology in the Soviet Union is virtually entirely imported from the West. In the early 1930's, the U.S.S.R. was importing unit record equipment manufactured by Powers and Hollerith. The SAM business machine plant was established in Moscow in 1932 with Western assistance,

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[1]Virtual memory is a particular hardware-implemented memory addressing system; a virtual processor is a software capability in which each user may be served by a separate operating system.

[2]DARPA - the Defense Advanced Research Projects Agency.

and it began to produce copies of Western machines. This practice of copying earlier models of Western machines continues to the present time although Soviet modifications of the Western models are now more frequent, so that the copies are not as faithful as they once were.

The list of computer technological advances pioneered in the West that made their appearance in the Soviet Union after a lag of from three to twelve years is rather lengthy. The point to be made is that literally all significant technological innovations in computer technology have occurred in the West. Advances in Soviet computer technology have been without significant exceptions, direct transplantations. Obviously, this may not always be the case. If computer technology in the U.S.S.R. receives the required technological input from the West, and if the Soviet authorities decide to elevate it high on the scale of priorities --and that appears to be the case--it is reasonable to expect that there will be independent Soviet contributions to this technology.

There are several significant features of Western computer technology that the Soviets have failed, thus far, to acquire. The first of these is the technique of large-scale mass production of high quality computer components, subsystems, and systems. For all practical purposes, each better quality Soviet computer is a custom-made item. A second element that the Soviets have yet to master is reliability engineering and quality control. Third, but certainly not least, the Soviets have yet to inject into their computer industry the kind of creative dynamism so characteristic of the Western computer scene.

In computers the Soviet Union is 10 to 12 years behind the U.S. in developing its own hardware technology, and 10 to 15 years in software. This is a narrower gap than in the past, but they remain particularly weak in the technologies of mass storage, microelectronics, and in systems design and software. In certain areas of software, however, they are only 6 to 8 years behind the U.S. due to the confusion in our export control legislation which has permitted the Soviets to legally obtain U.S. software exports. Soviet integrated circuits appear to be improving, also due to the fact that they were able to obtain the necessary technology and know-how from the West, but they are still about 8 to 10 years behind the leading edge of U.S. technology.

However interesting Soviet work on the theory of automatic programming may be, it has not contributed to software that would economize programming time and make computers more accessible to more users.

Almost precisely thirteen years ago, one of the highest officials in the USSR Academy of Sciences in Moscow leaked to a Western scientist the Soviet decision to proceed with development of a family of third-generation computers closely patterned after the IBM/360. The working name for the project was RYAD, which is the Russian word for series. It should be noted that KGB agents, in the middle 1960's, succeeded via covert means in procuring several IBM/360 series computers, their manuals, blueprints, and specifications from IBM facilities in West Germany. These systems served as the models for production of RYAD series.

The Soviets and their COMECON partners decided that the RYAD hardware and software should be compatible with IBM and most other Western computers. This provided them with the benefit of IBM-compatible hardware and software around the world to aid their own computer effort.

Several years went by before any mentions of the ambitious undertaking were seen in the Soviet technical literature. The "official" version of the Unified System (US) development history places the date of decision to proceed in December 1969. Clearly, this is at least five years after the fact. The 1969 reference point actually refers to the signing of a multilateral agreement between the U.S.S.R, Bulgaria, Hungary, East Germany (GDR), Poland, and Czechoslovakia to cooperate on the ES (RYAD) project. More recently Cuba has been included, but it is believed that Cuba's role is highly limited. Most probably, Cuba will be accorded "most favored nation" status in purchasing ES equipment.

During the first two years of the 1971-75 five-year plan (1971-1972), there were many indications that announcement of the ES computers was imminent. At the same time, there were persistent reports of problems and delays; at least one firm deadline had to be pushed back. By the end of 1972, considerable dissension had cropped up among the East European participants, and it is possible that some members were on the verge of bolting, preferring to turn to Western imports in order to satisfy critical needs for modern computers.

By this time, the ES-1010 and ES-1020 computers had already been announced. However, they were "back door" announcements, brief statements of fact rather than a formal unveiling of a complete family of machines. These two machines reportedly went into production in 1972.

Also in 1972, the Czechs successfully tested a prototype of the 1021 machine (referred to at that time as the ES-1020A), and the Soviet version of the 1030 was approved for production. The Polish ES-1030 may not even yet be in production.

There were reports several years ago that the formal announcement of the series would be made with considerable fanfare. A massive display of the entire range of units in operation would be accompanied by lavish, fully-descriptive color brochures, and computer experts from all over the world would be invited.

The actual event took place in May 1973 with little advance publicity, no special fanfare, no color brochures, and very little of the displayed equipment in operation. (A notable exception was the East German display, which dazzled visitors with whirling tapes, blinking lights, and on-the-spot horoscopes.) Most significantly, the top machines in the series, the ES-1050 and the ES-1060, were missing. The Soviets openly admitted that they were (and still are) far from completion.

According to the intelligence sources, the Soviet nuclear weapon design and development facilities are still waiting for arrival of their first ES-1050 and ES-1060 computer systems. All the evidence at this point suggests that the Soviets have failed in their effort to develop and mass produce reliable high-speed third-generation computer systems.

The best Soviet computer produced in series so far is BESM-6, which was introduced in 1967. The BESM-6 boasts 32K (50 bits) of 0.8 sec core storage and has 16 registers operating at 300 nano-seconds. It uses two instructions per word and reportedly has five levels of instruction "look ahead." It is capable of simultaneously processing several programs and makes extensive use of overlapping various operations, such as storage accessing, arithmetic, and I/O (input/output) control. These features give the BESM-6 a capacity of 300,000 to 500,000 operations per second.[1]

Some of these machines have been sold to India, Pakistan, Afghanistan, and Eastern European countries, which lack hard currency to buy more advanced equipment from the West or Japan. One must stress, however, that the Soviet capacity to produce BESM-6 is limited to about 35 machines per year, that demand for them within the U.S.S.R. and its bloc considerably exceeds supply, and that at least 14 different machines in the United States, the United Kingdom, Germany, France, and Japan in 1967 were vastly superior.

Table 3

A COMPARISON OF THE ARITHMETIC CAPABILITY OF SOVIET BESM-6 COMPUTER WITH THAT OF EARLIER AND MORE POWERFUL AMERICAN COMPUTERS

Computer and Year	Years Since Appearance of American Computer at Least as Powerful	Number of Times the Most Powerful American Contemporary Computer is More Powerful
BESM-6 (1967)	2 (IBM 360/75) 1.5 MIPS	16 (IBM 360/90) (1967)
300,000 MIPS	3 (CDC 6600) 3 MIPS	40 (CDC Cyber 76) (1968)

The Soviet Union has only a few domestic minicomputer models in production (a situation similar to that in the United States in 1965-1966). No capability to produce microcomputers outside the laboratories is evident from the open Soviet computer literature.

[1]The officially rated capacity for BESM-6 is 1 million MIPS; however, because of its relatively small and not expandable 32K word storage the BESM-6 is able to achieve only about 300,000 to 500,000 MIPS.

BESM-6 computers (introduced in 1967) will continue to be the highest speed Soviet computers until the RYAD ES-1060 model becomes available (possibly in 1978) or the rumored BESM-8 (or BESM-X) is produced. Although the establishment of statewide networks of computers is a major Soviet objective, none is known to exist. Experiments with local multicomputer systems have been made, and some are in use.

To summarize, the Soviet Union's new general-purpose computing systems (RYAD) lag by at least a generation behind the new systems in the United States, but they nevertheless provide a step-function improvement of Soviet computer capabilities. In microcomputers and very high-speed computers, the Soviets have nothing that can be compared with U.S. capabilities. (See Figure 1, page 15).

The testing and deployment of Soviet MIRVs suggests an improvement of the U.S.S.R's computer capability: starting with 1973 tests, Soviet boosters carried on-board computers for the first time, but what general-purpose computers were used to back up the MIRV program is not known.

The important point is that, so far as we know, all presently deployed Soviet ICBMs were built on a computer technology corresponding to the U.S. technology of the early 1960s. They are tied to ground-controlled guidance systems based on relatively low capacity computers. The system will certainly be upgraded, but there are limits to such improvements, especially if the new computers still are not up to date and may not be available in sufficient numbers.

VI. Technology Transfer Mechanisms

In view of the fact that it is unable--by relying on its own resources--to bridge the computer gap between itself and the West, the Soviet Union is intensifying its efforts to obtain large computer systems, miniaturized computers and computer manufacturing technology from the West. The RYAD system itself is, of course, an example of adopting a Western computer design. At present, Western manufacturers are more than willing to sell their wares in the Soviet Union and other Soviet bloc countries, make licensing agreements, install complete manufacturing plans, and launch development efforts jointly with these governments. The only real obstacles to these efforts, no matter how many loopholes were in the system, were the export controls (under the old Trading with the Enemy Act and Export Control Act) placed on computer systems of certain size and associated equipment by CoCom (Coordinating Committee, composed of the United States, NATO nations, and Japan) and the U.S. Export Administration Office at the Department of Commerce with its interdepartmental committees. As might be expected, the current export control policies are considered too restrictive by the U.S. computer and electronic industry; on the other hand, the export control procedures were brought into jeopardy under

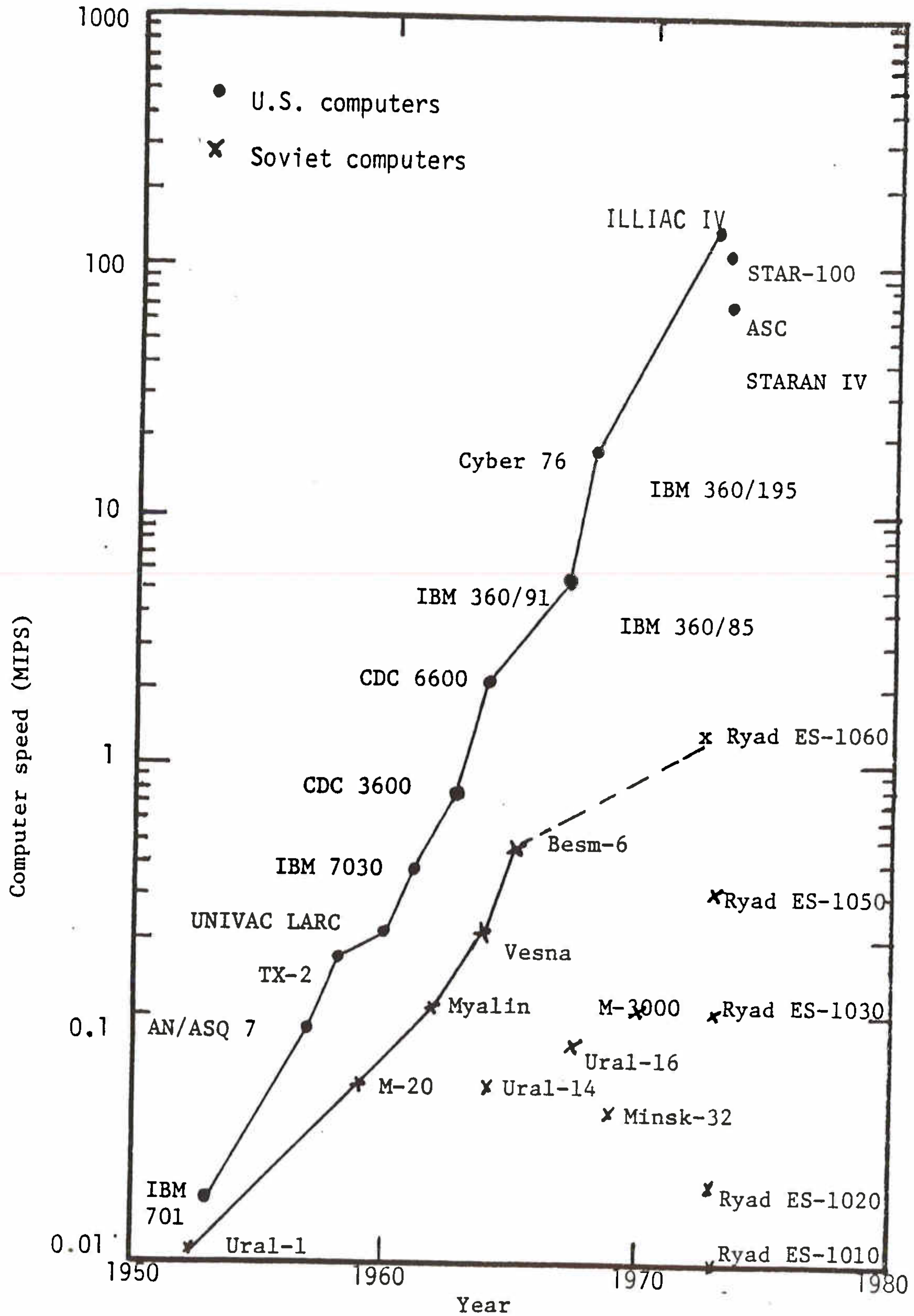

Figure 1 -- Comparison of U.S. and Soviet computer speeds

Kissinger's policy of transferring sophisticated technology and its products to the COMECON nations.

Three aspects of technology transfer are involved in the export control question: (1) transfer of products, (2) transfer of manufacturing capability (e.g., manufacturing and testing equipment or entire factories), and (3) transfer of design and manufacturing technology and know-how. The third forms a base on which the receiving country can build its own research, development, and manufacturing capabilities. All three aspects are involved in exporting computer technology to the Soviet Union and other communist-dominated countries.

In the first type of technology transfer--exporting complete products such as computers, peripherals, and components--the CoCom export restrictions and the relevant U.S. legislation (Export Administration Act) resulting in the export control procedures until a year ago applied to computers above a particular processing capability, semiconductors and computer testing and producing equipment. Officially, no computers in the IBM 360/50 class and larger could be exported to the communist-dominated countries. However, exceptions were made as a part of Henry Kissinger's detente policy. For example, about 50 CDC scientific computers have been exported to the Soviet Union and other COMECON countries. Among them were CDC 6200 and CDC 6400 computer systems, CDC Cyber 73, CDC Cyber 172 and other computer systems. From IBM, systems 360/50 and 360/65 have been exported, as well as the fourth-generation machines such as IBM 370/145, 370/155, and 370/158 computer systems.

The export of large computer systems will not only provide the Soviet Union with additional computing capacity in the military and nonmilitary spheres; but also will enhance Soviet strategic capabilities across the board. Where they will serve the civilian sector, they will free domestic computers for the military sector. The more serious computer technology transfer starts with licensing the Soviets to manufacture components, peripherals, memories, and computers, since this involves all the information for the manufacture of these devices (such as drawings, manufacturing techniques, tooling specifications), as well as assistance in setting up production lines. In some cases, such a licensing agreement involves the sale of production machinery as well. In other cases, a great deal of technical information is provided to the Soviet ministries by the Western firms in bidding for a contract and negotiating trade arrangements. The U.S. government has little information about what goes on under such agreements.

Another mechanism for transfer of technology is the technical exchange agreement, involving both the government and private sectors in the West with appropriate ministries in the U.S.S.R. For example, the Soviet Ministry of Science and Technology concluded a ten-year agreement with Control Data Corporation of Minneapolis, Minnesota, in October 1973. The agreement covered cooperation in a wide range of projects, including joint development of a new super computer, a joint peripheral manufacturing venture, and a nationwide time-sharing service and software development in the U.S.S.R.

Examples of the current rush to make arrangements with the Soviet Union and other COMECON governments include the following:

* Competition by several sets of U.S. and Western European companies for the contract to install computerized air traffic control systems in the Soviet Union. Participants are Sperry-Rand Univac and Raytheon, IBM and Thomson CSF of France, Lockheed Electronics and ITT, and Selenia of Italy and Saab of Sweden. Univac has been reported to be one of the finalists, with a proposal to install Arts-3 automated radar terminal systems now used in the United States. The other finalist is the Selenia and Saab team. IBM proposed to use triplex 360/65 computers as a part of its system.

* Competition to install electronic telephone exchange systems in the Soviet Union by ITT, CIT of France, Ericson of Sweden, Siemans of West Germany, and the Nippon Electric and Hitachi team of Japan. The ITT proposal would first sell the ITT 3200 processor, then license the Soviets for eventual production. (ITT has also signed a contract to install an electronic telephone exchange in Moscow; the export license is still pending.)

* Broadly worded agreements on scientific and technical cooperation with the Soviet State Committee for Science and Technology have been signed with some 30 to 40 U.S. firms. Among these are:

  -- Lockheed Corporation (navigation systems, oceanographic apparatus, air traffic control systems).

  -- ITT (telecommunications systems, electronic and electro-mechanical components).

  -- General Dynamics (telecommunications, computer-operated microfilm equipment).

  -- CDC (a possible joint venture for the development of an advanced computer and operation of a computer communications network. The computer would be based on advanced Soviet design and the prototype would be built in the Soviet Union with CDC assistance).

  -- Singer Business Machines (exchange of information and joint development in computers and electronic instruments).

  -- Sperry-Rand (to market Univac products in the Soviet Union).

Joint development agreements can be signed by a U.S. firm without approval, but the actual exports must be approved.

A number of U.S. firms have made arrangements to provide the Soviet Union with licenses to manufacture Western equipment or with actual turn-key manufacturing plants or are waiting for export licenses:

* CDC has signed an agreement with Romania to produce 1200-card/min readers, 250-card/min punches, and 200-line/min line printers. Romania will provide the capital, plant facilities and production equipment, and CDC will provide expertise and technical assistance.

* CDC has an agreement pending to manufacture 100-megabit disk memory units in the Soviet Union.

* Fairchild Camera and Instrument Corporation's agreement to set up a MOS, p-type semiconductor micro-circuit manufacturing plant in Poland is waiting for an export license. These circuits are regarded as inadequate for high-speed computers, but the contract also would include transfer of any new technology developed in the next five years.

* Westinghouse Electric is constructing a factory in Poland for the production of semiconductor rectifiers.

* Dataproducts, Inc., has made an arrangement with Videotron of Hungary to supply line printers; parts of printers would be assembled in Hungary, and Videotron would later be licensed to manufacture some of the parts.

The adoption by the Soviets of the IBM System 360 design for their Ryad family of computers represents another form of design information transfer. Such information is readily available from manufacturers in the United States. Indeed, the Soviets may be developing a considerable level of expertise in transferring Western designs into their own systems--it is rumored that IBM System 370 designs will be implemented in the Soviet Ryad-2 computers that are now being planned.

The United States component and computer industry is very interested in the Soviet and Eastern European market, which generates pressure on the U.S. Office of Export Administration to relax restrictions or make exceptions. At the same time, there is concern over transfer of technologcal expertise and know-how that, in the long run, may contribute to Soviet military capabilities. That this concern was shared by the U.S. Congress was evident in the 1974 extension of the Export Administration Act and in the Defense Authorization Act for FY 1975, both of which contain provisions authorizing the Secretary of Defense to recommend against proposed exports to a communist nation if it would increase that nation's military capabilities. If the President failed to follow the Secretary's recommendation, Congress, by majority vote within 30 days, could overrule the President. Thus, at the time, the Export Administration Act extension further strengthened the export control role of the Defense Department.

However, the 1976 extension of the Export Administration Act, which was vetoed by former President Ford in September of 1976, already demonstrated a change in the mood of Congress regarding the exports to the communist-dominated countries.

VII. Ineffectiveness of U.S. Controls

The U.S. control system is also ineffective because it lacks overall policy guidance. The current U.S. laws and regulations covering technology transfer to communist nations amplify the conflict between the need for control and the traditional American free trade posture. The basic U.S. law controlling our exports is the Export Administration Act of 1969 as amended by the Equal Export Opportunity Act of 1972. This law authorizes the Department of Commerce to control commercial exports to any nation for reasons of short supply, foreign policy, or national security. The mandate affecting exports to communist nations calls for promotion of trade and technology transfer to the maximum degree consistent with national security considerations.

U.S. trade policy is generally oriented to trade promotion and minimum regulation, as evidenced by the Trade Expansion Act of 1969 and, prior to that, the so-called Kennedy Round negotiations. The United States Senate seems to be encouraging this trend with respect to communist nations. The recently passed Senate version of the Export Administration Act, S. 69, would eliminate the distinction between communist countries and non-communist countries in our export control policy, seeking instead to focus on the national security implications of exports regardless of the country to which they are exported.

This conflict between our traditional free trade approach and our need for controls for national security purposes is resolved by the Office of Export Administration, Commerce Department, on a case-by-case basis in today's environment. The decision as to whether to grant a license for export of an item on the Commodity Control List is generally subject to interagency deliberations.

The negative impact of today's export controls on commercial trade is not so much due to overly restrictive controls on the transfer of technology and critical products. Instead, it is caused by lack of clearly defined objectives and by a control list administration that is excessively concerned with splitting hairs over product performance specifications and end-use statements. This current practice results in overloading the administrative staff, excessive delays in processing licenses, ambiguities between the U.S. and its CoCom allies, and an almost impossible burden on enforcement agencies.

Over the past five years, the Department of Defense has not assigned adequate resources to define U.S. control objectives. Instead, each review demands a cumbersome assessment by selected individuals on an ad hoc basis from Defense Research and Engineering, the service commands, and the intelligence community. The experience base developed is almost entirely historical in its perspective, with little definitive policy and few guidelines. As a consequence, there is no coherent policy for controlling current technology.

Clearly, a well-understood national technology transfer policy is necessary to prevent these decisions from being made on an ad hoc basis without regard for the overall impact on the U.S. Such a policy must clarify the primary importance of technology transfer rather than product transfers. This change in focus from the present approach would do much to resolve the inherent conflict between the desire for trade and the need for control in a manner consistent with both objectives.

VIII. Conclusion

The Cyber 76 affairs raises the question: are the present administration and the National Security Council committed to curbing the growing Soviet strategic advancement? If the present administration is determined to place a cap on further Soviet strategic expansion, it becomes obviously counterproductive to provide them with a strategic item which will help the Soviet Union to bridge the qualitative gap which exists between them and the United States.

In 1921, Lenin made the statement, "The capitalist countries...will supply us with the materials and technology we lack and will restore our military industry, which we need for our future victorious attacks upon our suppliers. In other words, they will work hard in order to prepare their suicide."

In 1973, Soviet Communist Party boss Leonid Brezhnev defined detente in the following statement made to the members of his Politburo and communist leaders of the Warsaw Pact countries:

> "We communists have got to string along with the capitalists for a while. We need their credits, their technology, and their agriculture. But we are going to continue a massive military buildup, and by the middle 1980s we will be in a position to return to a much more aggressive foreign policy designed to gain the upper hand in our relationship with the West."

In its study Detente in Soviet Strategy, The United States Defense Intelligence Agency informed the American President in one of the paragraphs:

"11. The Soviets needed Western trade, capital and technology - notably advanced US technology - not only for economic reasons. They value economic strength largely for its contribution to Soviet political and military power. Thus, the detente policy seeks to facilitate building a powerful operating base from which Soviet foreign policy goals can be pursued."

The proclaimed objective of eventual victory for "socialism" on a world scale makes it clear that any accommodation with the Western powers is a purely temporary phase while the Soviet Union and its satellites around the world build up their strength in the advancement of that standing objective. It is paradoxical for the West to assist the military might of a regime dedicated to the destruction of its creditors.

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Table 1

COMPUTER ARCHITECTURES

Architecture	Number of Concurrent Instruction Streams	Number of Concurrent Data Streams	Characteristics
Uniprocessor	Single	Single	The conventional computer organization; instruction and data look-ahead features; multiple, specialized execution units. Examples: CDC 7600, IBM Models 360 and 370.
Minicomputer	Single	Single	A subclass of uniprocessors characterized by low cost, small size, simple instruction set, short word length, and small random-access memory. Recently minicomputers have become more sophisticated and the distinction between a small "conventional" uniprocessor and a minicomputer lies more in price than in performance. Example: Digital Equipment Corporation's PDP 11.
Microcomputer	Single	Single	A "bare-bones" processor on a single circuit card or even on a single chip. Simple instruction set, short word length, very low price. Applications in hand-held calculators. Microcomputer capability is also improving and approaches that of early minicomputers. Example: Intel 8080.
Pipeline Processor	Single	Several	A subclass of uniprocessors in which specialized execution units can be arranged in tandem (pipeline) for the application of a sequence of operations to a data stream. Two or three pipelines may be in operation concurrently. Examples: CDC STAR, Texas Instruments' ASC.
Array Processor	Single	Many	A large array of relatively simple processors executing the same instruction on many data streams; various data flow patterns between elements. Examples: ILLIAC IV (64 elements), Bell Laboratories' PEPE (16 elements).
Associative Array Processor	Single	Many	A subclass of array processors in which the N processors are simple serial-by-bit units associated with the (super) words of an associative memory. Example: STARARAN IV.
Multiprocessor	Several	Several	Identical multiple processors operate concurrently on instructions and data from a common main memory. Examples: Burroughs B 6700, UNIVAC 1110, Honeywell 7000 series.
Federated Computer Systems	Several	Several	Also called multicomputer systems. Several complete uniprocessors with their independent memory systems and input-output devices cooperate in performing a set of computing tasks. They share data bases, work loads, etc. The computers may be dissimilar but are in the same locality. Examples: SAC Satin IV system which will contain a variety of computers, B-1 avionics system of some 30 minicomputers.
Computer Networks	Several	Several	Remotely located computer systems connected by means of telecommunications. Users of the network can submit their tasks to be processed by any computer system in the network. Systems in the network may have different architectures. Example: ARPA Network.

Table 2

GENERATIONS OF U.S. COMPUTER TECHNOLOGY

Generation	Time of Introduction	Hardware Technology	Software and Architecture
1	1951-52	Vacuum tubes; modularity on individual component level	Machine language programming, symbolic assemblers, subroutines, program libraries. Special-purpose architectures.
2	1958-60	Transistors; modularity on single logic gate level.	Higher-level language (FORTRAN, COBOL, ALGOL), monitors macroassemblers, executive programs. General-purpose computer architectures.
3	1963-65	Integrated semiconductor logic circuits; modularity on multiple logic circuit level.	Operating systems, many programming and simulation languages, modular programs. Centralized, multiple-processor architectures; families of systems.
4	1970-72	Medium- and large-scale integration; modularity on subsystem function level.	Extendible language, metacompilers, subprograms in hardware, conversational systems. Networks of computer systems. Virtual memory systems.