23303 M

Directorate of Intelligence

Secret

23303

CIA SW 89-10023X

# Soviet Bloc Computers: Direct Descendants of Western Technology

A Research Paper

| | |
|---|---|
| **Warning Notice** | Intelligence Sources or Methods Involved (WNINTEL) |
| **National Security Information** | Unauthorized Disclosure Subject to Criminal Sanctions |

| | | |
|---|---|---|
| **Dissemination Control Abbreviations** | NOFORN (NF) | Not releasable to foreign nationals |
| | NOCONTRACT (NC) | Not releasable to contractors or contractor/consul |
| | PROPIN (PR) | Caution—proprietary information involved |
| | ORCON (OC) | Dissemination and extraction of information controlled by originator |
| | REL... | This information has been authorized for release t |
| | WN | WNINTEL—Intelligence sources or methods inv |
| | A microfiche copy of this document is available from OIR/DLB (482-7177); printed copies from CPAS/IMC (482-5203; or AIM request to userid CPASIMC). Regular receipt of DI reports can be arranged through CPAS/IMC. | Classified by<br>Declassify: OADR<br>Derived from multiple sources |

All material on this page is Unclassified.

Directorate of Intelligence

Secret

# Soviet Bloc Computers: Direct Descendants of Western Technology

**A Research Paper**

This paper was prepared by and , Office of Scientific and Weapons Research. Comments and queries are welcome and may be directed to , OSWR, or

*Reverse Blank*

Secret
*SW 89-10023X*
*June 1989*

# Soviet Bloc Computers: Direct Descendants of Western Technology

**Summary**

*Information available as of 30 April 1989 was used in this report.*

The Soviet Bloc will continue to rely heavily on Western computers through the 1990s to guide their indigenous computer development efforts and to compensate, through acquisition of Western hardware and technology, for the lack of indigenous production capabilities.

The Soviet Union and Eastern Europe lag the West in all aspects of general purpose digital computer technology, ranging from at least five years for microcomputers (also known as personal computers or PCs) to more than 15 years in high-performance magnetic disk peripherals. If production volume and reliability were taken into account, the lag would be even greater. The progress that has been achieved is, in large part, a result of acquiring Western technology, ranging from microelectronic and printed circuit board production technology to use of Western computers for reverse-engineering

The Soviet lag in computer technology and production is adversely affecting military and civilian computer applications. In military developments, the Soviets are avoiding complex multimission systems that require high-performance computers and disk drives. The impact is most critical for those applications with intensive computational requirements, such as ballistic missile defense, and those with large data bases, such as command and control. Without significant advances in computer technology, the performance and reliability of future Soviet weapon systems could be jeopardized. For example, Moscow's ability to develop or acquire advanced computer technology will have a direct impact on its ability to deploy improved antiballistic missile (ABM) radars for reentry vehicle discrimination and multiple target handling. Soviet managers and military leaders have become increasingly conversant with the role that computer-aided design (CAD) can have on improving the availability, reliability, and performance of weapon systems while reducing the human and material resource requirements. Soviet capability to design and produce composite materials for the next generation of airborne and space vehicles depends indirectly on modern computers in the laboratory and on the plant floor.

In civilian developments, plans for industrial modernization will be hampered by the lack of up-to-date computer systems. Lack of engineering workstations and high-speed computers will continue to stifle the productivity and creativity of Soviet scientists and engineers. Engineering workstations are needed to implement computer-aided technologies—such as

CAD, computer-aided manufacturing (CAM), and computer-aided testing (CAT)—which are key elements in modernization of the Soviet civilian—and also military—aviation industry.

Implementing increased CAD usage will require not only engineering workstations but also a computer literate work force that is able to take advantage of them. Without large numbers of computers for education, the Soviets cannot implement their plans for extensive training programs to prepare engineers, designers, and technicians working in CAD, CAM, and computer-aided engineering (CAE), as well as computerized management information systems. These programs will require significant development efforts and substantial improvements in the quantity and quality of production of Soviet computer equipment

Soviet Bloc PCs are produced in small numbers, are low-performance systems, and are generally designed for special purposes rather than for general office or laboratory use. Even the limited numbers of PCs produced in the Soviet Bloc are heavily dependent on Western-manufactured components. Soviet plans to produce and make available 1.1 million general purpose PCs by the end of 1990 are, in our judgment, unrealistic.

The Soviets and East Europeans are six to 10 years behind the West in traditional 16-bit minicomputer technology and 10 to 15 years behind the West in 32-bit superminicomputers. In the important category of large mainframe computers, the Soviets are having great difficulty even providing models equivalent to those available in the West eight to 15 years ago, and this gap is growing. We estimate that Soviet development of high-speed scientific computers (commonly grouped as supercomputers) lags the West by more than 12 years and will probably remain 10 to 15 years behind through the year 2000. Recent organizational changes and innovations designed to improve indigenous computing capabilities have had little effect to date, and we project the gap will grow through the 1990s

In our view, the Soviet bureaucracy will find it difficult, despite Mikhail Gorbachev's modernization program, to take the necessary steps to correct many of the computer industry's well-recognized problems. If the Soviets obtain turnkey production facilities or detailed production know-how from the West—as they have done in the past—they may be able to narrow, at least temporarily, a specific technology gap. The proliferation of high-speed computers in the West will increase Soviet prospects for acquisition, potentially allowing them to decrease their lag with the West. However, even with turnkey facilities and increased acquisition of Western hardware, the best the Soviets can hope for over the next 10 years is to slow the rate at which the Western lead on computers is growing.

## Contents

**Insets**

# Soviet Bloc Computers: Direct Descendants of Western Technology

## Background

The USSR has made substantial progress during the last 15 years in computer technology and production techniques, largely because of Moscow's heavy reliance on the West. Despite the USSR's large-scale acquisitions, its comparative progress has been overwhelmed by rapid advances made in the West and in Japan. (Figure 1 summarizes the Soviets' status relative to the West in several important areas of computer technology. These estimates are based on the difference between the initial delivery dates of functionally equivalent US and Soviet civilian computer products.

There are many reasons why the Soviets trail the West (including Japan) in computer technology:

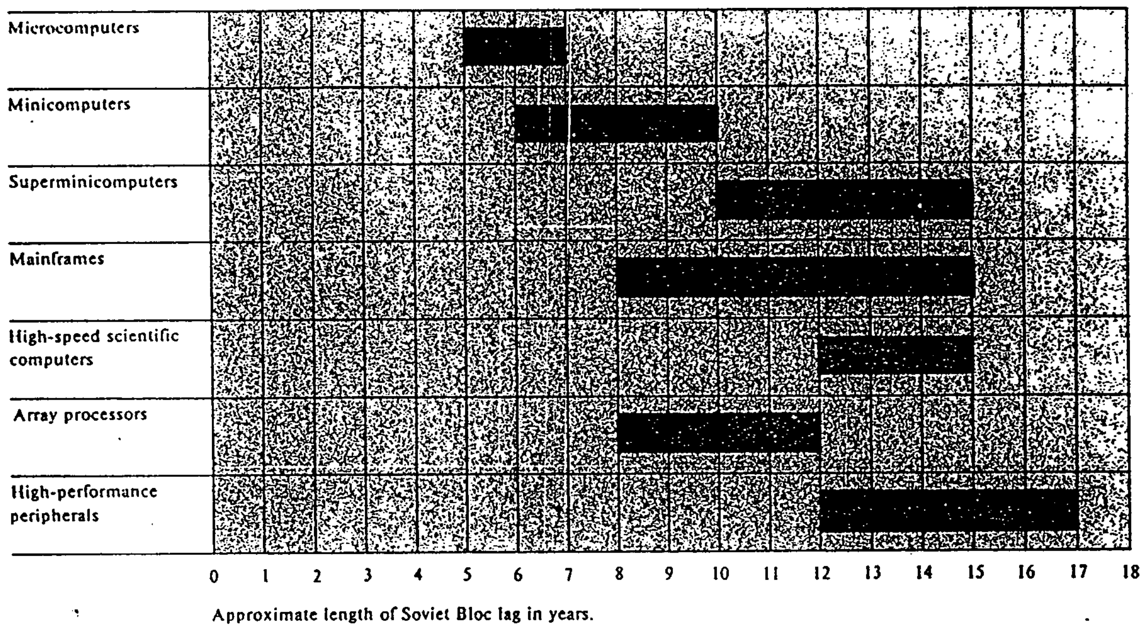
- The centrally planned Soviet economy does not permit adequate flexibility to respond to design or manufacturing changes frequently encountered in computer production. This often results in a shortage of critical components, especially for new products.
- The extraordinary compartmentation of information in the USSR—especially on technologies with potential military applications—restricts the flow of information. This results in much duplication of work because of a lack of knowledge about other activities.
- The Soviets are preoccupied with meeting production quotas, frequently at the expense of component and system quality control.
- There is a lack of adequate incentives for Soviet managers to take the risks associated with innovations or new technology.
- There is poor coordination between design institutes and production facilities. This problem has resulted in products that have to be redesigned to fit a factory's production capabilities.
- The Soviets lag in computer-aided design and computer-aided manufacturing (CAD/CAM) techniques because of a late development start and, ironically, because of the lag in computer technology.
- Soviet officials are concerned that a computer could be a powerful tool for antirevolutionary activity and that a proliferation of computers might reduce the tight control of information in the USSR. These concerns have delayed and restricted access to and firsthand knowledge about computers and their applications.
- There are provincial disputes within and between ministerial and institutional organizations.
- Poor customer support—including inadequate user feedback, poor installation support, and delayed maintenance—frequently result in reduced efficiency and productivity for computers in use

Similar reasons account for the Soviet lag in microelectronics technology, automation, instrumentation, and test equipment. Lags in components and basic electronic tools that are essential for modern computers also contribute directlv to the Soviet lag in computer technology

Although the Soviets have had sufficient numbers of computers for high-priority, low-volume military and civilian projects, the remaining user community, including Soviet Bloc allies, has experienced shortages and delays in obtaining desired computer systems. The shortage of Soviet automation equipment has seriously hindered the modernization of the Soviet industrial base and, thus, the growth of its economy.

Historically, there has been a tendency in the USSR to avoid the complex multimission military systems—for which computers are an essential subsystem—that

**Figure 1**
**Comparison of West Versus East Computer Technology**




are frequently preferred in the West. The generally conservative Soviet weapons design philosophy has probably not taxed Soviet computer capabilities in the past. Also, the large physical size of Soviet computers has probably discouraged their incorporation into weapons systems (see figure 2)

Lags in high-speed scientific computers and in high-performance magnetic disk technology have constrained Soviet computer system performance for applications requiring high input-output data rates, such as large real-time command, control, and communications systems. These problems have been openly acknowledged by the Soviets in their writings and in discussions with Western colleagues. Indeed, early computer inadequacies led to a Soviet decision in the late 1960s to copy US computer technology.

## The State of Computer Hardware Technology

### Major Systems

*Microcomputers.* Microcomputers available in the USSR are of low performance; produced in small numbers; and generally designed for special purposes, such as machine-tool control, process control, and

***Roundtable Discussion of the State of Soviet Computing***

*During an extraordinary roundtable discussion described in an August 1987 Soviet open-press article, high-level Soviet officials gave several glaring examples of problems with Soviet computer production, capabilities, and usage. Participants included Ye. Velikhov, vice president of the USSR Academy of Sciences; I. Bukreyev, first deputy chairman of the State Committee on Computer Technology and Informatics; G. Ryabov, chief designer of supercomputers; B. Yermolayev, deputy chief designer of the ES (Edinaya Systema or Unified System) series [a] of mainframe computers; and V. Kurochkin, first deputy minister of the radio industry*

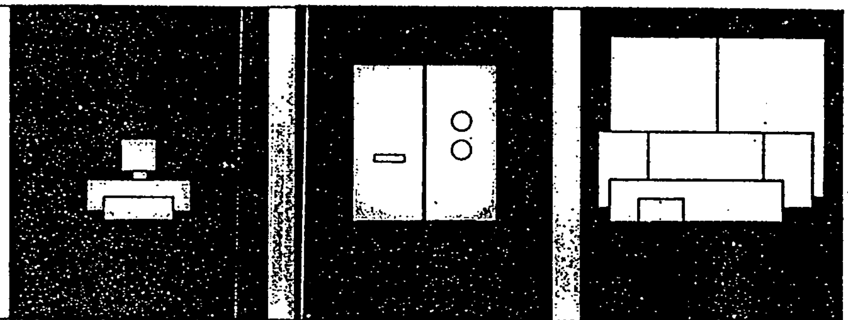
*The roundtable discussed the urgent need to increase the mean time to failure (MTTF, one measure of a computer's reliability) of Soviet computers. Kurochkin assured his colleagues that by 1 January 1988 the ES 1036 and ES 1061 mainframe computers produced by his industry would have their MTTF increased from 300 to 500 hours (as compared with typical MTTFs for Western computers of 20,000 hours). However, even these minimal gains come at a high cost to the Soviets. A previous increase in the MTTF of the ES 1061 from 150 to 300 hours required a two-year effort, 550 square meters of additional manufacturing space, 400 additional pieces of production and test equipment (at a cost of 2 million rubles), 170 additional workers, and 16 percent more production time. Kurochkin emphasized the resistance encountered to these types of changes—from the factory manager's viewpoint they are completely nonproductive expenditures. In addition to the high cost of these measures, they lead to a decrease in production volume*

*The participants agreed that the computational capabilities of Soviet computers are limited by Soviet component industries, primarily semiconductors and printed circuit boards (PCBs), which substantially lag Western industries. This lag is largely blamed on Soviet failure to make the capital investment when it was needed. Velikhov stated that the output of the Soviet electronic machine-building industry will have to increase fivefold by 1995 just to maintain the gap with the West. Soviet Minister V. Kolesnikov pointed out that the practice of a designer simply copying a Western computer, circuit for circuit, and expecting Minelektronoprom to develop the circuits is no longer feasible. The panelists agreed that development of the next generation of Soviet computers will require close cooperation between the various industries and designs that take into account the lack of Soviet developments in large-scale integration (LSI) and very-large-scale integration (VLSI) circuits.*

*The final topic of discussion was the effectiveness of computer usage in the Soviet Union. Quoted statistics showed that, on average, large mainframes that are expected to be used 20 hours a day were only being used 13 hours and, as a worst case, only about seven hours in some ministries. According to V. Bezrukov, director of the USSR Gosplan computer center, a variety of reasons contribute to this underutilization, including power fluctuations that cause computer malfunctions, computers that are not installed because of lack of false flooring and other installation material, shortages of disk drives (only four 100-megabyte drives are allotted per computer) that cause computers to stand idle part of each day, and the lack of basic supplies, such as printer ribbons. S. Bushev, director of the USSR Central Statistical Administration, added that, although all regional administrations have computers capable of communicating with each other, lack of hardware to connect the computers to the communications lines is forcing data transfer via telegraph, with subsequent manual data entry. The point was made that if these problems occur in the largest, best equipped computer centers, the ordinary user must suffer even worse impediments*

[a] Ryad, *the Russian word for series, is often usec*

**Figure 2**
**US PCs Versus Soviet Minicomputers and Mainframe Computers**



| | | | |
|---|---|---|---|
| Model | IBM PS/2 Model 70 | SM-4 (PDP-11/40) | ES-1035 (IBM 370/135) |
| Speed | >3 million instructions per second | .28 million instructions per second | .15 million instructions per second |
| Processing data rate | 169 | 6-7 | 8.4 |
| Memory | 16 megabytes | .248 megabyte | 1-2 megabytes |
| Word size | 32 bit | 16 bit | 32 bit |
| Space required | <1 meter² | 15 meters² | 20 meters² |
| Weight of system | 22.72 kgs | 636.36 kgs | 9090.90 kgs |

This chart compares East-West computers that are in widespread use, rather than the state of the art. The SM-4 and ES-1035 are produced in sufficient numbers so that a Soviet facility would have a realistic expectation of being able to purchase one. The weights given are for entire systems, including disk and tape drives, terminals, and power supply.

*Figure 3. The AGAT, the Soviet copy of a US Apple PC*

*Figure 4. Soviet ES-1840 IBM PC-compatible computer*

measurement/test control. The Elektronika-60—of which perhaps several thousand are installed—is the only Soviet 16-bit system that is in wide use in the USSR. Upgraded versions of the Elektronika-60, designated MS-12XX, are now being delivered. All of these, however, are designed for industrial-type applications. We do not believe they are designed for desktop or "PC-like" applications that could satisfy the Soviet requirement for a low-cost, high-performance, general purpose, microcomputer system.

Beginning in the early 1980s, the USSR embarked on several programs to mass-produce PCs to satisfy internal demand:

- The Soviet AGAT (see figure 3), modeled after the Apple II, was to be the primary machine used in the computer literacy program and was widely distributed to primary and secondary schools. According to many Western experts, the AGAT was a notable failure: a total of about 6,000 units were produced over a three- to four-year period. The Soviets experienced severe problems in hardware reliability and producibility and in software availability.

- The Elektronika BK-0010 was introduced after the AGAT and was, we believe, somewhat more successful: total production to date is estimated at fewer than 10,000 units. One significant design feature was its partial compatibility with US Digital Equipment Corporation's (DEC) machines. However, a technical evaluation of the BK-0010, [redacted] suggested that, although the computer is being sold publicly, it is little more than a toy, useful only for games and simple instructional applications.

- The first Soviet copy of the IBM PC, the Iskra 250, was to be the principal tool for scientists and engineers and was to be widely distributed at the university level. Production of the Iskra-250 is limited to a few thousand a year as is production of newer copies of IBM machines—the ES-1840 (see figure 4), the ES-1841, the Iskra 1030, and others. These machines represent a progressive effort by the Soviets to standardize the industry on the IBM PC, which will enable the Soviets to take advantage of the wide variety of compatible hardware and software sold on the world market.

Successful mass production of PCs is highly dependent on the availability of supporting technologies, notably microprocessors and memory chips. [redacted] there is a general shortage of integrated circuits (ICs), and large percentages of those received are defective. In 1983 the Soviets claimed development of the K1810 microprocessor, which is a copy of the Intel 8086 used in an early model of the IBM PC. [redacted] current production volume is limited and that the reliability of the K1810 is poor. In addition, adequate supplies of high-capacity memory devices (for example, 64K [1] dynamic random access memories—DRAMS) are limited, with production only in the hundreds of thousands per year, as compared with hundreds of millions per year in the West and Japan.

[redacted] have claimed that the USSR plans to rely on Eastern Europe to augment Soviet production, but these countries cannot satisfy their own internal demands. Despite Moscow's attempts to direct and coordinate microcomputer developments among Eastern European countries, production is chaotic. Although each country is unique and our technical information is largely limited to claims made in Soviet Bloc open literature and brochures, East Bloc microcomputer production can be characterized generally by:

- A wide variety of different models being produced by a large number of producers using hand assembly. This results in extremely limited quantities, generally a few hundred or less.
- A heavy reliance on critical components (for example, microprocessors and memory devices) from the West. This means many "Soviet Bloc PCs" are being assembled from imported Western kits.
- A heavy reliance on limited and uncertain supplies of Soviet electronic components of questionable reliability.
- An almost total reliance on Western high-performance peripherals (such as hard disk drives)

Bulgaria is attempting to concentrate production on a relatively small number of models. [redacted] total production to date has been less than 100,000 units. Until recently the Bulgarians had not used IBM-compatible technology, and, as a result, their products found little acceptance outside of Bulgaria. Like other Communist countries, they now produce mainly IBM PC-compatible models, using many critical parts illegally imported from the West (see figure 5)

[1] In this case, 64 kilobytes = 1,024 × 64 bits )

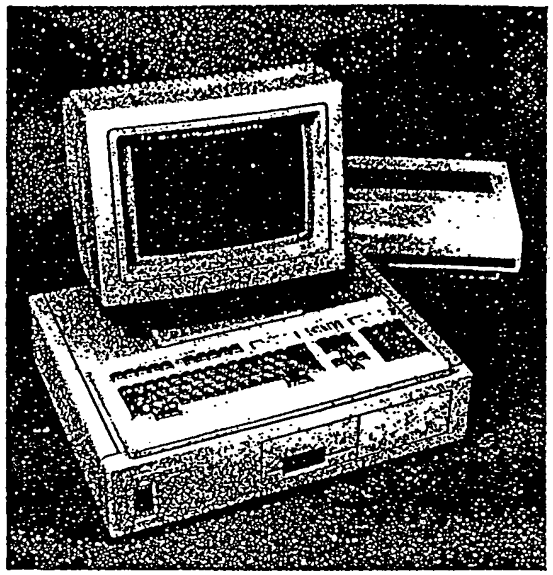


*Figure 5. Bulgarian IZOT-1832 PC*

East Germany is the most successful Soviet Bloc country, at least from a technical point of view. Production is concentrated on a small number of models, the industry is concentrated at Robotron—a successful producer of large computers—and systems are offered in modern configurations. PCs that are available reportedly are highly regarded and are reliable. There is, however, a problem of availability, because the products are based on East German or imported Soviet microprocessors that are in short supply. Total production to date, as in the case of Bulgaria, is on the order of 100,000 units [redacted] (see figure 6).

According to open literature, Czechoslovakia is having serious parts supply and production problems and produces only minimally acceptable microcomputers in very small quantities—about 10,000 units in 1987.

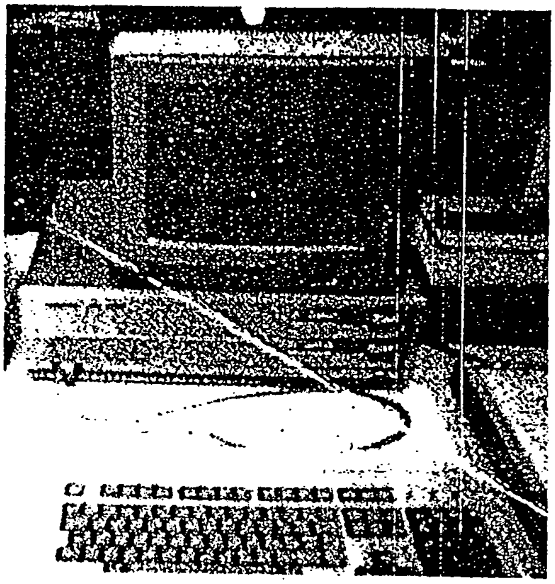


*Figure 6. East German Robotron EC 1834 PC*

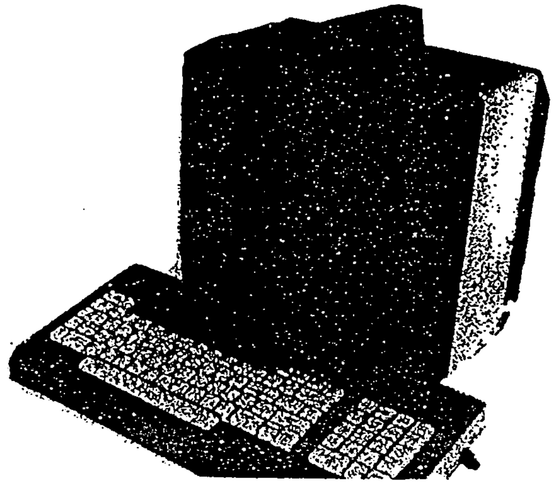


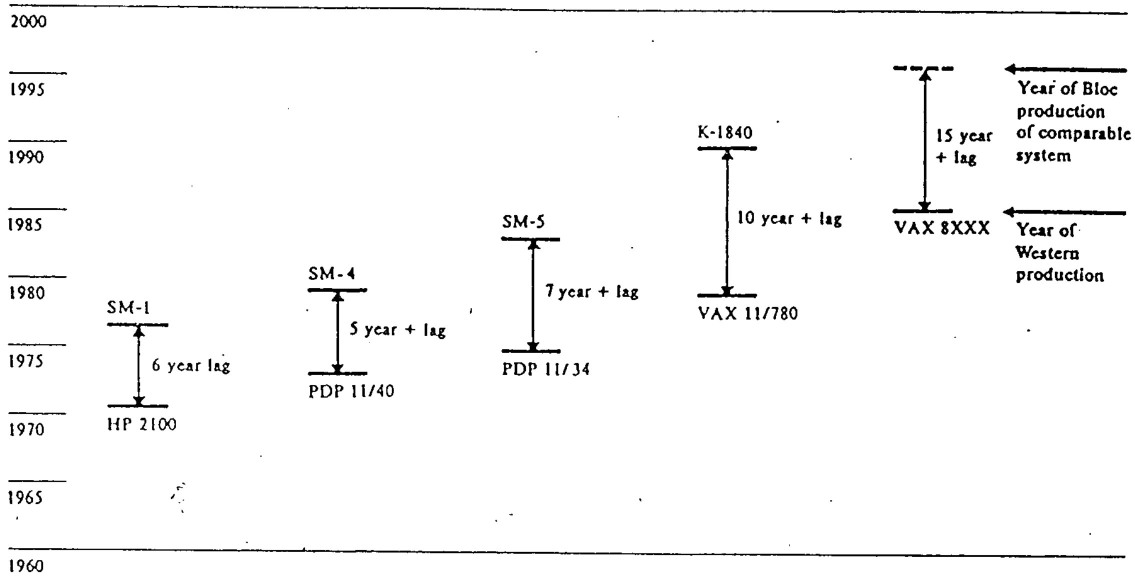
*Figure 7. Hungarian SM-1633 (MERA 660) PC*

Hungary and Poland have made progress in assembling IBM PC-class machines, using critical parts imported mainly from the Far East (see figure 7). Hungary and Poland have been quite successful in acquiring embargoed and unembargoed complete Western PCs, including IBMs, despite Coordinating Committee on Export Control (COCOM) regulations. At the other extreme, Romania seems to be insignificant in this technology and has no plans to expand its limited capability. All Bloc offerings suffer from a lack of availability of either domestically produced or imported hard disk drives.

***Minicomputers and Superminicomputers.*** In our judgment, the Soviets and East Europeans are six to 10 years behind the West in traditional 16-bit minicomputer technology and 10 to 15 years behind in 32-bit superminicomputer technology. The Soviets are now producing minicomputers of a size and performance that were available in the West nearly 10 years ago. Moreover, they did not deliver their first superminicomputer until 10 years after the first US model. (Figure 8 shows the lag between initial Western production of a computer and Soviet Bloc production of a functional duplicate.) This Soviet technology lag is translating into an even greater applications lag. We estimate that the USSR is at least 10 years behind the West in numerical control and flexible automation systems in manufacturing, which depend heavily on embedded minicomputers.

In the mid-1970s, Soviet computer-related literature and conferences began to reflect increased activity in minicomputer technology and applications. There has been a steadily increasing number of references in Soviet literature to minicomputer applications for CAD and CAM, including process control. As a result of a successful Council for Mutual Economic Assistance (CEMA) cooperative program in development of mainframe computers, the Council of Principal Constructors of Minicomputer Systems was created in 1974 to coordinate minicomputer development within CEMA. The Soviet Union assumed the major role and developed four new minicomputers: the SM-1, the

Figure 8
Western Lead Over Soviet Bloc in Mini/Superminicomputers




Year of Western system production versus production of Bloc clone.

SM-2, the SM-3, and the SM-4.[2] This group, and probably the SM-5, constitutes the first generation of SM minicomputers, the SM-I family. (Figures 9 to 11 are typical configurations of Soviet minicomputers.)

The SM-1 and SM-2 are modeled after the US Hewlett-Packard HP-2100 architecture and primarily used for process control. The SM-3 and the SM-4 are modeled after the low end of the DEC PDP-11 minicomputer line and are intended primarily for scientific and engineering control applications. [redacted] the SM-3 and SM-4 apparently can execute most DEC software without modification

[1] SM stands for *systema malaya*, or small system.

SM-4 models are being produced in the USSR, Bulgaria, Czechoslovakia, and Poland. [redacted] that other computer models from East Germany and Romania are in the SM-4 class or are being modeled after the PDP-11 series.

In the late 1970s, according to open literature, CEMA countries began coordinating production of the second generation of SM small computers that includes both microcomputers and minicomputers, the SM-II family. CEMA has adopted new nomenclature for this next generation:

- SM-50: General purpose microcomputers for applications such as control and communications.


*Figure 9. SM-5, Soviet-built PDP-11/34 copy*

- SM-51: Small computers maintaining software compatibility with the SM-I family.
- SM-52: High-performance, real-time small computers; this class will eventually include high-performance 32-bit superminicomputers.
- SM-54: Special processors for character recognition, fast Fourier transforms, and other specialized applications.

Nearly 30 systems using this nomenclature have been identified in Soviet open literature. Many of the systems are still under development; other systems seem to have acquired a new name for an old system. We believe the lack of successful production of most of these models indicates that the Soviets are falling further behind the West

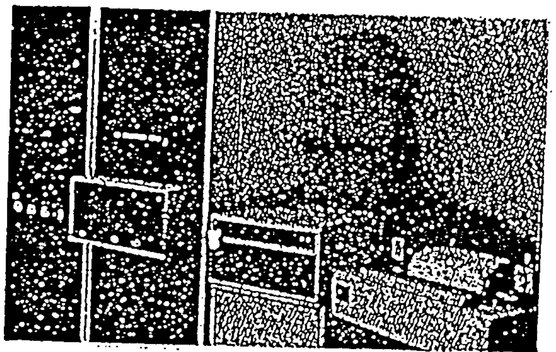


*Figure 10. SM-4, Soviet-built PDP-11/40 copy*

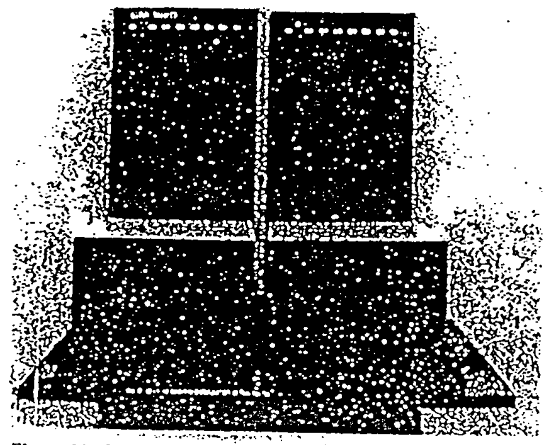


*Figure 11. Soviet SM-II, Model SM-14X*

Several Soviet Bloc countries are developing copies of DEC VAX 32-bit superminicomputers. Bulgaria, Czechoslovakia, Hungary, and the USSR are attempting to copy the VAX 11/750. The USSR, Czechoslovakia, Hungary, and East Germany are also developing a VAX 11/780 copy (see figures 12 and 13). On the basis of our limited technical data about these machines, we believe their performance is significantly lower than that of the DEC originals. The East German VAX 11/780 copy, the K-1840, does not have cache memory or a floating point processor, [redacted] Moreover, the Soviet copy of the VAX 11/750 is much larger than the original and requires 10 times the electrical power.

[redacted] the majority of these "VAX clones" are, at best, only in the prototype or very limited production stage and that it will be several years before there is substantial production of any of these copies. East Germany seems to be the most successful so far in producing a VAX copy. [redacted] We believe these VAX copies probably make extensive use of imported Western parts. For example, when the East Germans displayed the K-1840 at a spring trade fair, a well-qualified visitor was able to view the inside of the computer and observed extensive use of Western electronic components. [redacted] the K-1840 is an exact chip-for-chip and board-for-board copy of the DEC original. Some of the boards, however, were copied from those of Western plug-compatible manufacturers rather than directly from DEC. In addition, Western disk drives are being supplied with all the machines

The Soviet Bloc is in the process of developing copies of the newer DEC 32-bit superminicomputers. The Soviet Union, East Germany, and Bulgaria are attempting to copy the DEC MicroVAX II. These copies are scheduled for availability in 1991. [redacted] The Research Center of the Microelectronics Combine (KME) in Erfurt, East Germany, started to reverse-engineer the MicroVAX's ICs in 1986. A completely new semiconductor production line was being developed by Zeiss to accommodate this effort.

[redacted]

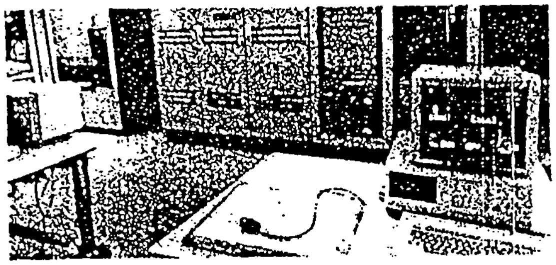


*Figure 12. K-1840, East German copy of VAX 11/780*

East Germany also has copies of the DEC VAX 8XXX series under development at Robotron. The work is reportedly at the design stage and will require the production of several specialized semiconductors. [redacted] work on developing the VAX 8600 and the VAX 8800 is progressing in parallel. We believe it will be at least 10 years before these machines reach serial production in the Soviet Bloc. Duplicating these computers will require East German advances in printed circuit boards, semiconductor memories, application specific integrated circuits (ASICs), and overall manufacturing capabilities.

*Mainframe Computers.* We estimate that the Soviets are eight to 15 years behind the West in development of general purpose mainframes (see figure 14). Progress in the West has been so substantial that the Soviets are having technical difficulties even holding ground in this area. Despite pronouncements to the contrary, Soviet developments represent only marginal evolutionary movement. Soviet efforts to introduce Ryad III, their newest family of computers, have been delayed [redacted] the Ryad III will represent only a marginal improvement over Ryad II. We believe the Soviets will continue to fall even further behind the West over the next five to 10 years because of continuing problems with bringing new machines into production, unreliability of machines they do produce, and lack of peripheral support. (Figure 15 compares the operating speed, in millions of instructions per second [MIPS], of top-of-the-line US and Soviet mainframe computers for 1980 and 1988.,

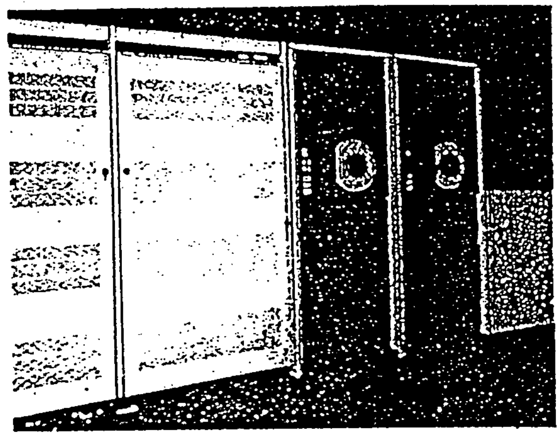
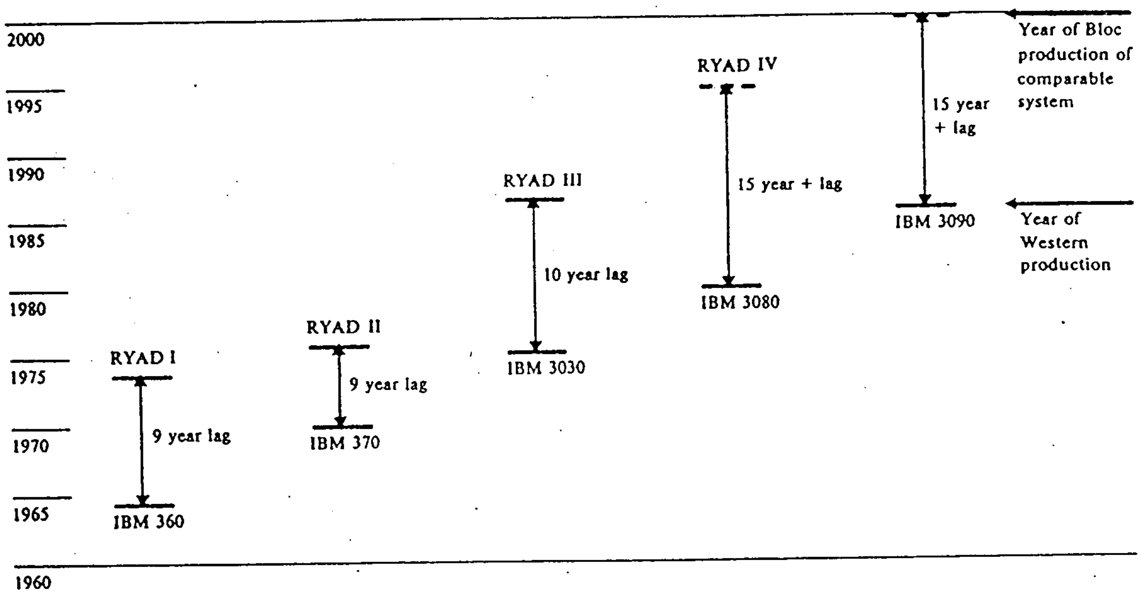


*Figure 13. SM-52/12, Czechoslovak copy of VAX 11/780*

Soviet Ryad mainframe computers are modeled after IBM systems—the Ryad I on the IBM 360; the Ryad II on the IBM 370 (except the largest model, which may be based on the IBM 3033); and the Ryad III ostensibly on the IBM 43XX and the IBM 303X models. Each of these Ryad series consist of several models that vary in their computing capabilities and are intended to satisfy a specific class of user. These mainframes are widely used in military and civilian applications

Ryad I models are no longer produced, although most models are still extensively used throughout the Soviet Bloc. Although modeled after the IBM 360 series, we believe the Soviets required a series of evolutionary upgrades before Ryad I achieved significant compatibility with the IBM. The high-end machines in the series, particularly the ES 1060, suffered serious delays in delivery and went into production only after introduction of the Ryad II. Peripheral development, in particular disk drives, substantially lagged computer development, further diminishing the utility of already marginal computers. The greatest problem with the Ryad I was its lack of reliability. An article in *Pravda* described inadequately trained service personnel, lack of spare parts, lack of automated test equipment, and shoddy service as common problems.

**Figure 14**
**Western Lead Over Bloc in Mainframe Computers**

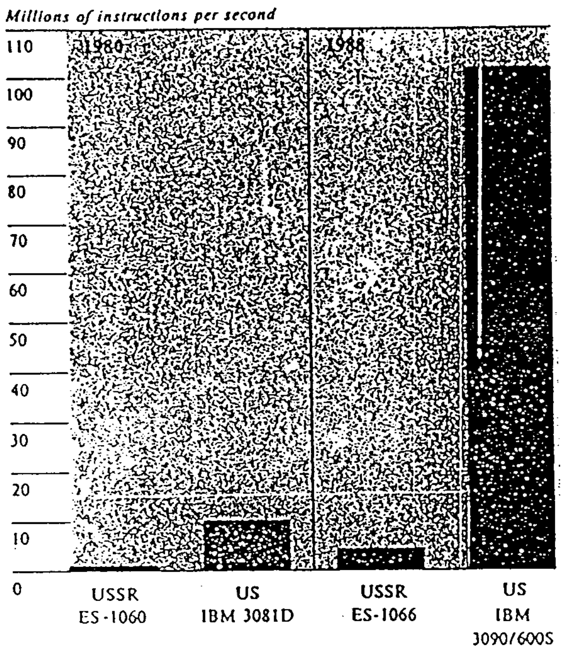



The most significant accomplishment of the Ryad I series development was the establishment of a compatible line of computer systems for Soviet Bloc production

The Ryad II family is in production and is produced in sufficient numbers to satisfy at least high-priority users. Although the Ryad II models offer improvements over the Ryad I—such as virtual memory, larger disk stores, semiconductor memory, and an expanded instruction set—they suffer many of the same reliability problems as the Ryad I, particularly in the larger machines. In addition, the lack of high-capacity, high-reliability disk drives continue to hinder computational capabilities. As with the Ryad I models, the Ryad II models underwent a series of upgrades before achieving technical compatibility with the IBM 370 series. Figures 16 to 18 show a variety of Ryad II models in typical configurations.

The Soviets are having difficulties with Ryad III development. The Ryad III program, announced in 1976, is based on faster, more densely packed logic and memory circuits, larger and more advanced secondary stores, improved telecommunications capabilities, and specialized processors. However, we believe delays and problems with this program may be forcing the Soviets to classify upgraded Ryad IIs as Ryad

Figure 15
Comparison of US and Soviet Mainframe Computers




IIIs. The few models that have been described in Soviet literature or viewed by Western observers do not seem to meet the outlined goals of the Ryad III program [redacted] an ES 1066 (see figure 19) displayed at a 1987 trade fair as a Ryad III model did not seem to be a substantial upgrade of a Ryad II. Although the Soviets claimed it operated at a speed of 12 MIPS, [redacted] evaluated its operation at closer to 1 MIP (approximately comparable to a VAX 11/780). The East Germans displayed their Ryad III ES 1057 at the 1988 Plodiv trade fair in Bulgaria. According to a press article, it has an operating speed of 1 MIP

[redacted] if the Soviets continue to follow IBM's evolutionary path, we would expect Ryad IIIs to be based on the IBM 43XX series (a series of small mainframes first produced by IBM in 1979) at the low end and on the IBM 303X at the high end. [redacted] the East German Ryad model ES 1057 is supposed to be based on the IBM 43XX.

According to public announcements by the Soviets, future Ryad developments will include upgrades to the Ryad III and development of a Ryad IV series. On the basis of past Soviet performance, upgraded Ryad III models will not be in service until 1990 at the earliest. The limited information we have on the Ryad IV series suggests that it is under development and that the Soviets expect to place it in service in the early 1990s. [redacted] East Germany's model of the Ryad IV would copy IBM's "latest architecture," use complementary metal oxide semiconductor (CMOS) technology, and have capabilities in the 1 to 5 MIPS range. A prototype is scheduled for early 1991.

If the Soviets and their allies continue to follow IBM's lead, they will need to do extensive reworking of the IBM design to adapt it to available Soviet technology. Complex multilayered boards, dense packaging of components, and sophisticated cooling technology that IBM began using in 1980 for their 308X models are beyond Soviet capabilities and are likely to remain so through the early 1990s. In addition, these computer performance improvements will require the Soviets to make parallel advances in the development of semiconductors and storage technology

*High-Speed Scientific Computers.* Soviet development of general purpose, high-speed scientific computers (commonly grouped together as supercomputers)—required for large-scale scientific computing—lags the West by 12 to 15 years and will probably remain 10 to 15 years behind through the

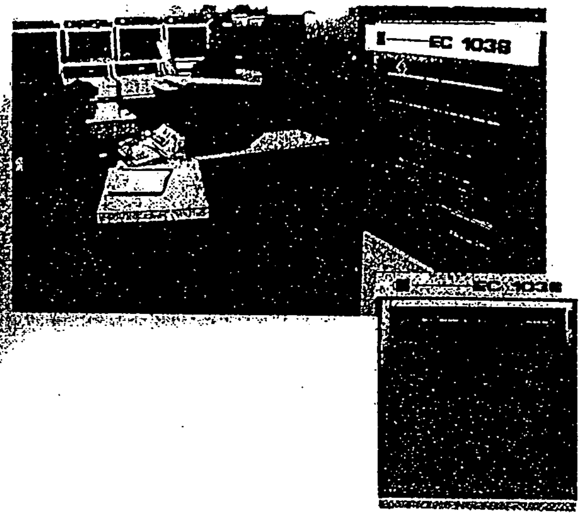


***Figure 16.** Soviet ES-1036 mainframe, Ryad II*

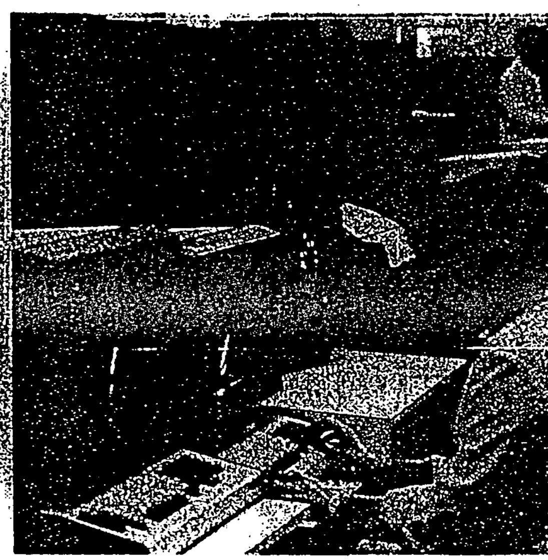


***Figure 17.** Soviet ES-1045 (left) and ES-1046 (right) mainframes, Ryad II*

*Figure 18. Soviet dual ES-1060 Ryad II system*

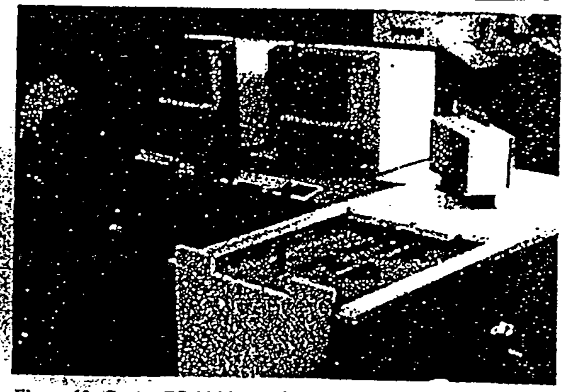


*Figure 19. Soviet ES-1066 mainframes, Ryad III*

year 2000. However, Soviet research on computer architectures that use large-scale "parallelism" could allow the Soviets to significantly increase their capabilities for certain applications. We believe that, at present, the Soviets have no machines in the true "supercomputer" class. The best Soviet scientific computers have only one-sixth the speed of their Western counterparts (see figure 20), and Soviet claimed computer capabilities are probably greatly exaggerated.

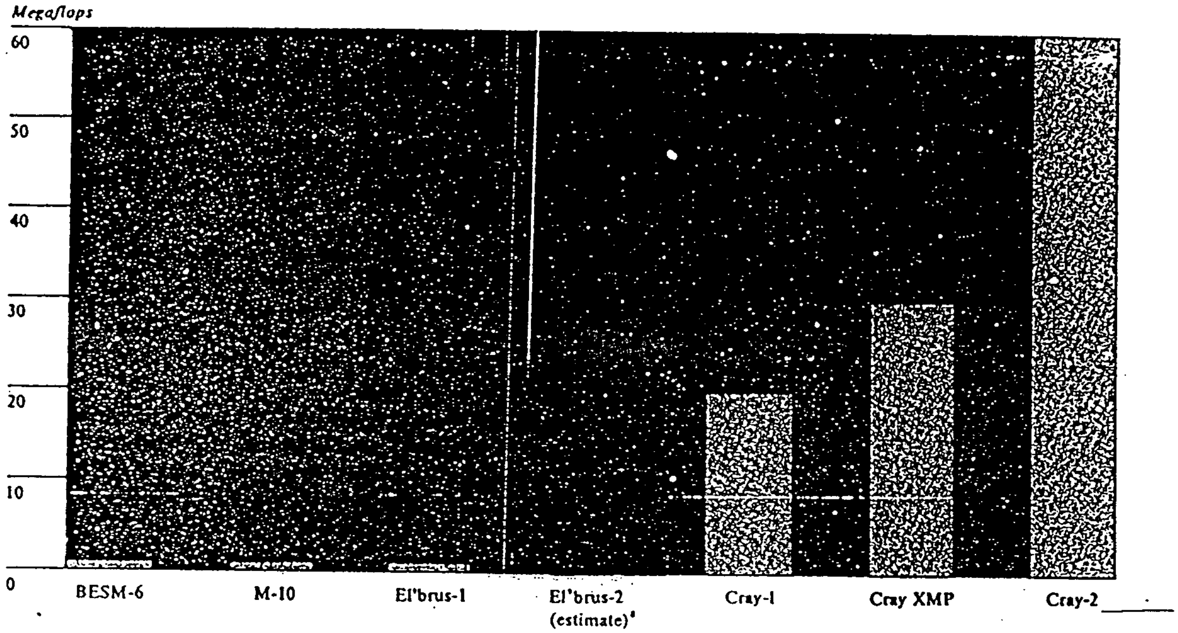
Strict export controls on supercomputer technology have precluded the Soviets from developing a supercomputer based on a Western system. Left to their own devices, the Soviets have not achieved supercomputing capabilities using indigenous technology. [redacted] recently called Soviet efforts to develop supercomputers an abysmal failure and claimed that another five or six years will be required before indigenous machines comparable to the US Cray-1 will be available. [redacted] the lack of a supercomputer has already curtailed several projects at the Institute of Space Research.

The BESM-6, first introduced in 1964, is still extensively used by the Soviet scientific computing establishments, despite its limited capabilities. It was originally designed with 32 kilobytes (KB) of memory and used magnetic drums for mass storage. It was updated in the mid-to-late 1970s, its memory was extended to 128 KB, and it used disk storage. Calculations of its speed put it in the 0.3 million floating point operations per second (MFLOPS) range. This performance level, which decreases to about 0.05 MFLOPS when input and output of data to secondary memory is required, is comparable to many advanced Western PCs. Production of the BESM-6 ended in the late 1970s.

In 1978 the developers of the BESM-6 announced a successor machine, the El'brus. The El'brus-1 family was designed to achieve high speed by using one, two, four, or 10 processors working simultaneously on a single problem. By 1982 [redacted] perhaps 10 El'brus-1 single processor models had been delivered to scientific institutes and that the Soviets planned to produce them at the rate of roughly 10 per year. However, many of the El'brus-1 computers were not working reliably and, in some cases, were not even functional because of missing subsystems.

The El'brus-2 follow-on appears to be identical in architecture to the El'brus-1, with the primary difference being the level of technology used. Along with an overall upgrade in the sophistication of semiconductors used, the El'brus-2 has additional vector processing components. The El'brus-2 also has from one to 10 processors and, by Soviet claims, is intended to operate at 125 MIPS.

**Figure 20**
**Comparison of US and Soviet Supercomputers**




[a] Based on Soviet performance claims of a tenfold speed increase, relative to the El'brus-1.

Guriy Marchuk, President of the Soviet Academy of Sciences, stated in [redacted] mid-1987 that the El'brus-2 would be available for delivery to Soviet industry and research institutes by mid-1988. There is evidence that El'brus-2 models were being delivered to select institutions in 1987. [redacted] at the University of Moscow claimed in May 1987 that he was using an El'brus-2 for his work [redacted] a new computer was expected in early 1988.

In late 1985 an El'brus-3 was discussed by the Soviets, but the [redacted] suggests that it is unlikely to go into production until the early 1990s. It is intended to have up to 16 processors, with a speed of about a billion operations per second—a capability comparable to the US Cray-2.

Soviet performance plans for the El'brus-3 are probably exaggerated. The Soviets have greatly exaggerated performance capabilities for all El'brus computers. The Soviets have announced theoretical computation rates ranging from 1.5 million "operations" per second for the standard El'brus-1, up to over 150 million "operations" per second for a multiprocessor El'brus-2, and 1 billion "operations" per second for the future El'brus-3. Our analysis of the specifications for the El'brus reveals that these "operations" are far short of useful, full-precision, floating point arithmetic operations. The El'brus-1, with a single processor, achieves only about 0.8 MFLOPS for typical benchmark scientific computing problems. With two processors, we compute only a marginal improvement to about 1.0 MFLOPS. Even in a 10-processor configuration, we estimate a benchmark of only 1.4 MFLOPS for the El'brus-1. On the basis of Soviet performance claims of a tenfold speed increase relative to the El'brus-1, we estimate a speed of 10 to 15 MFLOPS for the El'brus-2

Soviet research continues to concentrate on achieving high computing speeds through the use of parallel architectures, according to a wide variety [redacted] open-source articles. This approach allows the Soviets to shift the design burden from one of their weaknesses—design and production of sophisticated electronic devices—to one of their strengths—innovative mathematics and algorithm design. Instead of using densely packaged, high-speed VLSI logic and memory chips to achieve "supercomputing" speeds, the Soviets will attempt to interconnect multiple numbers of relatively slow, unsophisticated processors. The problem of achieving high speed, essentially dividing the work evenly among the individual processors, is left to the designers of the operating system and application software.

Although the Soviet El'brus computers interconnect a small number of large processors, new systems under development will link tens to hundreds of relatively small microprocessors together. One of the more promising lines for Soviet achievement of widespread, high-speed computing is MARS (the Soviet acronym for Modular, Asynchronous, Expandable System). MARS is an attempt to link together up to 100 32-bit microprocessors. This attempt parallels research presently being done in the West and is intended to satisfy the requirements of a broad range of Soviet scientists and engineers who require high-speed computing. MARS' general characteristics include:

- High-speed scientific "number-crunching" capabilities.
- Flexible architecture for applications with different computing requirements.
- Object-oriented approach to data to facilitate and automate programming and to provide the basis for such artificial intelligence (AI) components as knowledge bases and inference engines.
- Highly user-friendly interfaces to make the system easy to use by non-computer-literate workers.

The heart of MARS will be a 32-bit Kronos microprocessor, which the Soviets have modeled after the British-made INMOS transputer. The transputer and Kronos are essentially microprocessors with additional features, primarily communication buses, that allow them to be readily built into networks and arrays for parallel processing. [redacted] a single-chip Kronos exists only in prototype. Development work on MARS is continuing by implementing the Kronos design with multiple chips. Planned compatibility between the Soviet Kronos and the British transputer has been demonstrated by substitution of the transputer for Kronos during development work on MARS

While emphasizing development of multiprocessor computers, there is evidence of at least one effort in the Soviet Bloc to design a Cray-like supercomputer. [redacted] a project to develop a Cray software-compatible supercomputer was initiated sometime before 1985 and involved the Soviet Institute of Information Transmission Problems (IPPI) and the GDR Central Institute for Cybernetics and Information Processes (ZKI). [redacted] this project was started so that the Soviet Bloc could take advantage of Western software already written for the Cray. The head of the project claimed that IPPI had acquired some Cray software. IPPI had also acquired Fairchild ICs used in the Cray and was reverse-engineering them, in cooperation with ZKI

**Figure 21**
**Comparison of US Versus Soviet Array Processors**

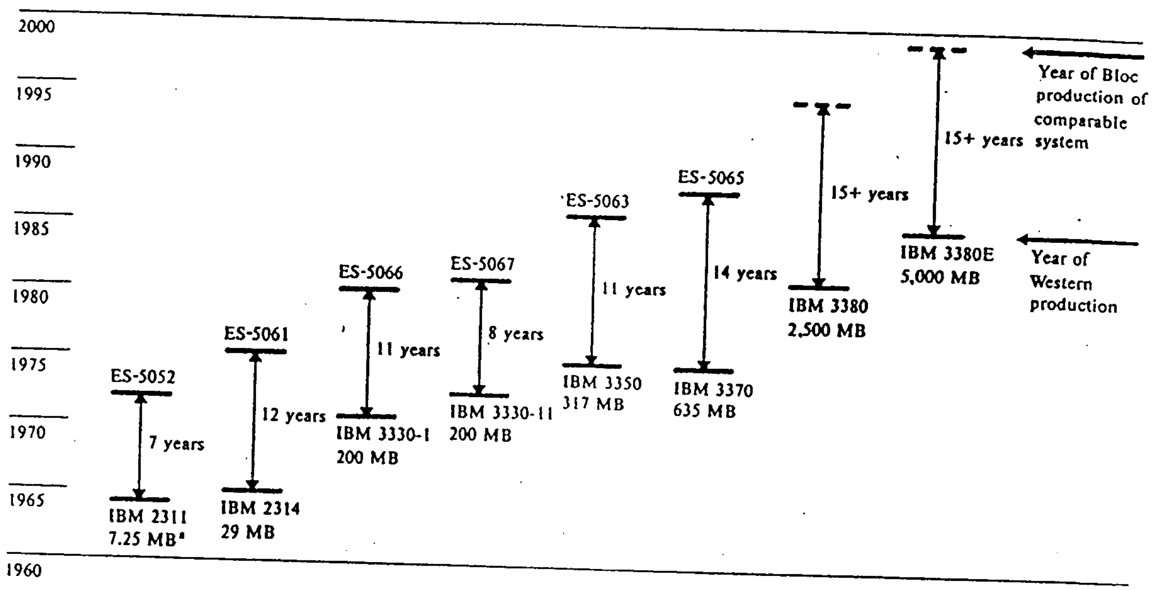
| | US | USSR |
|---|---|---|
| |  |  |
| | FPS-5000 series | PS-2000 |
| Host | Multiple | PDP clone |
| Speed | 8-62 MFLOPS[a] | 5 MFLOPS |
| Add time | 25-75 milleseconds | 8.3 ms |
| Multiply time | 25-75 ms | 2.5-6.2 ms |
| 1024-fast Fourier transform | 2.7 ms | 15 ms |
| Size | 19-inch Electronic Industry Association standard rack | 71 x 91 x 182 centimeter cabinet |

[a]Millions of floating point operations per second.

The Soviets have developed a variety of array processors for connection to their mainframe and minicomputers. Although lacking the overall flexibility of general purpose, high-speed computers, array processors can offer significant performance benefits in certain applications, such as signal and image processing, and in the processing of seismic data. Published performance parameters indicate that Soviet array processors are eight to 12 years behind the West in overall capabilities. Even if Soviet Bloc array processors are able to achieve claimed capabilities, which we doubt, Soviet ability to process data, such as that from radar, is, by Western standards, limited. In addition, perhaps an even greater Soviet problem is the size and weight, rather than the speed, of their array processors. The capabilities of Soviet machines that take up several racks of space can be achieved in the West on a few plug-in boards (see figure 21). This offers enormous advantages when the system is to be used on a military platform for real-time processing of data

Several other high-speed computers have been announced in Soviet open literature, although there is little specific information on them. The IZOT 1703, a multiprocessor jointly developed with the Bulgarians, was cited in 1986-88 Soviet and Bulgarian scientific journals as having a performance of 60 MFLOPS. The IZOT 1703E, another multiprocessor system

**Figure 22**
**Western Lead in Magnetic Disk Technology**




Year of Western system production versus production of Bloc clone.

[a] Megabytes

jointly developed by the Soviets and Bulgarians, consists of 10 ES-2706 array processors connected to an ES-1037 mainframe. According to Soviet Bloc press articles, a single ES-2706 is claimed to be capable of 12 MFLOPS. The ES-1766, with an announced speed of 100 MFLOPS, will connect up to 256 processors and looks like an attempt to develop a machine of the minisupercomputer class. It is likely that most of these machines are, at best, laboratory prototypes. We do not know whether the Soviets will develop machines in full-scale production for widespread use. In addition, given past Soviet exaggerations, we expect actual performance capabilities of these machines to fall far short of announced claims.

**Peripherals**

***Magnetic Disk Drives.*** The most serious computer hardware problem facing the USSR and Eastern Europe is a lack of disk technology. This deficiency limits the performance of their computer systems in many applications, including military applications. The Soviets and Bulgarians, the major producers of large disk drives in the Warsaw Pact, are 12 to 17 years behind the West in high-performance magnetic disk technology (see figure 22). Since the introduction of their first 100-megabyte (MB) drive in 1975, CEMA developers have achieved little more than evolutionary upgrades to a technology nearly 20 years old in the West. In the wake of movements to introduce microcomputers throughout their economies, the Soviet Bloc is facing the same difficulties in supplying small Winchester (sealed, nonremovable disk packs) drives for PCs.

Reliability and maintenance are two critical areas of failure for CEMA disk drive producers. In particular, Bulgarian-made disk drives have become targets of severe criticism throughout the Soviet Bloc because of their unreliability. In the mid-1970s, [redacted] Bulgarian disk drives were superior to Soviet models. The opposite now seems to be true. According to [redacted] dissatisfaction with Bulgarian disk drives is causing other Soviet Bloc countries to begin their own production. The East Germans in particular have emphasized development of indigenous production facilities.

Bulgarian drives have several major design flaws:
- Poor servosystem controls and system enclosures.
- Inadequate filtering systems and startup procedure controls.
- Faulty spindle brake systems.

A technical evaluation [redacted] of the Bulgarian 200-MB disk drive (ES-5067) revealed poor overall quality and crude construction. The drive had not been tested before packaging and delivery and would not operate once it was uncrated.

Production of disk drives is concentrated in the USSR and in Bulgaria; other Soviet Bloc countries have only limited capabilities. The 29-MB drive (ES-5061) is probably the only disk drive that is produced in sufficient quantities to satisfy the needs of a broad spectrum of users. Complaints about the availability, reliability, and interchangeability of packs, however, continue, even for this model. Major production problems center on the disk coating technology, the disk head manufacture, and the mechanical positioning systems.

The highest capacity disk drives in volume production are the 200-MB units from Bulgaria (ES-5067) and the USSR (ES-5080), with only the Bulgarian unit in widespread use. In addition to its meager storage capacity, this drive has a low data transfer rate, limited availability, and a high rate of failure. [redacted] that delivery of the 200-MB drive may take up to six months after one is ordered. There may then be a further delay of several months for technicians to install the drive. The Bulgarian 200-MB drive is the size of a small washing machine, while 200-MB drives produced in the West can be held in one hand (see figure 23). Bulgaria has been manufacturing small numbers of the ES-5063 since 1987—a 317-MB drive using Winchester technology. A 635-MB Winchester drive (the ES-5065) has been developed, and limited prototype production may have begun in 1988

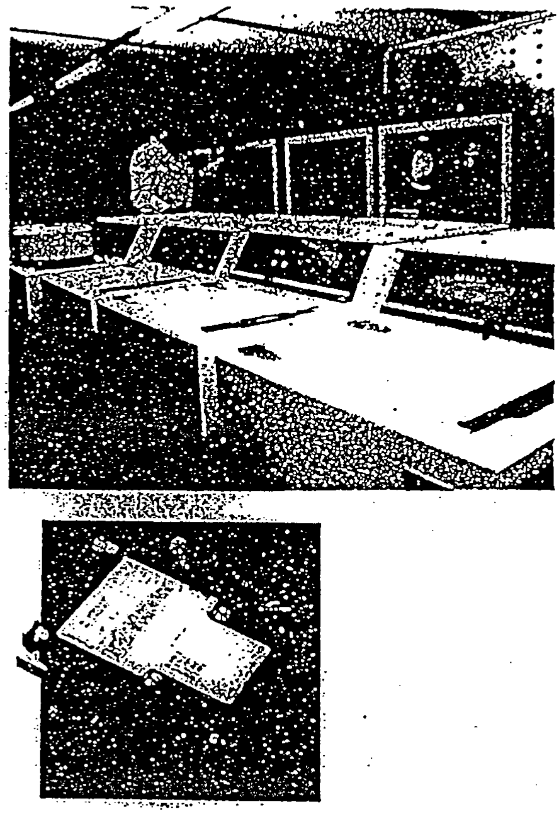


*Figure 23. Comparison of Bulgarian and US 200-megabyte disk drive*

Development work is under way in several countries on small, 5.25-inch Winchester-type drives. The Hungarians exhibited an MW-1000 at the 1985 Budapest trade fair that they claimed was the first Winchester

*Western Disk Drive Technology at Stara Zagora*

*The disk drive plant at Stara Zagora has been the major supplier of disk drives to the Soviet Bloc since the early 1970s, when Bulgaria was assigned this task by CEMA. Bulgaria claims to export half of Stara Zagora's production to the Soviet Union, with the remainder being used in Bulgaria or sold elsewhere in Warsaw Pact countries. Since opening in 1972, the plant has continuously acquired Western technology because of the almost total lack of previous Bulgarian experience in high-technology manufacture. Although this influx of Western technology has allowed the Bulgarians to maintain their leadership position in the Soviet Bloc, mistakes in application of the imported technologies and substandard indigenous engineering support have created a 15-year lag with the West.*

*The most recent series of acquisitions of Western technology supported modernization of the plant, which began in 1983. The project was originally scheduled to be completed in 1985, but delays and additional expansion pushed the completion date to early 1988.* [redacted] *at least 20 Western firms,* [redacted] *supplied technology, much of which was COCOM-controlled, to the Stara Zagora project. Western help spanned the full spectrum of manufacturing technologies needed for the production and final assembly of hard disk drives. Among the key elements provided were engineering assistance (plant design and planning, training in operation of the plant, and design and construction of clean rooms); production assistance (computer control rooms for disk drive and IC production, and automated manufacturing systems); and manufacturing equipment (disk coating equipment, bonders, electronic cleaners, abrasive and polishing machines, grinding machines, milling machines, and test equipment for finished disks)*

*Although most of the upgrading at Stara Zagora was for the production of large, relatively high-capacity disk drives* [redacted] *This facility is designed to produce up to 30,000 hard disks a month, giving the Soviet Bloc the capability to mass produce small Winchester drives if they can also manufacture the read-write heads and mechanical components that the drives require. The small size, large storage capacity, and high reliability of Winchester drives is particularly important for use in PCs and in military computer systems. We expect these technology acquisitions to be reflected in improved capabilities of virtually any Soviet weapon system that incorporates a computer.*

drive developed in a socialist country. The drive has a claimed capacity of 10 MBs. The unit shown was described as a developmental model, with a prototype and a small test series scheduled to be built in 1986. Series production was expected in 1987, but we have no evidence that this has occurred.

The East Germans claim to have developed small Winchester drives for use with Warsaw Pact minicomputers. Three different models with unformatted capacities ranging from 16.8 to 39.2 MBs have been announced. We have no evidence that these drives are in series productio[redacted]

[redacted] East Germany was to begin producing a Winchester drive with a 15- to 35-MB capacity for PCs, the 5501, in 1988

Although the low performance of Bulgarian and Soviet disk drives may impose only inconveniences for the majority of computers in use, system performance of current and future Soviet high-speed scientific and large general purpose computers is being and will be severely hampered without further advances in disk technology. Some military systems requiring the high-speed processing of large amounts of data most likely have been negated, delayed, or reduced in capability because of disk drive deficiencies. The impact is most serious on large, real-time computational applications, such as ballistic missile defense, and on high-volume, high-speed data transfer applications requiring large data bases, such as command, control, and communications systems.

*Floppy Disks.* Despite concerted efforts to increase production of floppy disk drives and disks, both are still a rare commodity in the Bloc. Floppy disk technology in the Soviet Bloc lags that in the West by approximately five years. Many floppies produced are still using single-sided, double-density techniques. The 8-inch format disks still widely used in the Soviet Bloc have been made obsolete in the West by smaller 5 1/4- and 3 1/2-inch floppies. In addition to the problems of availability, Soviet Bloc floppy disks and disk drives have very poor reliability. However, recent purchases of several turnkey floppy disk drive plants from the West will likely improve availability and reliability in the Soviet Bloc. [redacted]

*Magnetic Tape Drives.* The state of the art in magnetic tape drives in the USSR and Eastern Europe is 1,600 bits per inch (bpi) density with a data transfer rate of 189 KBs per second. Comparable equipment first appeared in the United States in 1966. The next improvement, 6,250 bpi at 1.25 MBs per second, has been in use in the West since 1973. When the problems of drive quality and reliability and of tape quality and availability are considered, the comparison would be even more unfavorable to the Soviet Bloc. Although models with a density of 6,250 bpi have been announced in Bulgaria and have recently been rumored to be available in the USSR, there is only limited evidence of their use

Tape drives are the external storage devices most commonly used with Soviet and East European computer systems. Given the problems with disk drives described earlier, tape drives are often the only mass memory facilities available to many civilian Soviet and East European computer users. Although the evidence is fragmentary for military installations, we believe that tape drives perform a similar function for many of these users

There is little technical or other quantifiable data available on the production and use of magnetic computer tape in the USSR and Eastern Europe. The USSR and East Germany produce magnetic tape, reportedly using Western technology and equipment. We do not know the production rates. East Germany advertises production of computer tape capable of 6,250 bpi recording density, although we have not been able to substantiate these claims. Complaints of poor quality and inadequate supplies of indigenous tape persist; users uniformly prefer Western tape, which we believe to be widely available

### Targeting the West for Advanced Hardware

[redacted] a high-priority program to acquire Western computers and their technology has been in effect since the late 1960s. During the late 1960s and early 1970s, the major emphasis was on IBM mainframe technology. Successful acquisitions, mainly illegal, led to development and production of the Ryad I and Ryad II families of IBM-compatible machines. Similarly, major acquisition targets during much of the 1970s were DEC minicomputer models, critical to Soviet production of DEC-compatible SM minicomputers. More recent Soviet emphasis has been on acquiring Western microcomputer, superminicomputer, and supercomputer technology. Although US computer technology has been the primary Soviet target, other Western countries [redacted] have also been targeted. Many of these countries produce hardware or software compatible with IBM and DEC machines and engage in other programs that are of interest to the Soviets [redacted]

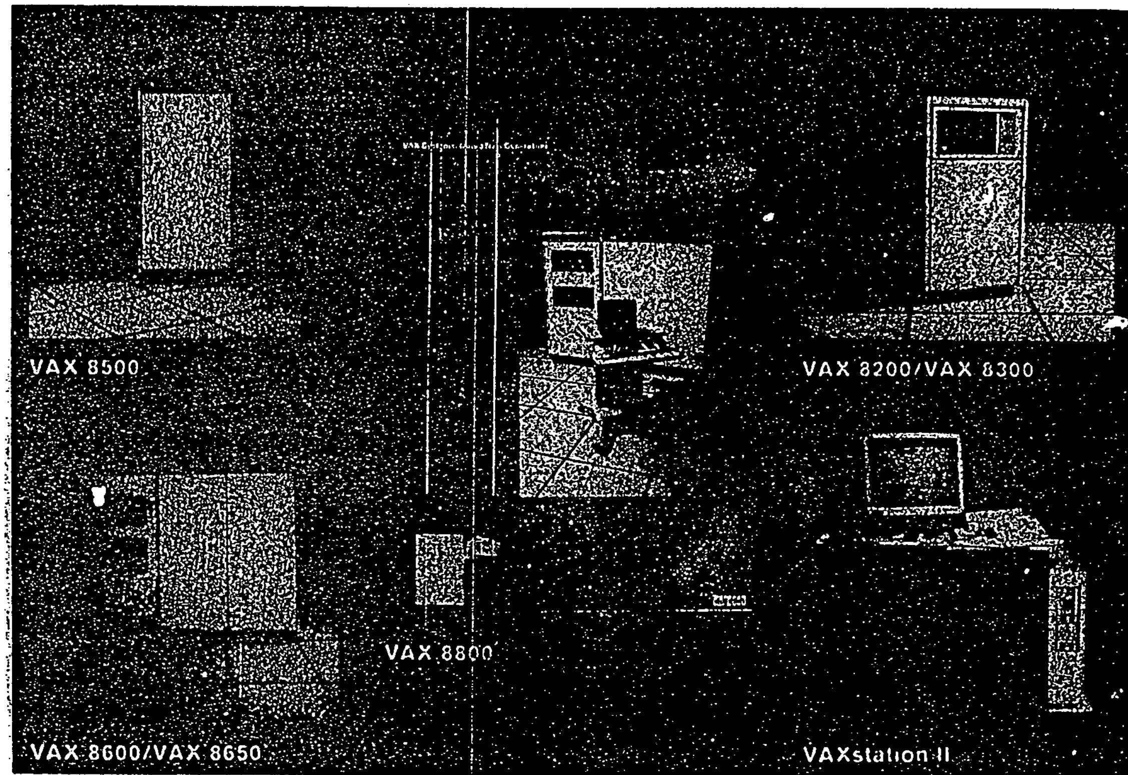



*Figure 24. VAX systems: now a new generation*

[redacted] the primary computer target for Soviet illegal acquisition in the 1980s has been the US VAX family of superminicomputers (see figure 24). The Soviets use illegally acquired VAX computers directly in military-related activities such as CAD/CAM for integrated circuits, mechanical design, and automated manufacturing. VAX superminicomputers are also used in Soviet communications and image-processing activities.

The Swedish and German seizures in late 1983 of VAX hardware, software, and related equipment destined for the USSR is a prime example of Soviet attempts to acquire computer technology. [redacted] West German and Swedish authorities detained a cargo ship at the Hamburg and Helsingborg ports, respectively, and removed various computer equipment. The equipment was originally shipped to West Germany from where it was illegally shipped on to South Africa for testing and repackaging before proceeding to the USSR. The equipment seized was valued at nearly 30 million 1983 dollars and included seven large VAX 11/780 central processing units, 300-megabyte disk drives, 70 color graphic terminals, network and other hardware, and software. On the basis of a detailed study of the hardware and software configurations, we believe advanced semiconductor research and development was the intended application.

illegal acquisition of VAX computers and legal and illegal acquisition of other computer technology have contributed substantially to Soviet computer capabilities:

- Acquisitions have allowed the Soviets to minimize their lag and develop a modern data-processing capability. By acquiring and copying Western technology, the Soviets have incorporated improvements, albeit with a substantial lag, in their computer systems.
- These copies of US computer systems have been widely used by the military.
- Illegally acquired Western systems have been used directly in high-priority military-related applications such as computer-aided-design (CAD) for weapons research and design programs

**Soviet Bloc Needs**

The Soviets will need to improve a wide variety of indigenous technologies to match Western computer developments (see figure 25). Soviet gains in central processor unit (CPU) speed, which will come primarily from denser packaging of higher speed circuits, will require Soviet advances in ICs and manufacturing technology. They will need to develop at least a moderate level of VLSI production capabilities and expand their production capacity for all types of ICs. In addition, the Soviets will need substantial improvements in their capabilities for designing and producing multilayer printed circuit boards (PCBs). As the packaging of circuits increases in sophistication, the manufacturing process also becomes more complex. This will require greater attention to quality control at each manufacturing step and increased testing during assembly.

Soviet problems in semiconductor electronics are confirmed by continuing illegal acquisition of up to 100 million relatively low-technology devices a year from the West, such as 8-bit microprocessors and 4-KB and 16-KB DRAMs. Other elements necessary for mass production of microcomputers, particularly precision production technology and automated production and test equipment, are also lacking in the USSR and continue to be priority targets for acquisition from the West.

Soviet Bloc countries will need to improve disk drive manufacturing capabilities to take advantage of any increase in computer performance. Increasing the data transfer rates and storage capacity of Soviet Bloc disk drives will require more sophisticated read-write heads, disks that are machined to higher tolerances, improved coating formulations and application methods for the magnetic media, and greatly improved quality control.

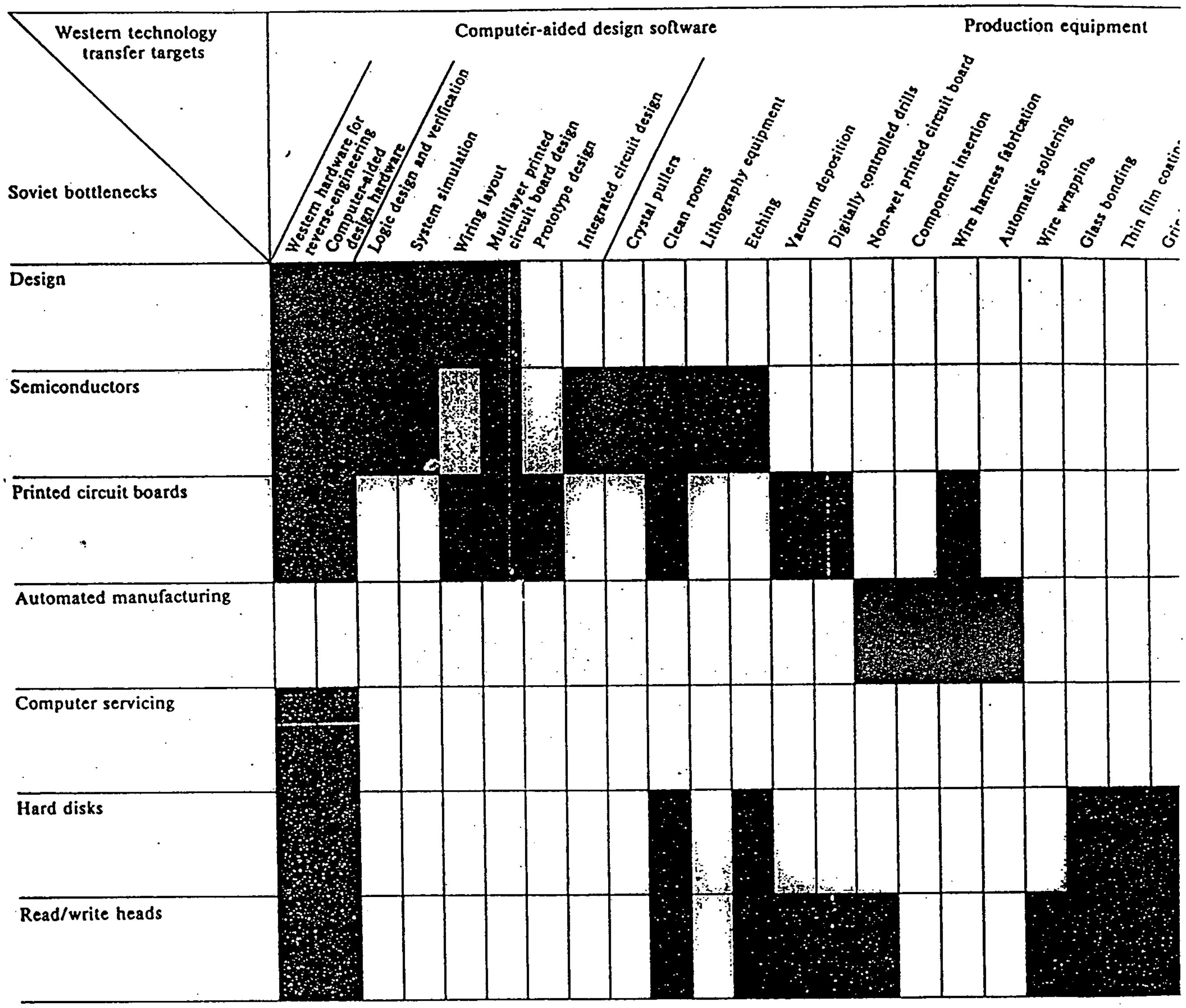
***Design Technology.*** We believe Soviet engineers will continue to depend on Western computers as their prime source of design direction. Reverse-engineering, however, will become increasingly difficult, requiring extensive adaptation and compromise. In addition, the Soviets will need state-of-the-art CAD hardware and software from the West, including:

- CAD workstations.
- Application software for:
  - Logic design and verification.
  - System simulation.
  - Wiring layout optimization.
  - Prototype design

***Integrated Circuits.*** The Soviet computer industry is constrained, in part, by gross deficiencies in the semiconductor industry. The Soviets need to increase the quality, reliability, and quantities of ICs they produce. The goal of producing millions of PCs by the early 1990s will require increased Soviet production of microprocessors and memory chips. Advances in mainframes and development of supercomputers will require faster, more reliable ICs and greatly expanded VLSI capabilities to achieve required circuit density. To meet these goals the Soviets will be targeting the West for:

- Automated crystal pullers.
- Clean room technology.
- Lithography and etching equipment.
- Epitaxial and nonepitaxial deposition equipment.
- Automated test equipment.

**Figure 25**
**Soviet Computer Technology Requirements and Western Targets**




*Reverse Blank*

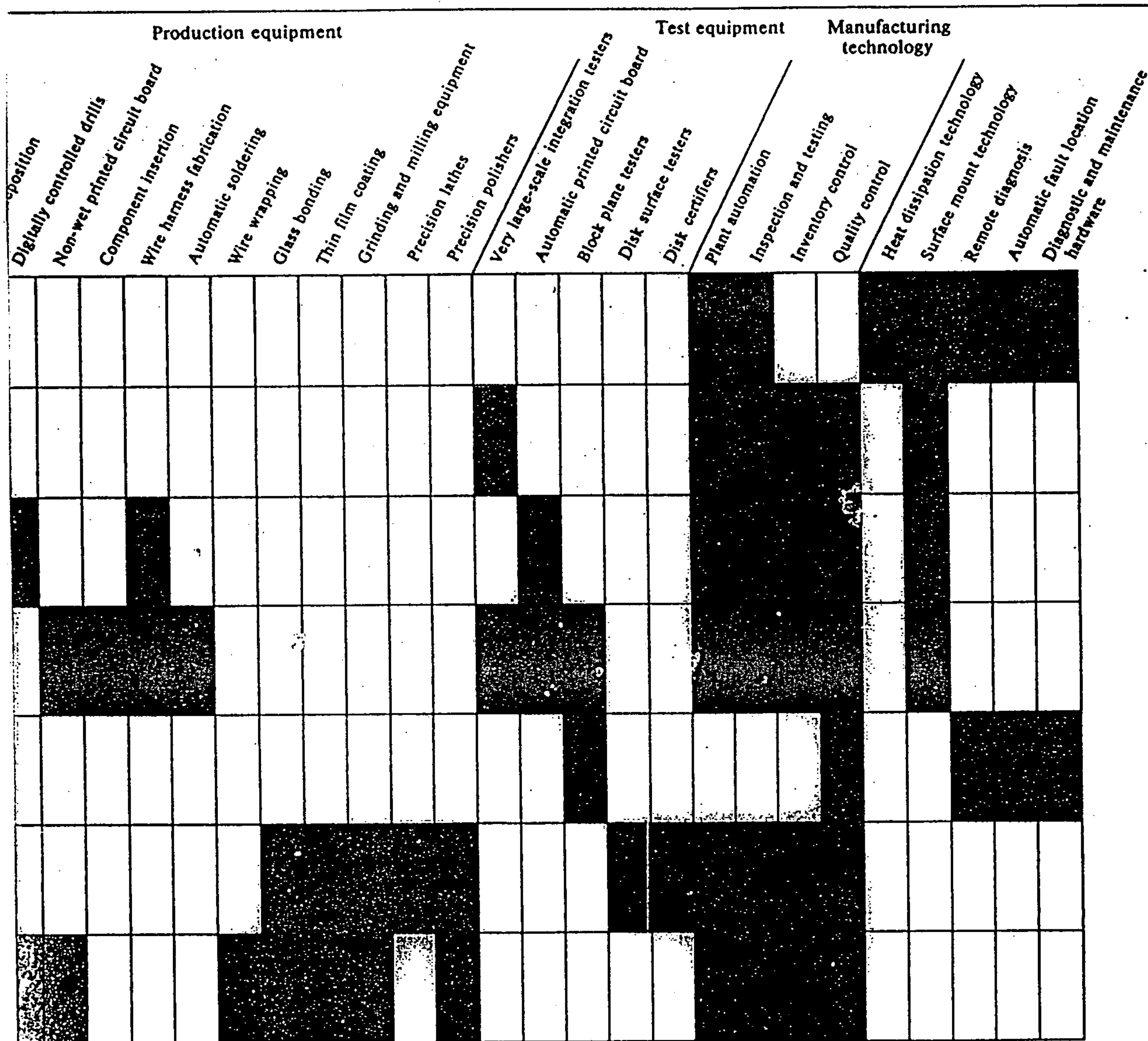

Production equipment
Test equipment
Manufacturing technology
position
Digitally controlled drills
Non-wet printed circuit board
Component insertion
Wire harness fabrication
Automatic soldering
Wire wrapping
Glass bonding
Thin film coating
Grinding and milling equipment
Precision lathes
Precision polishers
Very large-scale integration testers
Automatic printed circuit board
Block plane testers
Disk surface testers
Disk certifiers
Plant automation
Inspection and testing
Inventory control
Quality control
Heat dissipation technology
Surface mount technology
Remote diagnosis
Automatic fault location
Diagnostic and maintenance hardware

*Figure 26. Construction and testing of ES-1060 mainframe computers at Minsk Computer Plant*

***Multilayer Printed Circuit Boards.*** Matching Western computer advances will require significant Soviet advances in packaging electronic components. Essential improvements will be needed in Soviet ability to produce multilayered PCBs and to design and implement cooling techniques to dissipate the heat of densely packed ICs. The Soviets will be looking to the West for help in increasing the sophistication of PCB production and in increasing production capacity to alleviate an overall shortage. Surface mount technology for ICs will also eventually be targeted by the Soviets to achieve needed circuit density required in modern computers. Targeted Western technology will include:

- CAD software for design of multilayer boards.
- Digitally controlled multispindle drills.
- Equipment and technology for dry methods of PCB production.
- Equipment for testing multilayer boards.
- Technical know-how for dissipating heat in high-speed computers.
- Technology for surface mounting of components.

***Automated Manufacturing Technology.*** We believe that the Soviets will seek to increase the level of automation in manufacturing processes (see figures 26 to 28). Many of the Soviets' computer production problems are a direct result of poor workmanship during the manufacturing process. Automation will increase productivity and product reliability. Eventually, it will facilitate production of more advanced computers. Automated production equipment and technical know-how will be key targets in the West, which specifically include:

- Improved plant management techniques.
- Information on inspection and test procedures.
- Automated inventory control systems.
- Information on quality control.
- Equipment for automatic insertion of components.
- Automatic wire harness fabrication machines.
- Automatic soldering and wire wrapping machines.
- Automatic test equipment for:
  - Circuit boards.
  - Subassemblies.
  - Backplane wiring.

We believe joint ventures between the Soviets and Western firms offer the potential for providing much of the manufacturing know-how the Soviets need for improving computer production

*Figure 27. Mainframe construction at Minsk Computer Plant*

***Improved Computer Servicing.*** Lack of service and maintenance support severely hampers the utility of Soviet computers, according to [redacted] open Soviet literature. The Soviets will very likely attempt to incorporate various Western techniques for computer-aided servicing in future generations of computers. Western technologies of interest to the Soviets include:

- Techniques for automatic fault location and servicing.
- Techniques for performing remote diagnostics and maintenance.
- Diagnostic and maintenance hardware.
- Diagnostic and maintenance software.

***Disk Drive Production Technology.*** Disk drive production is also a critical Soviet and East Bloc deficiency. Principal difficulties lie in the integration of several precision manufacturing technologies [redacted] the difficulties include an inability to machine aluminum disks to high tolerance, formulate the metallic coating, bond the coating to the disk, maintain a clean room environment throughout the manufacturing and assembly process, obtain adequate quantities of materials and finished parts from suppliers, and test the intermediate and finished products. We believe that Soviet Bloc targeting will extend from individual pieces of production equipment to entire turnkey facilities, including technical know-how. Specific targets include:

- CAD application programs for disk drive design.
- Clean room technology.
- Glass bonding technology.
- Technology for manufacture of thin film heads:
  - —Photolithography equipment.
  - —Etching equipment.
  - —Vacuum deposition equipment.
- Oxide and binder coating technology.
- Thin film coating technology.
- Grinding and milling machines.
- Precision lathes.
- Precision polishing equipment.
- Surface finish testers.
- Disk certifiers and formatters.
- Testing and alignment equipment for finished disk assemblies

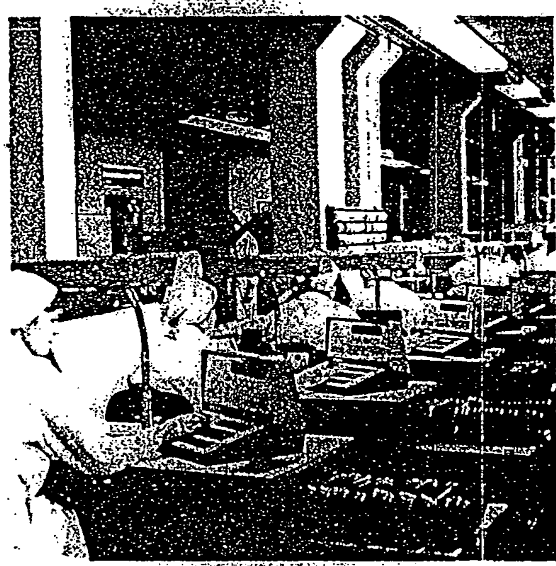


*Figure 28. Assembly of Soviet SM-3 and SM-4 minicomputers*

**Western Sources of Supply**

Over the near-term the Soviets will look to the United States, Japan, and Western Europe for the vast majority of their technology needs. However, newly industrialized countries, especially those in Asia, will become increasingly attractive targets to the Soviets for high technology. Although COCOM member countries maintain substantial leads in commercial and military computer technology, non-COCOM countries are expanding the supply of commercial computer technology. The Far East already is a major supplier of PCs to the Bloc.

The United States, Japan, and Western Europe now and for the forseeable future hold the lead in the underlying technologies that drive computer production:

- Semiconductor device and component technologies.
- Interconnect technologies.
- Mass storage technologies.
- Network and communication technologies

However, many of the newly industrialized countries are investing heavily in these and other high-technology industries. Even without state-of-the-art capabilities, these countries will become increasingly attractive targets to the Soviets as Western countries tighten export controls

The production of PCs and their peripherals in the newly industrialized countries is particularly notable. Countries such as South Korea, Taiwan, and Singapore in the Far East, as well as India and Brazil, are close to the forefront of PC technologies and can rapidly mimic Western developments. In many cases this is as a result of legal transfer of the underlying technologies by the United States and other COCOM nations.

At the other end of the computer scale, the proliferation of high-speed computers worldwide will increase Soviet prospects of reducing the Western lead in this area. Although the United States and Japan are the only sources of supercomputers, manufacturers in Western Europe will probably enter the market by the early 1990s. New manufacturers in the United States are offering wider ranges of prices and capabilities. Some machines now offer near-supercomputer capability at a fraction of the cost of traditional machines, and future developments will lead to even lower costs and higher performance.

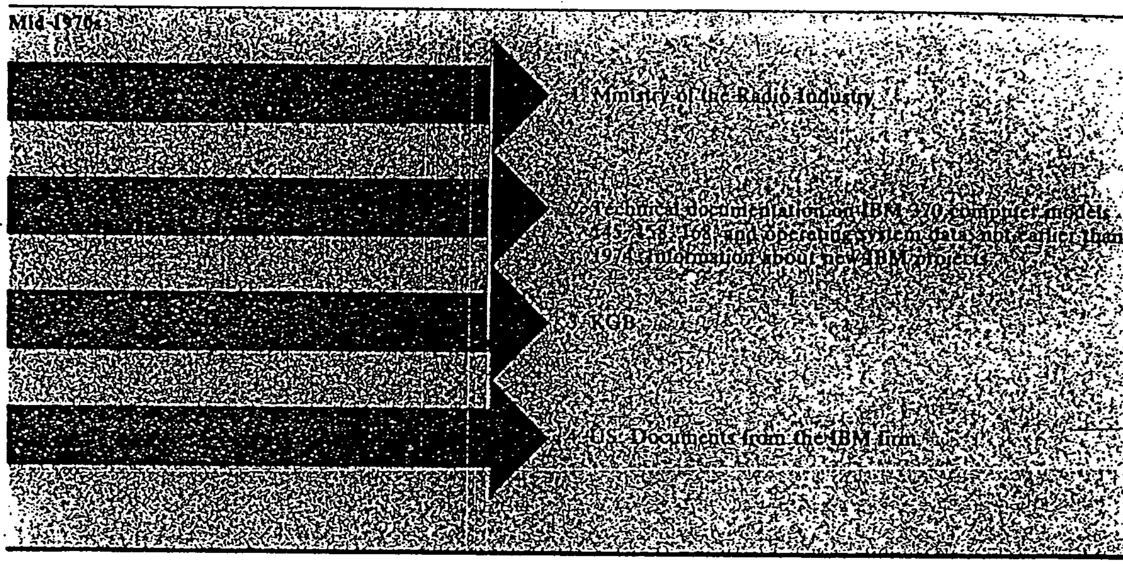
**Soviet Approaches to Acquisitions**

The Soviets' massive, well-organized campaign for acquiring Western computer technology consists of two separate programs, one managed by the Military Industrial Commission (VPK) and one by the Ministry of Foreign Trade. The VPK program, primarily working through intelligence channels, seeks computer hardware, blueprints, product samples, and test equipment that will help Soviet designers reverse-engineer Western computers. Figure 29 shows a typical VPK requirement that targeted technical documentation on the IBM 370 system, information that was eventually used in the design of Soviet Ryad II mainframes.

The Ministry of Foreign Trade administers a trade diversion program to acquire manufacturing and test equipment to improve production capabilities. This program depends largely on Western traders to provide the Soviets with Western technology, ranging from individual computers to entire turnkey production lines for semiconductors, disk drives, or printed circuit boards. We believe Soviet computer advances will depend heavily on the Soviets' ability to acquire and use Western production technology

When possible, the Soviets will seek to purchase entire turnkey plants. Embargoed Western computer hardware and software, particularly for CAD/CAM, will directly support the Soviet Bloc computer industry in the research laboratory and on the manufacturing floor. East Germany makes extensive use of DEC VAX computers and Tektronix workstations in their reverse-engineering of Western hardware. In addition, Western computer hardware will continue to give the Soviets' research and development direction and serve as a benchmark for Soviet measurement of their indigenous computer developments

**Figure 29**
**VPK Requirement Targeting IBM 370 Technical Documentation**




In addition to the "traditional" methods of technology acquisition, *glasnost* has created new opportunities for the Soviets. For instance, joint ventures with Western firms offer a potential avenue for acquiring a wide variety of Western technology. Even joint ventures for production of relatively unsophisticated computers will provide the Soviets with management and production know-how that will benefit the manufacture of more sophisticated items.

Although many joint ventures are being discussed, only a few minor agreements have been signed, according to intelligence and open press reporting. Western businesses appear to be encountering the traditional problems in negotiating with the Soviets, including access to Soviet markets, convertibility of ruble profits, legal jurisdiction, and other operational matters. The ultimate value of joint ventures to the Soviets will depend on how successful they are in working out these problems.

Joint ventures offer the potential for not only providing the Soviets with Western production know-how, but also give them a Western partner who could serve as a conduit for Western production equipment and semiconductors [redacted] virtually every joint venture calls for initial production to be dependent on imported Western components. For example, in early 1988 the Soviet Ministry of Instrument Making, Automation Equipment, and Control Systems (Minpribor) was seeking a Western partner to cooperate in designing and manufacturing a new series of PCs in the USSR. [redacted] the Soviets want to develop:

- A design center for PC components and microelectronic devices.
- CAD software to support product design.
- A printed circuit board fabrication facility.
- A printer assembly facility.
- A hard disk drive manufacturing facility.
- An automated PC assembly facility for 50,000 units a year.

These developments will support the manufacture of a new, three-model series of PCs. The primary model is to be configured as a CAD workstation and will be IBM compatible. A further requirement is support for parallel development of more advanced products to prevent future reliance on obsolete technology.

The Soviets will also have access to an ever expanding market of used high-technology equipment for satisfying many of their Western technology requirements. This equipment ranges from computer hardware to production equipment. As an example, much of the Western production equipment supplied to the Bulgarians for hard disk production at Stara Zagora was secondhand.

There is great incentive for the Soviets to purchase used Western technology, particularly computers. Although the computers are considered "outdated" by Western standards, in reality they are very likely only 3 to 5 years old—making the used Western computers several years more advanced than what the Soviets can produce indigenously. Prices for used computers are typically a fraction of that for new computers—for instance, used VAX 11/750s that listed new at $90,000 sell used for as little as $15,000. In addition, it is easier to divert secondhand computers, particularly those originally sold new to European end users. [redacted] US reexport licensing requirements are virtually ignored by European secondhand computer sellers. [redacted] allege that falsification of end users in export licenses is so common that listing a destination in Austria or Switzerland for a used computer is almost assumed by them to be a diversion.

## Outlook for Civilian and Military Programs

On the basis of past performance and of our current assessments of Soviet technological capabilities, we expect the Soviets to fall further behind the West in computing capabilities throughout the 1990s. In our view, the Soviet bureaucracy will find it difficult, despite Gorbachev's modernization program, to take the necessary steps to correct many of the computer industry's well-recognized problems. Therefore, we expect Soviet reliance on US and Western computer technology to persist and illegal acquisition attempts to continue. If the Soviets obtain turnkey production facilities or detailed production know-how from the West—as they have done in the past—they may be able to narrow, at least temporarily, a specific technology gap

Recent organizational changes and innovations designed to address some of the problems of the industry have been largely unsuccessful. In 1986 the State Committee for Computer Technology and Informatics (GKNTI) was established to foster coordinated computer production and applications. The Department of Informatics, Computer Technology, and Automation of the USSR Academy of Sciences will attempt to focus and concentrate fundamental research in information technologies. Also, 21 All-Union Scientific Complexes (MNTKs) were created to speed up the process of innovation in the Soviet economy. The MNTK for PCs is charged with organizing and coordinating the development and production of PCs to meet the total requirements of the national economy. Success demands the nearly impossible task of coordinating the efforts of 34 different ministries—four that develop and produce computers and 30 others that make materials, parts, and components for them

We believe that in the future the Soviets will be forced to incorporate more advanced technology into their weapon systems to stay competitive with Western military developments. Without significant advances in computer technology, the performance and reliability of these future Soviet weapons systems could be jeopardized. For example, Moscow's ability to develop or acquire advanced computer technology will have a direct impact on its ability to deploy improved antiballistic missile radars for reentry vehicle discrimination and multiple target handling. Soviet capability to design and produce composite materials for the next generation airborne and space vehicles depends indirectly on modern computers in the laboratory and on the plant floor.

The weapon systems most directly affected will be those that require fast computers with large main memory, fast disk drives, and the ability to exchange data with other computers. Examples include command, control, communications, and intelligence ($C^3I$) support on the front and theater level, mobile command and control systems, intelligence and dissemination systems, and airborne warning and control system (AWACS). Other weapon systems such as tanks, planes, missiles, and tactical communications are dependent on computers in a less direct way. These systems incorporate microprocessors, memory chips, and other ICs that generally require computers to design them.

Engineering workstations are needed to implement computer-aided technologies—such as CAD, CAM, and computer-aided testing—which are key elements in modernization of the Soviet military and civilian aviation industry. Soviet managers and military leaders have become increasingly conversant with the role that CAD can have on improving the availability, reliability, and performance of weapon systems, while reducing the human and material resource requirements.

Implementing increased CAD usage will require not only engineering workstations but also a computer-literate work force that can take advantage of them. Without large numbers of computers for education, the Soviets cannot implement their plans for extensive training programs to prepare engineers, designers, and technicians working in CAD, CAM, and CAE (computer-aided engineering), as well as computerized management information systems. These programs will require significant development efforts and substantial improvements in the quantity and quality of production of Soviet computer equipment.

# Appendix

## Tables of Computer Parameters

**Table 1**
**USSR: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| Agat | K588 | 8 | | Apple II |
| Elektronika BK 0010 | K181 | 8 | 16 to 32 | |
| Elektronika DZ 28 | K580 | 8 | 16 to 32 | |
| Elektronika MS 1201 MS 1211 MS 1212 | K1801 | 16 | 64 to 256 | |
| Electronika NTS-80-20 | K1801 | 16 | 56 | |
| Elektronika 60 ES-1840 ES-1841 | K581 | 16 | 56 | |
| Iskra 123 | | 16 | | |
| Iskra 124 | | 16 | | |
| Iskra 2106 | K580 | 8 | 4 to 16 | |
| Iskra 23 | K580IK80 | 8 | | |
| Iskra 250 | K1810 | 16 | 64 to 256 | IBM PC |
| Kristall 60 | K580IK80 | 8 | | |
| ME-80 | 8080 | 8 | | |
| Neva 501 | K580 | 8 | 4 to 32 | |
| PS-305 | K155, K556RE4 | 12 | | |
| PS-310 | | 16 | | |
| PS-315 | K589 | 16 | | |
| Radio-86RK | KR580IK80A | 8 | 128 to 256 [b] | |
| SM-11 | K536IK1 | 16 | | |
| SM-12 | K536IK1 | 16 | | |
| SM-1300 | | 16 | 512 | |
| SM-1800 | K580 | 8 | 64 to 128 [b] | |
| SM-1810 | K1810VM86 | 8 | 1,024 [b] | |
| SO-04 | KR580 | | | |
| UVS-01 | KR580IK80 | 8 | | |
| V7 | KR580IK80 | 8 | | |
| VEF Mikro 1021 | K580 | 8 | 16 to 64 | |
| VM 03 | U8000 | 16 | | |

[a] All Soviet.
[b] As published; technically, an 8-bit microprocessor can only address, directly, 64 kilobytes of memory.

**Table 2**
**Czechoslovakia: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| Consul 2710 | MHB 8080 [a] | 8 | 16 to 48 | |
| Consul 2712 | MHB 8080 [a] | 8 | | |
| Consul 2713 | MHB 8080 [a] | 8 | | |
| Consul 2714 | MHB 8080 [a] | 8 | | |
| IQ 150 | 8080 | 8 | 128 to 256 [b] | |
| IQ 151 | MHB 8080 [a] | 8 | 32 to 64 | |
| MARS (SM 53/10) | MHB 8080 [a] | 8 | | |
| Mikromodus 530 | MHB 8080 | 8 | 16 to 216 [b] | |
| MMS 800 | MHB 8080 [a] | 8 | | |
| MMS 810 | MHB 8080 [a] | 8 | 32 to 384 [b] | |
| MVS 810 | MHB 8080 [a] | 8 | 4 to 48 | |
| PMD 85 | MHB 8080 [a] | 8 | 48 | HP 85 |
| SM-01 | 8080 | 8 | 256 [b] | |
| SM-02 | | | 320 to 512 | |
| SM-03 | | 8 | 480 [b] | |
| SM-2138 | 8080 | 8 | | |
| SM-50/40-1 | | 8 | 520 | |
| SMEP PP 02 | MHB 8080 [a] | 8 | 40 to 64 | |
| SMEP PP 03 | MHB 8080 [a] | 8 | 64 | |
| SMEP PP 06 | 8080 | 8 | 256 [b] | IBM PC |
| SMEP SP 01 | MHB 8080 [a] | 8 | 32 | |
| TEKST 01 (SM 6915) | MHB 8080 [a] | 8 | 64 | |
| TEMS 8000 PAS | 8080 | 8 | | |
| TNS | U880 [c] | 8 | | |

[a] Czechoslovak.
[b] As published; technically, an 8-bit microprocessor can only address, directly, 64 kilobytes of memory.
[c] East German; all others are United States.

**Table 3**
**East Germany: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| A5120.16 | U880 and 8000 | 16 | 256 | |
| A5510 | U880 | 8 | 64 | |
| A-6401 (K 1620) | U830 | 16 | 512 | |
| A-6421 (K 1620) | U830 | 16 | | |
| A-6422 (K 1630) | | | | |
| A-6491 (K 1630) | | | | |
| A-6492 (K 1630) | | | | |
| A-7100 | K1810 [a] | 16 | 256 | |
| HC 900 | U880 | 8 | 32 | |
| K-1510 | U808D | 8 | 128 [b] | |
| K-1520 | U880D | 8 | 512 [b] | |
| K-1610 | U830 | 16 | | |
| K-1620 | U830 | 16 | | |
| K-8922 | U880 | 8 | 64 | |
| KC 85 | U880 | 8 | 16 to 64 | |
| MMS 16 | K1810VM86 [a] | 16 | | |
| R-1715 (SM 1904) | U880 | 8 | 64 | |
| Robotron ZE-1 | U880D | 8 | | |
| SM-1630 | | 16 | 1,024 | |
| SM-50/10-1 | | 8 | 128 [b] | |
| Z9001 | U880 | 8 | 16 | |
| 16 bits | U8000 | 16 | 128 to 512 | |
| EC 1834 | K1810 | 16 | 64 to 256 | IBM PC |

[a] Soviet; all others are East German.
[b] As published; technically, an 8-bit microprocessor can only address, directly, 64 kilobytes of memory.

**Table 4**
**Hungary: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| Agrinfo 100 | U880 [a] | 8 | 64 | |
| Aircomp-16 | Z80A | 8 | | |
| Aircomp-32 | Z80 | 8 | | |
| Aircomp-64 | U880 [a] | 8 | 64 | |
| Alfa-X | Z80 | 8 | 16 | |
| AX-II | 6502 | 8 | 48 to 256 [b] | Apple II |
| Buro-X | Z80 | 8 | 64 | |
| Comp-X | Z80 | 8 | 64 | |
| Comput-80 | 8080 or Z80 | 8 | 512 [b] | |
| Control M884-W | Z80 | 8 | 64 | |
| Cosy Fama | U8000 [a] | 16 | 512 to 4,096 | |
| Cosy Famulus | U8000 [a] | 16 | 512 to 1,024 | |
| CTX 80 | Z80 | 8 | 64 | |
| Data Star | 80286 | 16 | 512 to 1,024 | IBM PC/AT |
| Eaststar | 8088 and M68000 | 8 and 16 | 1,024 | |
| EMG-777 | AM2901 and Intel 8085 | 8 | 128 [b] | |
| Emily | Z80 | 8 | 64 | |
| EMU-11 | 3000 | | | |
| ES 1833 | 8088 | 8 | | |
| Floppyline E | F8 | 8 | 32 to 512 [b] | |
| Floppymat SP | F8 | 8 | 192 to 512 [b] | |
| Homelab-3 | Z80A | 8 | 16 to 64 | |
| Homelab-II | Z80A | 8 | | |
| HT-1080Z | Z80 | 8 | 512 [b] | |
| HT-1080Z/64 | U880 [b] | 8 | | |
| HT-680X CDP | SM-601 [c] | 8 | 512 to 4,096 [b] | |
| IM 16 | 8088 and M68000 | 8 and 16 | 2,048 | |
| IPT 002 | Z80 | 8 | 16 to 64 | |
| Komat | | 8 | | |
| Master | 8085 | 8 | 398 [b] | |
| MAT | 80286 | 16 | 512 to 3,072 | IBM PC/AT |
| MFB | U880 [a] | 8 | | |
| MGP-80 | 8080 | 8 | 64 to 512 [b] | |
| Mickey-80 | Z80 | 8 | 128 [b] | |
| Microcontrol 84 | Z80 | 8 | 64 | |
| Microcontrol 86 | 8086 | 16 | 256 | IBM PC |
| Microstar 1103 | K1801 [d] | 16 | 64 | |
| Microtest 2 | | 8 | | |
| Minimod | U880 [a] | 8 | 32 to 64 | |
| MMT | Various | 8 | | |

**Table 4 (continued)**
**Hungary: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| Mobi-X | 8085 | 8 | 2 | |
| Motra | SM-601 [c] | 8 | | |
| MS 600 | U880 [a] | 8 | | |
| MS 700 | Various | 8 | 1,024 [b] | |
| Multi Center | Z80 | 8 | 256 [b] | |
| Multi WS | M68000 | 16 | 256 | |
| MXT | 8088 | 8 | 256 [b] | |
| N 68 | SM-601 [c] | 8 | | |
| Nez 215 | | 8 | 64 | |
| Norax 64 | Z80 | 8 | 64 | |
| OBC 64 | SM-601 [c] | 8 | | |
| ODS 6800 | SM-601 [c] | 8 | 96 to 192 [b] | |
| OL 622/1 | 8080 | 8 | | |
| PDV-38 | Z80 | | | |
| Primo | U880 [a] | 8 | 16 to 48 | |
| Pro/Primo | Z80 | 8 | 64 | |
| Procom 16 | | 16 | 1,024 to 4,096 | |
| Professor | M68000 | 16 | 16 to 16,384 | |
| Profi-8 | U880 [a] | 8 | 512 to 16,000 [b] | |
| Profi PC | 8088 | 8 | 256 [b] | |
| Prolocon | 8085 | 8 | 64 | |
| Proper-16M | 8088 | 8 | 256 [b] | |
| Proper-16W (ES 1833) | 8088 | 8 | 32 | |
| PTA-4000 + 16 | 5801 | 8 | | |
| RAAB-80 | Z80A | 8 | 64 | |
| RAAB-84 | Z80A | 8 | 64 | |
| RAAB-86/AT | 80286 | 16 | | |
| Rosy-80 | Z80 | 8 | | |
| SAM-80 | 8080A | 8 | | |
| SAM-85 Mirko | 8085 | 8 | | |
| Samds | 8085 | 8 | 64 | |
| Sam-E-DS | 8085 | 8 | 62 | |
| Slave | 8085 | 8 | 62 | |
| SLK-80 | U880 [a] | 8 | | |
| SLK-80/A | Z80 | 8 | | |
| SM-1633 (MERA 660) | 8086 | 16 | 64 | IBM PC |
| Super XT | 8088 | 8 | 256 [b] | IBM PC/XT |
| Syster | Z80 | 8 | 512 [b] | |
| Szamszov | 80286 | 16 | | |
| TM 16 | M68000 | 16 | 256 to 1,024 | |
| TPA-11/170 | AM 2900 | 8 | 64 | |

**Table 4 (continued)**
**Hungary: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| TR-80 | 8085 | 8 | | |
| Transmic-16 | M68000 | 16 | 2,048 to 8,172 | |
| Transmic-8 | Z80 | 8 | 256 [b] | |
| TRDS | 8085 | 8 | 64 | |
| Trousmc 16 | M68000 | 16 | 256 to 1,024 | |
| TV Computer | U880 [a] | 8 | 32 to 64 | |
| TZ 80 | Z80 | 8 | 256 [b] | |
| Varyter | Z80A | 8 | 512 [b] | |
| Varyter XT | 8088 | 8 | 256 to 704 [b] | IBM PC/XT |
| Videoplex 3 | | 16 | 544 | |
| VM 02 | U8001 [a] | 16 | 128 to 256 | |
| Volan | Z80 | 8 | 64 | |
| VPC | U880 [a] | 8 | | |
| VT 16 | 8088 and Z80 | 8 | 256 [b] | |
| VT 32 | M68000 | 16 | 512 to 2,048 | |

[a] East German.
[b] As published; technically, an 8-bit microprocessor can only address directly 64 kilobytes of memory.
[c] Bulgarian; all others are US.
[d] Soviet.

**Table 5**
**Poland: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| AC 825 | U880 [a] | 8 | 48 | |
| Compan | MCY7880 [b] | 8 | 64 | |
| Complex XT | 8088 and 8087 | 8 | 128 to 1,024 [c] | IBM PC/XT |
| CS 80 | U880 [a] | 8 | 64 | |
| CS 88 PC | 8088 and 8087 | 8 | 64 to 640 [c] | IBM PC |
| ELWRO-500 | MCY7880 [b] | 8 | 512 [c] | |
| ELWRO-600 | 8080 | 8 | 64 | |
| ELWRO-700 | U880 [a] | 8 | 16 to 48 | |
| ELWRO-800 | 8088 | 8 | 256 [c] | IBM PC |
| EMIX-86 | 8086 | 16 | 128 to 640 | IBM PC |
| IMP 85 | 8085A | 8 | 64 | |
| IMP 86 | 8088 and 8087 | 8 | 128 to 640 [c] | IBM PC |
| Mazovia-1016 | | 16 | 512 | |
| Meritum-1 | Z80 | 8 | 128 [c] | |
| Meritum-2 | U880 [a] | 8 | 18 | TRS 80 |
| Mevax 6600 | Intel 8088, 8087 | 16 | 512 | |
| Mevax 86 | 8088 and 8087 | 8 | 64 to 640 [c] | IBM PC |
| MK 4501/2 | 8085 | 8 | 64 | |
| MPC | 8085 | 8 | 64 to 512 [c] | |
| MSA 80 | MCY 7880 b | 8 | 64 to 512 [c] | |
| Neptune 184 | 6502 | 8 | 32 | |
| Quasar PC | 8086 | 16 | 64 | IBM PC |
| Rosa | 8080 | 8 | | |
| RTDS 8 | 8085 | 8 | 16 | |
| Solum | | 8 | | |
| Star PC/XT | 8088 and 8087 | 16 | | |
| START PC/XT | 8088 and 8087 | 8 | 64 to 640 [c] | IBM PC/XT |
| ZLA-01 | MCY 7880 [b] | | | |
| ZX 81 | U880 [a] | 8 | 1 to 64 | |

[a] East German.
[b] Polish; all others are US.
[c] As published; technically, an 8-bit microprocessor can only address directly 64 kilobytes of memory.

**Table 6**
**Bulgaria: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| BALIK | SM-601 [a] | 8 | 16 to 64 | |
| BK-1000 | M6800 | 8 | | |
| EMK-11 | SM-600 [a] | 8 | | |
| ES-1831 | 8086 | 16 | | |
| ES-1832 | 8088 | 8 | 256 [b] | IBM PC |
| IMKO-1 | 8080 | 8 | | |
| IMKO-2 | SM-600 [a] | 8 | | |
| IMKO-3 | SM-600 [a] | 8 | 8 to 64 | Apple II |
| IMKO-4 | 8088 | 8 | 256 to 512 [b] | |
| Intelext | 8088 | 8 | 640 [b] | IBM PC/XT |
| Interlab 1610 | M68000 | 16 | | |
| Interlab 1620 | M68000 | 16 | | |
| IZOT 1029 | SM-601 [a] | 8 | 32 | |
| IZOT 1030 | K1810 [c] | 16 | 192 to 1,024 | |
| IZOT 1031 | U880 [d] | 8 | | |
| IZOT 1035 | SM-601 [a] | 8 | 32 | |
| IZOT 1036 | 8088 | 8 | 64 to 256 [b] | IBM PC |
| IZOT 1037 | 8088 | 8 | 64 | IBM PC/XT |
| IZOT 1039 | K1801 [c] | 16 | 64 to 512 | DEC PDP |
| IZOT 1041 | SM-601 [a] | 8 | 64 | |
| IZOT 1060 | K1801 [c] | 16 | 64 | |
| IZOT 1832 | 8086 | 16 | 64 to 256 | IBM PC |
| MIC 16A | 8088 | 8 | 64 to 256 [b] | IBM PC |
| Orgtech 80/600 | Z80 and M6800 | 8 | 64 | |
| Pravetz 8B | SM-600 [a] | 8 | 64 | Apple II |
| Pravetz 8D | U880 [d] | 8 | 16 | |
| Pravetz 8M | SM-600 [a] | 8 | 64 | Apple II |
| Pravetz 16 | 8088 | 8 | 64 to 256 [b] | IBM PC |
| Pravetz 16C | 8088 | 8 | 256 [b] | IBM PC |
| Pravetz 16MN | 8088 | 8 | 256 [b] | IBM PC |
| Pravetz 16N | 8088 and 8087 | 8 | | IBM PC |
| SM 650 | SM-650 [a] | 8 | 64 | |
| Super 11 | 8088 | 16 | 512 | |

[a] Bulgarian.
[b] As published; technically, an 8-bit microprocessor can only address directly 64 kilobytes of memory.
[c] Soviet.
[d] East German; all others are US.

**Table 7**
**Romania: Selected Microcomputers**

| Model | Microprocessor [a] | Word Length (*bits*) | Memory (*kilobytes*) | Compatibility With US Model |
|---|---|---|---|---|
| AMIC | Z80 | 8 | 256 [a] | |
| CA 109 | 8080 | 8 | | |
| CEN-80 | 8080 | 8 | | |
| DAF 2015 | 8080 | 8 | | |
| Felix C-32 | | 8 | 524 [a] | |
| Felix M118 | K580 [b] | 8 | 16 | |
| Felix M216 | 8086 | 16 | 128 to 1,024 | |
| M80 | 8080 | 8 | | |
| PRAE 1000 | 8080 | 8 | | |
| PRIM XX | 8080 | 8 | | |

[a] As published; technically, an 8-bit microprocessor can only address directly 64 kilobytes of memory.
[b] Soviet; all others are US.

**Table 8**
**USSR/Eastern Europe: Minicomputers and Superminicomputers**

| Model | Producer | Comparable Equipment | Word Length (*bits*) | Speed (*thousands of operations per second*) | Memory (*bytes*) | First Delivered |
|---|---|---|---|---|---|---|
| **Minicomputers** | | | | | | |
| SM-I family | | | | | | |
| SM-1 | USSR | HP 21XX | 16 | 130 | 8 to 64 | 1978 |
| SM-2 | USSR | HP 21XX | 16 | 154 | 64 to 256 | 1978 |
| SM-3 | USSR, Czechoslovakia, Poland, Romania | PDP-11/05 | 16 | 175 | 64 to 512 | 1977 |
| SM-4 | USSR, Czechoslovakia, Bulgaria, Poland | PDP-11/40 | 16 | 280 | 64 to 248 | 1979 |
| SM-5 | USSR | PDP-11/34 | 16 | 400 | 32 to 512 | 1983 |
| SM-II Family | | | | | | |
| Elektronika-60 | USSR | LSI-11/2 | 16 | 250 | 4 to 8 | Early 1980s |
| Elektronika-79 | USSR | | 16 | 3,000 | 4 | |
| Elektronika-100 | USSR | PDP-11/40 | 16 | 800 | 1982 | |
| Elektronika-1211 | USSR | | 16 | 890 | 64 to 256 | |
| MERA-400 | Poland | | 16 | 500 | 128 | Late 1970s |
| MERA-60-15 | Poland | LSI-11/40 | | | | |
| Procom-6 | Hungary | PDP 11 | 16 | | 1,024 to 2,048 | |
| SM-1210 | USSR | | 16 | 1,000 | 4,096 | 1986 |
| SM-1403 | USSR | | 16 | | 26 | 1985 |
| SM-1410 | USSR | PDP-11 | 16 | | | 1981 |
| SM-1420 | USSR | | 16 | 1,000 | 682 to 2,670 | 1983 |
| SM-1600 | USSR | | 16 | | 682 to 2,670 | 1983 |
| SM-1644 | USSR | | 16 | 450 | 60 to 8,192 | |
| SM-50-3 | Poland | LSI-11/40 | 16 | | | 1983-84 |
| SM-50/40-1 | Czechoslovakia | | 8 | | 520 | 1982 |
| SM-50/40-2 | East Germany | | 8 | | 512 to 1,000 | |
| SM-50/50-1 | Czechoslovakia | PDP-11/34 | 16 | 370 | 512 to 4,096 | 1984 |
| SM-50/50-3 | Poland | LSI-11/2 | 16 | | 1 to 8 | 1983-84 |
| SM-50/60 | USSR | | 16 | | ? to 128 | 1984 |
| SM-52/11 | Bulgaria | PDP 11/60 | 16 | 2,000 | 1,024 to 2,048 | 1983 |
| SM-53/50 | USSR | | 16 | 1,000 | 4,096 | Early 1980s |
| TPA-11/40 | Hungary | PDP 11/40 | 16 | | 64 to 256 | 1976 |
| TPA-1148 | Hungary | PDP | 16 | | 256 to 4,096 | 1982 |
| TPA-70 | Hungary | | 16 | | 64 | Mid-1970s |
| **Superminicomputers** | | | | | | |
| SM-52/16 | Bulgaria | 11/750 | 32 | | | |
| SM-52/12 (SM-1505) | Czechoslovakia | 11/780 | 32 | | 2,000 to 8,000 (16-kilobyte chips) | 1987 |
| TPA-11/440 | Hungary | | 32 | | 4,000 | |
| TPA-11/540 | Hungary | 11/730 | 32 | | | |
| TPA-11/580 | Hungary | 11/780 | 32 | | 2,000 to 32,000 (64-kilobyte chips) | |
| K-1840 | East Germany | 11/780 | 32 | | 2,000 to 16,000 | |
| Elektronika-82 | USSR | 11/750 | 32 | | | |

**Table 9**
**USSR/Eastern Europe: Ryad Mainframe Computers**

| Model | Producer | Family | Comparable Equipment | Speed (*thousands of operations per second*) | Memory (*megabytes*) | First Delivered |
|---|---|---|---|---|---|---|
| ES 1010 | Hungary | Ryad I | | 5.0 | 0.008 to 0.064 | 1973 |
| ES 1011 | Hungary | Ryad I | | | ? to 1 | 1981 |
| ES 1012 | Hungary | Ryad I | | 6.0 | ? to 1 | |
| ES 1015 | Hungary | Ryad II | IBM 370/115 | 16 | 0.064 to 0.256 | 1983 |
| ES 1017 | Hungary | Ryad III | | | | |
| ES 1020 | USSR, Bulgaria | Ryad I | IBM 360/30 | 16 | 0.064 to 0.256 | 1973 |
| ES 1021 | Czechoslovakia | Ryad I | IBM 360/30 | 28.5 | 0.016 to 0.064 | 1973 |
| ES 1022 | USSR, Bulgaria | Ryad I | IBM 360/ 22,/30,/50 | 80.0 | 0.128 to 1 | 1975 |
| ES 1025 | Czechoslovakia | Ryad II | IBM 370/125 | 35 | 0.128 to 0.256 | 1981 |
| ES 1026 | Czechoslovakia | Ryad II | IBM 370/125 | 50 | 0.128 to 0.512 | 1983 |
| ES 1027 | Czechoslovakia | Ryad III | | 400 | ? to 2 | 1985 |
| ES 1030 | USSR, Poland | Ryad I | IBM 360/40 | 80.0 | 0.128 to 0.512 | 1973 |
| ES 1032 | Poland | Ryad I | IBM 360/ 40,/50,/135 | 210 | 0.128 to 1 | 1975 |
| ES 1033 | USSR | Ryad I | IBM 370/ 135-145 | 170 | 0.256 to 0.512 | 1977 |
| ES 1035 | USSR, Bulgaria | Ryad II | IBM 370/135 | 150 | 1 to 2 | 1981 |
| ES 1036 | USSR | Ryad II | IBM 370 | 300 | 2 to 4 | 1984 |
| ES 1037 | USSR, Bulgaria | Ryad III | | 500 | ? to 4 | |
| ES 1040 | East Germany | Ryad I | IBM 360/ 50 | 350 | 0.512 to 1 | 1973 |
| ES 1045 | USSR, Poland | Ryad II | IBM 370/145 | 650 | 0.256 to 3 | 1981 |
| ES 1046 | USSR | Ryad II | IBM 370/148 | 1,000 | 4 to 6 | 1985 |
| ES 1050 | USSR | Ryad I | IBM 360/ 50,/75 | 500 | 0.256 to 1.025 | 1975 |
| ES 1052 | USSR | Ryad I | BM 360/ 65-75 | 700 | ? to 1 | 1980 |
| ES 1055 | East Germany | Ryad II | IBM 370/155 | 475 | 0.256 to 4 | 1979 |
| ES 1055M | East Germany | Ryad II | IBM 370/158 | 450 | 1 to 4 | 1981 |
| ES 1056 | East Germany | Ryad II | IBM 370? | 505 | 2 to 4 | 1986 |
| ES 1057 | East Germany | Ryad III | IBM 43XX, 303X? | 1,000 | 16 | 1988 |
| ES 1060 | USSR | Ryad II | IBM 370/165 | 1,200 | 1 to 8 | 1979 |
| ES 1061 | USSR | Ryad II | IBM 370/168 | 1,500 | 1 to 8 | 1984 |
| ES 1065 | USSR | Ryad II | IBM 3033 | 4,500 | 2 to 16 | 1983 |
| ES 1066 | USSR | Ryad III | | 5,500 | 6 to 16 | 1986 |
| ES 1067 | USSR | Ryad III | IBM 3032 | | | |
| ES 1068 | USSR | Ryad III? | | | | 1988 |
| ES 1077 | USSR | Ryad III | | 100,000 with array processor | | |
| ES 1087 | USSR | Ryad III | IBM 3081 | | | |

**Table 10**
**USSR: High-Speed Scientific Computers**

| Model | Producer | Comparable Equipment | Claimed Speed (*millions of operations per second*) | Estimated) Effective Speed (*MFLOPS* [a]) | Memory (*megabytes*) | First Delivered |
|---|---|---|---|---|---|---|
| BESM-6 | USSR | CDC 3600? | 1.0 | 0.3 | 0.8 | 1966 |
| M-10 | USSR | | 5.0 | 0.7 | 5 | 1979 |
| Elbrus-1 (1 processor) | USSR | Burroughs 6700, 6800 | 1.5 | 0.8 | 4.5 | 1978 |
| Elbrus-1 (10 processors) | USSR | Burroughs 6700, 6800 | 12.5 | 1.4 | | |
| Elbrus-2 | USSR | Burroughs 6700,6800 | 150 | 10 to 15 | | 1986-87 |
| Elbrus-3 | USSR | | 1,000 | | | |
| IZOT 1703 | USSR/Bulgaria | | 60 | | | 1987? |
| ES 1766 | USSR | | 100 | | | 1987? |

[a] Millions of floating point operations per second.

**Table 11**
**USSR/Eastern Europe: Array Processors**

| Model | Country | Speed (MFLOPS [a]) | Host Processor | First Delivery |
|---|---|---|---|---|
| PS-2000 | USSR | 5 to 40 | SM-2 | 1982 |
| PS-3000 | USSR | | SM-1210 | 1985? |
| PS-4000 | USSR | | | |
| ES-2310 | Hungary | 5 | ES-1010 | |
| ES-2335 | Bulgaria | 10 | ES-1035 | 1980? |
| ES-2345 | USSR | 30 | ES-1045 | 1980? |
| ES-2700 | USSR | 120 (MOPS [b]) | ES-1045 | 1987? |
| ES-2702 | USSR | | ES-1035 | |
| ES-2706 | Bulgaria | 60 (MOPS) | ES-1035 | |

[a] Millions of floating point operations per second.
[b] Millions of operations per second.

**Table 12**
**USSR/Eastern Europe: Rigid-Media Magnetic Disk Drives**

| Model | Producer | Type | Capacity (*megabytes*) | Transfer Rate (*kilobytes/second*) | Average Access Time (*milliseconds*) |
|---|---|---|---|---|---|
| ES-5050 | USSR | Removable | 7.25 | 156 | 90 |
| ES-5051 | USSR | Fixed | 100 | 83.25 | 250 |
| ES-5052 | Bulgaria | Removable | 7.25 | 156 | 95 |
| ES-5055 | East Germany | Removable | 7.25 | 156 | 90 |
| ES-5056 | USSR | Removable | 7.25 | 156 | 75 |
| ES-5058 | Czechoslovakia | Removable | 7.25 | 156 | 90 |
| ES-5060 | Hungary | Fixed | 0.8 | 150 | 10 |
| ES-5061 | Bulgaria | Removable | 29 | 312 | 50 |
| ES-5063 | Bulgaria | Fixed | 317 | 1,000 | 32 |
| ES-506301 | USSR | Fixed | 317 | 1,000 | 32 |
| ES-5064 | USSR | Fixed | 11.5 | 120 | 50 |
| ES-5065 | Bulgaria | Fixed | 635 | (Production not expected before 1990) | |
| ES-5066 | USSR | Removable | 100 | 806 | 55 |
| ES-5067 | Bulgaria | Removable | 200 | 806 | 55 |
| ES-5067.02 | Bulgaria | Removable | 2X100 | 806 | 30 |
| ES-5067.04 | Bulgaria | Removable | 2X200 | | |
| ES-5080 | USSR | Removable | 200 | 806 | 30 |

**Table 13**
**USSR/Eastern Europe: Floppy Disk Drives**

| Model | Producer | Disk Size (*inches*) | Capacity (*kilobytes*) | Density (TPI [a], BPI [b]) | Type |
|---|---|---|---|---|---|
| ES-5074 | Bulgaria | 8 | 400 | 48, 3251 | SS [c]/SD [d] |
| ES-5075 | Czechoslovakia | 8 | 400/800 | 48, 3251 | SS/SD |
| ES-5082 | Bulgaria | 8 | 400/800 | 48, 3251/6502 | DS [e]/DD [f] |
| ES-5083 | Bulgaria | 8 | 800/1,600 | 48, 3404/6807 | DS/DD |
| ES-5088 | Bulgaria | 5.25 | 109 | 48, 2591 | SS/SD |
| ES-5088M | Bulgaria | 5.25 | 109/218 | 48, 2591/5182 | SS/DD |
| ES-5088M1 | Bulgaria | 5.25 | 125/250 | 48, 2769/5563 | SS/DD |
| ES-5321 | Bulgaria | 5.25 | 218/437 | 48, 2718/5461 | DS/DD |
| ES-5321M | Bulgaria | 5.25 | 250/500 | 48, 2946/5893 | DS/DD |
| ES-5088.02 | Bulgaria | 5.25 | 218 | 48 | SS/DD |
| MF-8000 | Hungary | 5.25 | 1,200 | 96 | DS/HD [g] |

[a] Tracks per inch.
[b] Bits per inch.
[c] Singlesided.
[d] Single density.
[e] Doublesided.
[f] Double density.
[g] High density.

**Table 14**
**USSR/Eastern Europe: Magnetic Disk Packs**

| Model | Producer | Capacity (*megabytes*) | Number of Disks | Number of Surfaces | Tracks per Surface | Recording Density (*bits per millimeter*) |
|---|---|---|---|---|---|---|
| ES-5053 | Bulgaria | 7.25 | 6 | 10 | 200 | 45 |
| ES-5258 | | 7.25 | 6 | 10 | 200 | |
| ES-5261 | Bulgaria | 29/58 | 11 | 20 | 100/200 | 90 |
| ES-5266 | Bulgaria | 100 | 12 | 20 | 200 | 176 |
| ES-5266.1 | Bulgaria | 100 | 10 | 19 | 411 | 159 |
| ES-5267 | Bulgaria | 200 | 12 | 20 | 815 | 159 |
| ES-5269 | Bulgaria | 1.22/2.45 | 1 | 2 | 100/200 | 44/88 |
| ES-5269.1 | Bulgaria | 3.1 | 1 | 2 | 200 | 44 |

**Table 15**
**USSR/Eastern Europe:**
**Reel-to-Reel Magnetic Tape Drives**

| Model | Producer | Transfer Rate (*kilobyte/seconds*) | Packing Density (*bits/inch*) | Tape Speed (*inches/second*) |
|---|---|---|---|---|
| ES-5002.02 | Poland | 100/200 | 800/1600 | 200 |
| ES-5002.03 | East Germany | 96/189 | 800/1600 | |
| ES-5003 | USSR, Bulgaria | 160/315 | 800/1600 | 200 |
| ES-5003.03 | Bulgaria | 96/189 | 800/1600 | 120 |
| ES-5003.05 | Bulgaria | 160/315 | 800/1600 | 200 |
| ES-5003.06 | Bulgaria | 160/315 | 800/1600 | |
| ES-5004 | Czechoslovakia | 64/126 | 800/1600 | 75 |
| ES-5010 | USSR | 64 | 200/800 | 75 |
| ES-5010.01 | USSR | 64 | 200/800 | 75 |
| ES-5012 | USSR | 16/64 | 200/800 | 75 |
| ES-5012.01 | Bulgaria | 16/64 | 200/800 | |
| ES-5012.03 | Bulgaria | 96 | 800 | 120 |
| ES-5014 | USSR | 126 | 800/1600 | 75 |
| ES-5015 | Czechoslovakia | 240 | 800/1600 | 160 |
| ES-5016 | East Germany | 48 | 200/800 | 60 |
| ES-5017 | USSR, East Germany | 64 | 200/800 | 75 |
| ES-5017.02 | East Germany | 64 | 200/800 | |
| ES-5017.03 | | 16/64 | 200/800 | 75 |
| ES-5019 | Poland | 96 | 200/800 | 120 |
| ES-5022 | Czechoslovakia | 64/128 | 800/1,600 | 75 |
| ES-5025 | USSR | 64/126 | 800/1,600 | 75 |
| ES-5025.03 | USSR | 64/126 | 800/1,600 | |
| ES-5026 | Bulgaria | 126/712 | 1,600/6,250 | 75 |
| ES-5027 | Bulgaria | 189/738 | 1,600/6,250 | 120 |
| ES-5028 | Bulgaria | 315/1,230 | 1,600/6,250 | 200 |
| ES-5612 | Bulgaria | 96/189 | 800/1,600 | 120 |