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East European Microelectronics: Internal Development and Ties to Soviet Industry

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An Intelligence Assessment

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East European Microelectronics: Internal Development and Ties to Soviet Industry [redacted]

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An Intelligence Assessment

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This paper was prepared by [redacted] 25X1
[redacted] Office of Soviet Analysis, and [redacted] 25X1
[redacted] Office of Imagery Analysis. Comments
and queries are welcome and may be addressed to the 25X1
Chief, Defense Industries Division, SOVA [redacted] 25X1
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East European Microelectronics: Internal Development and Ties to Soviet Industry [redacted] 25X1

Key Judgments

Information available as of 1 June 1986 was used in this report.

The East European countries of the Council for Mutual Economic Assistance (CEMA) are trying to build up their microelectronics industries rapidly—particularly integrated circuit (IC) development and production. The buildup is designed to serve fast-growing East European requirements for microelectronics components but is also a response to considerable Soviet pressure. [redacted] 25X1

The Soviet Union's ambitious industrial modernization program, which calls for the extensive use of computers and microelectronics systems to improve industrial productivity, is creating heavy demands for more and better ICs. The military focus of the Soviet microelectronics industry has made it difficult for Soviet IC producers to ensure adequate deliveries for commercial and industrial applications. The Soviets have therefore increasingly turned to Eastern Europe to help satisfy the growing demand for ICs and, especially, products incorporating ICs, to meet the goals of industrial modernization. [redacted] 25X1

To enhance the Bloc's efforts to acquire, develop, and produce advanced microelectronic devices, the USSR and its East European allies have set up an elaborate division of labor within CEMA. The development of cooperative efforts in the microelectronics field has largely been driven by the various CEMA-level computer production programs that originated in the late 1960s. Integration has improved the technical capabilities of the Bloc members, reduced the duplication of effort in IC development, and increased the level of circuit standardization. Increased Bloc cooperation has also allowed the Soviets to better manage the legal and illegal acquisition of Western ICs and production equipment at a time of hard currency shortages and tightening Western export controls. The Soviets now are pushing their East European allies to embark on an ambitious cooperative program, known as the Comprehensive Program for Scientific and Technical Progress to the Year 2000, to upgrade Bloc production capabilities in microelectronics and several other key technology areas.
[redacted] 25X1

The East European countries began intensive development of their IC industries only in the late 1970s, nearly 15 years after the Soviets initiated their expansion effort. Eastern Europe's microelectronics industry is small by Soviet, US, or Japanese standards. We have identified and located 22 major East European IC production plants, encompassing more than 220,000 square meters of production floorspace. By comparison, the United

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States, Japan, and the Soviet Union have about 200, 100, and 75 plants, respectively. East European IC plants have been equipped largely with Western technology, and almost all major ICs known to be produced by them are based on US designs. 25X1

The German Democratic Republic (GDR) and Czechoslovakia have the most advanced industries in the region. The GDR has accounted for over one-third of production facility growth in Eastern Europe since 1977. It has recently constructed a new plant in Erfurt that incorporates highly advanced vibration control and air purification systems that could allow efficient production of the most complex devices produced in the Bloc. Czechoslovakia also has added production buildings to all of its major IC plants since 1980. It recently has stepped up efforts to acquire Western technology, probably to replace equipment destroyed in a fire at its leading IC plant in August 1985. 25X1

The rest of the Bloc is struggling to maintain a viable microelectronics base and has only recently started to increase investment supporting domestic production programs. Poland, Hungary, and Bulgaria have all purchased new IC production lines or constructed new production facilities since the early 1980s. Progress in Hungary, however, has been seriously set back by a fire in May 1986 at its main IC plant that destroyed an estimated 50 percent of the country's IC production capacity. Romania has failed to keep pace with the rest of the region and has the smallest and most technologically inferior IC industry in Eastern Europe. Romania has also been set back by a fire in May 1984 at its most advanced IC plant and has little hope of expanding its microelectronics base in the near term. 25X1

Because of its late start and the relatively low levels of investment, Eastern Europe's IC technology and production capabilities lag behind those of the United States and Japan by at least six to eight years and Soviet capabilities by one to two years. We use as an East European benchmark the capabilities of the region's most advanced industry—the GDR's—and measure progress in two key device types, memory circuits and microprocessors. Czechoslovakia lags the GDR by about two to three years, and the other East European countries are five to 10 years behind the GDR. 25X1

We estimate that the East European countries produced an estimated 180 million ICs in 1984, compared with nearly 1 billion in the USSR and 10.5 billion in the United States. East European users of ICs rely on large numbers of Soviet and Western ICs to augment domestic production. We estimate that during the early and middle 1980s the Soviets and East Europeans obtained, both legally and illegally, at least 100 million ICs annually from the West. 25X1

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The East European IC industry supports the Soviet Union mainly through the export of finished products, such as computers and automation equipment, that contain both Western and domestically produced circuits. Most East European products go to Soviet scientific and industrial users, but the GDR and Czechoslovakia also provide the Soviets with ICs and computer equipment that potentially have direct military applications. The East Europeans also participate in Soviet-managed clandestine acquisition and trade diversion programs that provide the Bloc with large amounts of sophisticated Western microelectronics technology. 25X1

The East European countries do not ship large numbers of ICs to the USSR. We believe only the GDR and Czechoslovakia are exporting ICs directly, and the quantities involved probably constitute no more than 2 to 3 percent of total Soviet consumption. Although data on shipments are sparse, the overall volume of ICs exported to the Soviets is probably less than 10 percent of total East European output, and these exports are almost certainly more than offset by imports of ICs from the USSR. 25X1

Although official statements and investment patterns indicate that East European IC industries will continue to grow, we do not believe their production will be sufficient to fulfill the rapidly growing requirements of IC consumers for at least the next 10 years. Thus, while the goal of reducing imports of Western ICs and IC equipment is still part of the CEMA development program, these imports are likely to rise, at least over the next five years or so, as the East European nations struggle to raise the quality and increase the quantity of their IC production. Stricter adherence to regulations of the Coordinating Committee for East-West Trade Policy by the Western allies could limit Eastern Europe's access to this equipment, however. Limiting the availability of advanced Western technology may force the countries increasingly to use Soviet equipment and know-how and to improve their own development and production technology to keep up with increasing domestic and Soviet demands. 25X1

We believe that East Germany will pull further ahead of the other East European countries in the development and production of ICs and may even challenge the USSR in some technology areas. Czechoslovakia will have to pour valuable resources into rebuilding and outfitting its recently damaged IC plant, which will hamper its efforts to upgrade production capabilities. Poland's hard currency shortages make it unlikely that it will substantially modernize its IC industry during this decade. The Bulgarians have had trouble assimilating heavy infusions of Soviet and Western technology over the past five years, and we do not foresee a significant increase in their capabilities until at least 1990. We believe that Hungary and Romania do not have the resources necessary to substantially upgrade IC production levels during this decade. 25X1

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Although we expect CEMA cooperation in the microelectronics field to intensify, we do not believe that these efforts will be enough to enable the East European CEMA countries to close the gap with the West in the development of ICs. At best, CEMA cooperation will serve to keep the gap from getting wider, and we believe that these countries will remain heavily dependent on Western ICs and production technology until at least the early 1990s. 25X1

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East European Microelectronics: Internal Development and Ties to Soviet Industry [redacted]

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Background

In the late 1970s the East European countries of the Council for Mutual Economic Assistance (CEMA)[1] stepped up efforts to develop their microelectronics industries. They have particularly stressed the development and production of integrated circuits (ICs), the key element of microelectronics technology and a fundamental determinant of success in industrial and military modernization (see insets). [redacted]

East European efforts are a response to growing domestic demands and to considerable pressure from the Soviets to modernize and expand the computer and microelectronics industries and provide greater support to Soviet industry. Despite impressive progress in IC development and production over the past two decades, the Soviets have experienced difficulties producing advanced semiconductor devices at levels commensurate with the investment in industrial capacity or with Western production (see inset, page 3).[2] One of the main factors contributing to the relatively low output of ICs is the fact that Soviet yield[3] rates have been consistently low by Western standards. Low yield rates are primarily caused by:

- Outdated and inefficient IC production and test equipment.
- Inadequate environmental control systems and poor quality control procedures.
- Low-quality raw materials, including silicon, deionized water, photoresists, and industrial chemicals and gases.
- Backward management practices, including a lack of flexibility and coordination, extraordinary compartmentalization of information, and overemphasis on production quotas at the cost of quality. [redacted]

[1] The East European countries of CEMA include Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and Romania. [redacted]

[redacted]

[3] Yield is a measure of the efficiency of the chip production process that shows the percentage of devices completed in working order. [redacted]

Integrated Circuits

Integrated circuits are semiconductor devices that combine many electronic components such as transistors, diodes, capacitors, and resistors on a single chip. Many ICs are fabricated on thin wafers of semiconductor material, usually silicon, and they are subsequently separated and packaged individually. The wafers are processed in clean rooms—specially designed sections of microelectronics production facilities that have temperature, humidity, and dust control systems. As ICs become more complex, stringent clean-room environmental control, as well as vibration control, becomes vital to achieving efficient production. [redacted] 25X1

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ICs can be defined by their relative levels of integration, that is, the number of circuit functions incorporated in the chip. The level of integration is usually defined by the number of transistors per chip. Transistors are semiconductor devices that act primarily as electrical switches. The levels of integrated circuit complexity (Western lexicon) are shown in the following tabulation:

Category	*Transistors Per Chip*	*Representative Device Types*
Small-scale integration (SSI)	*Less than 1,000*	*256-bit memory*
Medium-scale integration (MSI)	*1,000-9,999*	*1K[a] memory*
Large-scale integration (LSI)	*10,000-99,999*	*4K and 16K memories; 8-bit microprocessor*
Very-large-scale integration (VLSI)	*100,000 or more*	*64K, 256K, and 1-megabit memories; 32-bit microprocessor*

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[a] When used with memory chip information, K denotes an ability to store 1,024 bits of encoded computer data. [redacted] 25X1

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The Impact of Microelectronics: Applications of Integrated Circuits

Soviet and East European statements and articles suggest that rapid US and Japanese advances in IC technology are causing increasing concern about the Bloc's ability to compete in the military arena and to implement industrial modernization efforts. [redacted]

Integrated circuits (especially microprocessors) are the critical components in modern factory automation systems—consisting of robots, computer numerically controlled (CNC) machine tools, minicomputers, and microcomputers—that are helping to fuel economic growth in the West. In the Soviet Union, the widespread introduction of automated management and process control systems into industrial plants has been given a high priority in the 12th Five-Year Plan (1986-90) and is the primary goal of the program for the development, production, and use of computer technology up to the year 2000, endorsed by the Politburo in January 1985. In Eastern Europe, industrial modernization has also been accorded a high priority as part of plans to increase industrial efficiency and output and make more efficient use of raw materials. [redacted]

Developments in microelectronics also have improved the performance of military systems since the late 1970s. Advanced military systems in the West incorporate a wide range of complex microelectronics or optoelectronic devices that are often based in large part on integrated circuits. The increasing sophistication of these devices has made possible a variety of systems, including aerospace automated controls, missile guidance and delivery systems, fire control computers, "smart" munitions, and satellite navigation systems. In the area of land arms fire control systems, for example, increased use in the West of digital computer technology based on increasingly complex integrated circuits has led to a dramatic reduction in computer size, weight, and power consumption; the ability to operate under adverse conditions; and reduced repair time through the use of built-in test equipment. [redacted]

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In a May 1984 interview in Krasnaya zvezda, *Marshal Nikolay Ogarkov, then Chief of the Soviet General Staff, acknowledged the leap in the range and destructive powers of conventional weapon systems through the development of automated reconnaissance strike complexes, high-accuracy terminally guided combat systems, and electronic control systems. In the strategic arena, countering or emulating the US Strategic Defense Initiative will impose large demands on Soviet advanced sensor and computer technologies—both of which depend on complex IC devices.* [redacted]

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As a result, IC shortages appear to persist throughout the Soviet Bloc. Some much needed advanced IC types are manufactured only on a pilot basis at best, and a large share of annual Soviet IC output (perhaps as much as one-half) does not meet design requirements or quality standards. Complaints from low-priority Soviet users as well as from Eastern Bloc countries indicate that the Soviets still have not been able to satisfy the demands within CEMA for even the most basic circuits. [redacted]

This paper analyzes the growing capabilities of the East European CEMA countries to produce IC devices and their attempts to meet Soviet requirements for ICs and associated products. It examines the political and managerial framework established in CEMA to further integration and specialization in Soviet Bloc microelectronics production. It then examines the development of East European integrated circuit producers, the specific contributions of these producers to Soviet users, and how these contributions are changing over time. The appendix describes, in tabular form, all identified East European microelectronics plants. [redacted]

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Soviet Microelectronics: Playing Catch Up

The Soviet microelectronics industry has expanded rapidly over the past two decades in both technological and production capabilities. The Soviets began a large-scale construction program in the early 1960s to establish a viable and more unified microelectronics industry. The keystone in this expansion effort was the construction of a large microelectronics center in Zelenograd, approximately 40 kilometers northwest of Moscow. The Soviets refer to Zelenograd as their version of the US Silicon Valley. This center was established to help close the gap in microelectronics technology between the USSR and the United States; to coordinate development, planning, and training for the Ministry of Electronics Industry; and to boost the production of advanced semiconductor devices to satisfy military objectives. [redacted]

Throughout the 1960s, Soviet efforts to produce microelectronics devices were hampered by inadequate manufacturing facilities and shortages of reliable production equipment. Obtaining Western precision machinery and IC production technology in the 1960s enabled the Soviets, in the early 1970s, to achieve series production of their first successful family of IC devices, the Logika-2. The Soviets have continued to make the acquisition of foreign technology an integral element of their microelectronics program, and they have benefited substantially by examining and often copying advanced Western technologies. [redacted] 25X1

The Soviets have about 3 million square meters of production floorspace at the 74 microelectronics plants identified through imagery. If these IC facilities were fully equipped with Western production equipment operated at Western standards, we believe that the USSR could process up to 40 million wafers annually for discrete semiconductor devices and ICs. Actual Soviet wafer-processing capability probably is substantially lower. [redacted] 25X1

Although Soviet IC production capacity has grown steadily, floorspace growth rates in the mid-1980s had declined to about 10 percent of the peak rates attained in the late 1960s. According to recent policy statements, the Soviets are now concentrating on equipping existing facilities with more advanced production equipment instead of constructing additional plants. They may have difficulty implementing this shift in the near term, however, because of deficiencies [redacted] *in the quantity and quality of IC production equipment.* [redacted] 25X1 25X1 25X1

Managing CEMA Development

The Soviets are seeking to develop viable and competitive microelectronics industries throughout CEMA by emphasizing specialization and maximizing standardization. In the late 1960s and early 1970s, the East European countries developed their microelectronics industries using independent development strategies—most of them involving heavy flows of Western technology—which resulted in a significant duplication of effort and the production of incompatible products. Specialization was advertised as a way to enable CEMA countries to expand their markets and realize the efficiencies of larger production runs, which result in lower costs and higher quality in IC production. [redacted] 25X1

Increasing Bloc integration affords additional benefits for Moscow. It fosters greater political and economic interdependency among the CEMA countries, with the eventual goal of lessening the reliance on Western technology. The Soviets also are able to shift some of the IC research, development, and production burden to their East European allies, increasing supplies and allowing Moscow to concentrate on more advanced IC programs. In addition, greater electronics standardization may increase the combat effectiveness of the Warsaw Pact military forces. [redacted] 25X1

Furthering Industrial Integration

The development of cooperative efforts in the microelectronics field has largely been driven by the various CEMA-level computer development programs that originated in the late 1960s. To produce a compatible family of mainframe computers it was necessary to standardize the component base throughout the participating countries. Thus, CEMA's cooperation in the production of computer equipment opened the door to the creation of a unified microelectronic element base. [redacted]

Although the Permanent Commission for the Radio and Electronics Industry has been a part of CEMA since 1963, Bloc microelectronics cooperation did not begin in earnest until the 1970s. The foundation was laid in December 1969 when Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, and the USSR signed an agreement of cooperation in the development of a family of compatible mainframe computers. The program outlined and approved by the participants foresaw the creation of several computer types. Although differentiated by such characteristics as productivity, memory capacity, and range of peripherals, these computers have in common a unified base of fundamental elements, from peripheral units to integrated circuits, that constitute the building blocks of these machines. [redacted]

The agreement boosted the production of computers and, consequently, the demand for integrated circuits in the Bloc. According to Soviet production figures, from 1970 to 1980 the volume of output of the computer industry in CEMA as a whole rose more than 600 percent. The early models, which did not even use semiconductor memory, were probably equipped predominantly with Soviet and some Western chips for logic and input and output functions. By the end of the 1970s, when production of CEMA's minicomputer line started and the second generation models of the Ryad family began to appear, the East European countries were importing a wide variety of Western devices (most of them illegally) for incorporation in their computer systems and other products. Eastern Europe has subsequently made a concerted effort to increase domestic production capabilities for these ICs to meet the growing demands of its domestic users and reduce its reliance on imports. [redacted]

All CEMA cooperative computer efforts are coordinated by the Intergovernmental Commission for Cooperation in the Field of Computer Technology, established in 1969. This body, which is always chaired by a Soviet, includes a separate council on the microelectronics element base (see figure 1). The council coordinates the development and production of microelectronic devices for all data-processing equipment and serves as a forum for the member countries to discuss such issues as improving the quality and reliability of integrated circuits and developing the division of labor 25X1
for circuit production among the Bloc nations. [redacted] 25X1

The first of the major accords that applied directly to CEMA microelectronics integration came in 1975, when Bulgaria, Czechoslovakia, the GDR, Hungary, Poland, Yugoslavia,[4] and the USSR signed an agreement covering specialization in semiconductor instruments and 10 types of ICs. The agreement called for the signatories to exchange over 10 million ICs between 1975 and 1980 as part of various reciprocal trade agreements to be worked out among the participating countries. A follow-on accord known as the Agreement on a Common, Standardized Base of Components for Radioelectronics, Communications, and Computer Hardware was signed at the 35th CEMA Council session held in Sofia in 1981. It called for a unified system of standardized parts, special 25X1
equipment, semiconductors, and special materials for their production. An accord on microprocessors was also signed at this time, possibly as part of the above agreement. In line with the general agreement, specialists from the five original CEMA signatories began to develop a more standardized base of components including, among other products, radioelectronic and communications equipment and computer hardware. [redacted] 25X1

At the 36th CEMA Council session, held in June 1982, the CEMA nations signed an agreement on multilateral specialization and cooperation in the development and production of microelectronic components (including microprocessors) and pure materials for microelectronics. According to a Soviet journal

[4] Yugoslavia subsequently dropped out of the agreement. [redacted] 25X1

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Figure 1
The Intergovernmental Commission for Computer Technology

Intergovernmental Commission

Permanent Chairman
Coordinating Center
Leaders of National Sections

Bulgaria
Hungary
GDR
Cuba
Poland
Romania
USSR
Czechoslovakia

Organs of the Intergovernmental Commission

Economic Council
Council of Head Designers of ES (Mainframe) Computers
Council of Head Designers of SM (Mini) Computers
Temporary Working Group on Production Equipment and Test Apparatus
Council on Microelectronics Element Base
Council on Computer Applications
Council on Integrated Servicing of ES Computers
Council on Standardization of Computer Hardware

[redacted] 25X1

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article, the goal of the accord is to achieve the "widest possible fulfillment of demands for microelectronics devices of the member countries through the deepening of the international socialist division of labor." Some of the specific areas of concentration outlined in the agreement include:

- Computer-aided design (CAD): Bulgaria and the USSR.
- Instrumentation and test methods: Hungary.
- Precision optomechanics: GDR.
- Semiconductor material processing equipment: Romania.
- Large-scale and very-large-scale integrated circuit (LSI and VLSI) production equipment: USSR.
- Analysis, inspection, and metrology facilities: Czechoslovakia and the GDR.

The signatories also agreed to adopt or develop standardized processes and equipment to produce semiconductor substrates; design, produce, and test LSI and VLSI circuits, including 16- and 32-bit microprocessors and very-high-speed ICs (VHSIC); and mount ICs in various types of packages. The USSR and the GDR have been relatively successful in developing equipment related to their areas of specialization, but other programs are still in their formative stages. [redacted]

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Finally, in December 1985, the Soviet Politburo adopted—and the CEMA Executive Committee endorsed—an ambitious program for science and technology cooperation, known as the Comprehensive Program for Scientific-Technical Progress to the Year 2000, that calls for a restructuring of CEMA scientific-technical (S&T) and production ties. Under this program, according to Soviet Prime Minister Ryzhkov, new Soviet interbranch S&T complexes will orchestrate work on CEMA projects in priority areas and will be authorized to conclude contracts directly with counterpart East European organizations. Microelectronics has already been identified as one of the five priority areas for CEMA cooperative efforts, although the exact structure for any projects under this new program remains to be publicized. The East Europeans' official response to this program has been enthusiastic. [redacted] 25X1
[redacted] serious reservations on 25X1
the part of the East Europeans—primarily because of funding concerns. It is also possible that many East European countries are worried that this program is aimed primarily at speeding up Soviet modernization efforts and will not benefit their own economic situations in the near term. [redacted] 25X1

The CEMA countries are increasingly entering into bilateral cooperative development and trade accords based on reciprocal agreements for specialized production of IC products. Moscow has negotiated agreements with each of its East European CEMA allies to formalize joint development projects and IC shipments. [redacted] the GDR and the Soviet Union cooperated on a project to develop the 64K dynamic random access memory (DRAM) circuit in the belief that parallel efforts in both countries would speed up the design process. These countries now have a similar agreement for cooperation in the development of a 256K DRAM. Within Eastern Europe, East Germany has agreed to supply bipolar ICs to Czechoslovakia in return for power transistors. Similarly, the GDR has an agreement to supply semiconductor wafers and chemicals to Bulgaria in exchange for memory chips. [redacted]

Most of the CEMA countries have formed intergovernmental commissions with their major trading partners to manage CEMA-level bilateral cooperation efforts. For example, according to a recent Polish journal article, in late 1985 the joint Polish-Czechoslovak intergovernmental commission signed an agreement on future cooperation and coproduction in several electronics fields (see inset). [redacted]

There have been numerous reports in the East European and Soviet press on various bilateral and multilateral cooperative agreements on microelectronics development and trade within CEMA. These accords have included specialization in both the development of production equipment and the joint production of devices, but information on the actual impact of these efforts is hard to come by. In general, these agreements provide the East European countries with access to the large Soviet market for electronics, thereby making the development of indigenous IC technology more economically attractive to these nations. The cooperative efforts also served to focus IC development in CEMA, thus reducing duplication of effort and saving time and resources. [redacted]

In practice, however, cooperative efforts have not always gone as planned. For example, [redacted] the East Germans and Soviets agreed to establish parallel programs to develop a 64K DRAM circuit, but all cooperation ended as soon as the Soviets achieved a successful design. In addition, the agreement to build a 256K DRAM calls for the GDR to develop a more difficult architecture, even though the Soviets have better computer-aided design equipment. [redacted] the Soviets have refused to supply the East Germans with their most advanced CAD system, which is based on a Digital

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Growing Polish-Czechoslovak Cooperation in Electronics

In October 1985, Poland and Czechoslovakia signed an agreement on future cooperation and coproduction in the following electronics fields: 25X1

- *The Kasprzak Radio Factories in Warsaw, which produce a variety of electronic devices, together with Tesla in Bratislava, will jointly develop and produce compact disks and VHS-format video cassette recorders. Kasprzak will produce the drive mechanisms for the recorders, and Tesla will manufacture the electronic subassemblies.*

- *The Scientific Production Center for Unitra-Cemi Semiconductors in Warsaw is entering into a joint production agreement with Czechoslovakia. This agreement calls for the joint development of 64K memory chips and a new family of microprocessors. It also envisions the future development of a 32-bit microprocessor chip.* 25X1

- *A Polish-Czechoslovak design team, based at the Mera-Elwro Plant in Wrocław and at VUMs in Prague, will set up a division of labor for the production of specific types of 64K DRAM and 64K erasable programmable read-only memory (EPROM) circuits. The team also will be responsible for preparing the documentation for the available equipment for production of Winchester-type and optical disk drives.* [redacted] 25X1 25X1

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Equipment Corporation VAX minicomputer. Cooperation is also hindered by the wide differences in IC production capabilities among the individual East European countries. [redacted] the less developed Bloc members have had difficulty fulfilling the requirements of reciprocal trade agreements because of their inability to supply quality components. The Soviets have also had difficulty keeping East European partners supplied with certain IC devices. [redacted] Bulgaria, in 1983, started producing a copy of the Motorola 6800 8-bit microprocessor because it was not receiving microprocessors in the quantities promised by the Soviets. [redacted]

Controlling Dependence on the West

One of the primary reasons for the push within CEMA to develop an indigenous microelectronics capability is the desire to lessen the Bloc's dependence on the West for ICs and production equipment. The Western embargo on high-technology equipment makes it difficult for East European countries to acquire Western technology, and economic problems within CEMA are causing severe shortages of hard currency for the acquisition of Western goods. For example, [redacted] Poland in 1982 established the Coordination Commission for National Electronics R&D in "direct response to the embargo" (which was extended to include Poland after martial law was declared there in December 1981). The goal of the commission was to establish a national microelectronics industry "independent from Western countries," with sole reliance on nationally available raw materials, production facilities, and electronics know-how. Although the commission stressed self-reliance, it quickly became apparent that Western electronics technology, especially production equipment, would be needed. Poland has acquired this equipment and technology from the West illegally, [redacted]

The CEMA integration program has served to better manage—rather than lessen—Bloc reliance on Western technology. Specialization, by eliminating duplication of legal imports, probably has enabled some conservation of hard currency. [redacted]

The Coordinating Committee for Multilateral Export Controls

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The United States and its Western allies formed the Coordinating Committee (COCOM) in the late 1940s to control the export to the Soviet Bloc and China of technology having military applications. Discussions concerning goods that were not to be exported to the Bloc led to the establishment of multilateral lists. These lists (periodically reviewed and revised) serve to guide member governments in the execution of their national export control policies. COCOM is currently composed of the United States, the United Kingdom, Turkey, Portugal, Norway, the Netherlands, Luxembourg, Japan, Italy, Greece, France, the Federal Republic of Germany, Denmark, Canada, Spain, and Belgium. Over the past 15 years, the Bloc countries have successfully circumvented COCOM controls to obtain large numbers of ICs and production equipment and related technology to help establish their microelectronics industries. The United States convinced its allies to impose an embargo on high-technology equipment after the Soviets invaded Afghanistan in December 1979. The Bloc has since found it increasingly complicated and expensive to acquire microelectronics technology. [redacted]

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[redacted] Nearly half of all detected trade diversions involve microelectronics fabrication equipment and computers. East European participation in these technology acquisition programs has increased in recent years because of rapidly broadening collection opportunities afforded by the worldwide diffusion of advanced products and technology. [redacted]

[redacted]

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East European IC Industries

The East European microelectronics industry includes at least 64 integrated circuit R&D and production facilities, about 70 percent of which are concentrated in East Germany, Czechoslovakia, and Poland. [redacted] we have identified and located 22 major IC production plants (see appendix and figure 2). By contrast, we have identified 74 IC production plants in the USSR, and there are about 200 in the United States and 100 in Japan. [redacted]

The East European IC industries have been built largely through the use of Western technology, and almost all major ICs produced by them are based on US designs. This strategy has allowed the East European countries to develop an indigenous production capability more quickly and cheaply than would have been the case otherwise. As Western export controls have grown more restrictive during the 1980s, and as IC production equipment has become more complex and difficult to assimilate, the CEMA countries have started to turn also to the Soviets for assistance in modernizing their industries. [redacted]

East Germany and Czechoslovakia have the most advanced microelectronics industries in Eastern Europe. The GDR works closely with the Soviet Union in IC development programs, and the two countries produce approximately the same generic IC product lines. The Soviets, however, produce more device types and in larger quantities. The Soviets have a great advantage over the the East Germans in that they have been manufacturing ICs longer, have established a larger R&D and production base, and, in general, have more advanced IC production equipment—especially CAD systems necessary for efficient design of complex devices. [redacted]

Czechoslovakia has the second most advanced IC industry in Eastern Europe. Czechoslovakia and East Germany possess similar IC technology and produce similar product lines, but the Czechoslovaks produce ICs in smaller quantities—primarily because they suffer more quality-control problems than the East Germans and consequently have lower yield rates. Further advances in IC technology will be limited over the next few years by a fire that destroyed a leading Czechoslovak R&D center in August 1985. [redacted] 25X1

The rest of the Bloc is struggling to maintain a viable microelectronics base and has only recently started to increase investment levels in indigenous R&D and production programs. Poland, Hungary, and Bulgaria all have purchased new IC production lines or constructed new production facilities in recent years. Progress in Hungary, however, has been slowed considerably by a fire in May 1986 at its main IC plant that destroyed an estimated 50 percent of the country's production capacity. Romania has failed to keep pace and has the smallest and most technologically inferior IC industry in Eastern Europe. Romania's progress has also been set back by a fire in May 1984 at its most sophisticated IC production plant and has little hope of expanding its microelectronics base in the near term. [redacted]

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Expanding Production Capacity

Although Eastern Europe had established a small production capability for discrete components by the mid-1960s, major expansion of the microelectronics industry did not occur until the late 1970s—nearly 15 years after the Soviets initiated their expansion effort. The East European industry was slow in developing because it was not faced with large military, industrial, or commercial demands for microelectronics devices in the early-to-mid-1960s, as were the Soviet Union and Western countries. East European demand for ICs has increased sharply in recent years, primarily because of industrial modernization efforts and in response to technical developments in—and international marketing opportunities created by—the West. In addition, the USSR has stepped up its demands for ICs from Eastern Europe. [redacted]

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In an effort to meet growing IC demands, Eastern Europe increased production capacity—measured in facility floorspace—about 130 percent between 1977 and 1985. Despite these impressive expansion figures, the East European IC industry remains small when

Figure 2
East European Integrated Circuit Plants

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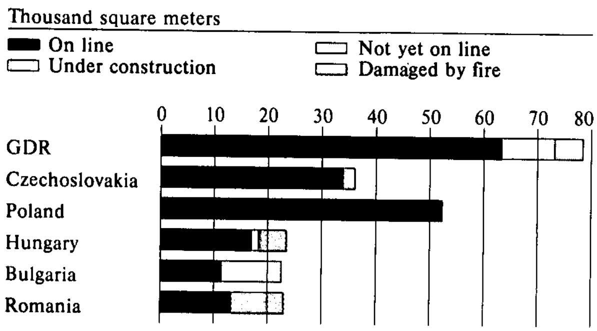
Figure 3
East European IC Production Floorspace by Country, 1986



[redacted]

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compared with the Soviet industry. As of 1986 the Soviets had about 3 million square meters of floorspace at known plants available for the production of semiconductor devices, compared with the roughly 220,000 square meters available for IC production at the 22 identified East European plants (see figure 3). [redacted]

The development of Eastern Europe's integrated circuit industry also has been much different from the USSR's. Analysis of Soviet microelectronics facilities has revealed that the Soviets erected a series of standardized production buildings during the 1960s and the 1970s. The Soviets may have attempted to incorporate improved clean-room design and vibration control in their buildings to allow for more efficient production of increasingly complex ICs. Eastern Europe does not follow similarly standardized construction procedures, and it chose not to copy Soviet designs. Its IC production facilities are a mixture of indigenous and Western designs, although the Soviets may have aided in the design of some plants. Analysis of East European plants revealed few similarities in building designs either within or between countries. [redacted]

East Germany has accounted for over one-third of the expansion in Eastern Europe's microelectronics industry since 1977. It has added production floorspace to all existing IC plants and built branch plants in Erfurt and Dresden. The newly constructed Erfurt Southeast Plant is the most sophisticated in Eastern Europe. It has been constructed with highly advanced vibration control and air purification systems to allow efficient production of VLSI devices. The Soviets probably do not yet have VLSI production facilities adequate to satisfy anticipated defense-industrial needs, and [redacted] they have sent several high-level delegations to tour the Erfurt Southeast Plant to examine its layout and clean-room design, perhaps in the hope of incorporating its unique design into their own future buildings. [redacted]

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Both Czechoslovakia and Bulgaria have greatly increased IC production floorspace in recent years. All of Czechoslovakia's major IC plants added production buildings in the early 1980s, both in response to growing demands and to raise the technological level of their products. The Bulgarians recently have begun an expansion drive to increase IC production floorspace dedicated to growing computer and disk drive production efforts. The Memory Disk Plant in Stara Zagora is being expanded and an IC production capability is being added. The Stara Zagora facility was externally complete in 1984, but plant contractors have reportedly experienced difficulty with clean-room design and equipment installations. Because of these delays, the production startup date is uncertain. The Bulgarian IC plant in Botevgrad also is being expanded. [redacted]

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Construction of new IC fabrication facilities in Eastern Europe peaked in the late 1970s and again in 1982 and 1983 but dropped sharply in 1980 (see figure 4). Possible explanations for the decline include:

- Shortages of hard currency—triggered by the high trade deficits in many East European countries in the late 1970s—which may have limited the acquisition of Western technology needed to outfit new plants.

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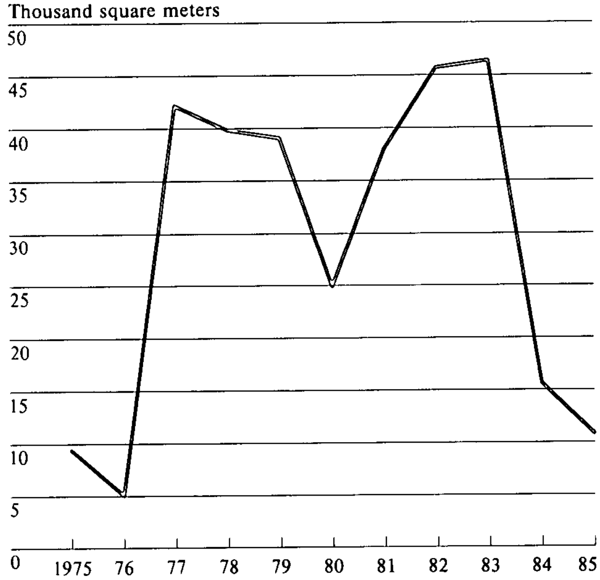
Figure 4
East European IC Production Floorspace Under Construction, 1975-85
Thousand square meters



[redacted]

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- The general cutback in investment programs in Eastern Europe that was initiated to make more resources available for consumption and to generate the export surpluses necessary to service the region's large foreign debt.

Poland was particularly hard hit during this time. It had established a strong microelectronics base during the 1970s by purchasing a French turnkey plant and importing a mixture of Western technology. Poland's intensive start in microelectronics was largely offset by its economic crisis, the subsequent collapse in investment, and the strengthening of the Western embargo. Poland has over one-third more IC production floorspace than Czechoslovakia but now lags that country in both output and technology. Since 1983, Eastern Europe's construction effort has again decreased sharply, and, as of 1986, expansion is occurring only at Erfurt Southeast and the Dresden ZFTM branch plant in the GDR, and at the Hungarian MEV plant in Budapest. [redacted] 25X1

Equipping Facilities

The East Europeans have established their IC industry primarily through the acquisition of Western know-how and equipment. Although the patterns for each country are different, an initial practice for many was to purchase Western turnkey facilities and licenses. Poland and Hungary established their microelectronics base by contracting with French and US firms, respectively, for technology, facility design assistance, equipment, and personnel training. Romania has always been strongly reliant on Western technology and has licensed French, West German, and British IC designs. [redacted] 25X1
[redacted] although the countries prefer Western, and especially US, technology, they have also imported 25X1
Soviet and East German equipment—primarily because of Western trade restrictions, but also to save hard currency and to support Bloc cooperation programs (see table 1). Continuing acquisition of Western technology, however, indicates that the East Europeans must still rely on Western know-how and equipment to produce more advanced devices with greater efficiency and in larger quantities. The USSR and 25X1
Eastern Europe have acquired at least several thousand pieces of major microelectronics fabrication equipment from the West during the last 10 years. This equipment has been used throughout the entire production process—from materials preparation to the final testing apparatus needed for sophisticated production lines. [redacted] 25X1

As an example of recent activity, during the latter half of 1985 Czechoslovakia and Bulgaria sharply increased acquisition efforts in the West. The Czechoslovaks reportedly placed orders during this period for more than $250,000 worth of wafer carriers and other equipment. This represents a fivefold increase over purchases of such equipment in any previous year. The Bulgarians reportedly have also purchased record

Table 1
Selected Technology and Equipment Acquisitions by Eastern Europe

Plant	Description	Date of Information	Origin
East Germany			
VEB Halbleiterwerk Frankfurt-Oder	High-purity water system.	1985	Japan
VEB Erfurt Southeast	Mask aligner.	1985	United States
ZFTM, Dresden	Nine wet-etch chemical acid processing systems.	1983	United States
Czechoslovakia			
Tesla Piešťany	16K DRAM production line.	1978-80	Japan
Tesla Piešťany (probable)	Four-inch wafer carriers.	1985	United States
Tesla Roznov	Photolithography equipment.	1983	East Germany United States
VUST, Prague	Sentry-7 measuring and test system.	1982	United States
Bulgaria			
Stara Zagora Memory Disk and IC Plant	Construction of IC fabrication line. Design of air conditioning systems and clean rooms.	1985	Japan
Botevgrad IC Plant	Design and construction of new facilities including clean rooms. Sale of IC technology and numerically controlled machine tools.	1984	Japan
	Production line for 16K DRAM complementary metal-oxide semiconductors.	1985	USSR
Poland			
TEWA Semiconductor Factory, Warsaw	Construction of IC plant. Sale of IC technology and equipment.	1978	France
	Cooperative development of VLSI production line.	1978	USSR
CEMI Organization	Attempt to obtain IC production line.	1985	Japan
Hungary			
Microelectronics Enterprise, Budapest	Two IC production lines—each with annual capacity of 10 million ICs.	1982, 1984	USSR
Tungsram, Budapest	License of IC assembly and test technology. Later attempts to acquire production technology failed.	1977	United States
Romania			
Microelectronica, Bucharest	Mask-making machinery, step and repeat cameras on order.	1980	East Germany
	Diffusion furnaces, etching equipment, air conditioning systems and clean rooms for metal-oxide semiconductor IC plant.	1980 1980, 1977	Holland United States Austria
IPRS Baneasa	License of IC production technology.	1971	China

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amounts of IC production equipment totaling $210,000, probably to be installed in their new IC fabrication facility in Stara Zagora. The types of machines and the size of the orders are consistent with the requirements of a full-scale production line. [redacted]

We believe, however, that the East Europeans may have difficulty importing the technology they need to enhance productivity because of COCOM restrictions and hard currency constraints. Moreover, although the Bloc countries have been able to obtain COCOM-controlled equipment and technology, they have had difficulty, [redacted] maintaining and repairing Western equipment and obtaining necessary spare parts. COCOM restrictions have made acquisition of Western technology much more expensive and difficult than in the past and have thus limited the scope and effectiveness of East European acquisitions. [redacted]

The East Europeans may now be forced to rely increasingly on the Soviets for the production technology to upgrade their integrated circuit industry. Hungary was almost totally dependent on Western IC technology and equipment throughout the early years of the industry's development but has found Western firms reluctant to transfer production technology in recent years. It has thus been forced to turn to the USSR for imports of technology and equipment. Since 1982, Hungary has purchased two production lines from the Soviet Union—one for metal-oxide semiconductor (MOS) ICs and another for bipolar ICs—each with a reported annual production capacity of 10 million devices. (If these production levels are actually reached, Hungarian IC production will increase 175 percent over 1982 levels.) In 1980 Bulgaria purchased a 4K RAM production line from the USSR. Acquisition of Soviet equipment and technology by East European countries will help them meet internal and trade demands for devices but probably will not increase their technological capability greatly. The Soviets are unlikely to sell their most advanced engineering instrumentation and production technology to Eastern Europe unless they are involved in a joint development program in which they are likely to obtain new technology. [redacted]

Figure 5
Estimated East European IC Production, 1980-85

Million ICs

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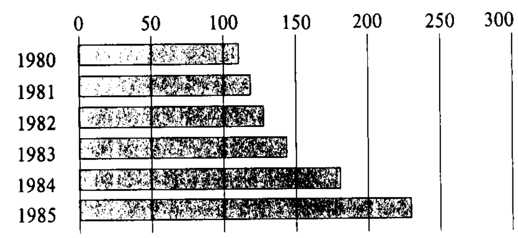

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Production of Integrated Circuits

While the performance of individual countries has been mixed, Eastern Europe as a whole has shown a steady average annual growth rate in IC production of about 15 percent since 1980[6] (see figure 5). Most of the growth can be attributed to East Germany and Czechoslovakia, whose IC output has increased on an average annual basis by 21 and 22 percent, respectively, during this period. The domination of the GDR and Czechoslovakia in total East European production has actually grown from 56 percent in 1980 to 70 percent in 1984 (see figure 6). Although IC production growth is expected to remain strong for East Germany and Czechoslovakia, we expect their share of total East European IC output to start declining as new IC fabrication lines in Hungary and Bulgaria come on line. [redacted] 25X1

Table 2 presents estimates of IC production for the individual East European countries during the 1980s. Most of these figures were taken from the statistical

[6] This figure appears more impressive than it really is because the IC industry in Eastern Europe is still in its infant stage, and total output figures are relatively low. [redacted] 25X1

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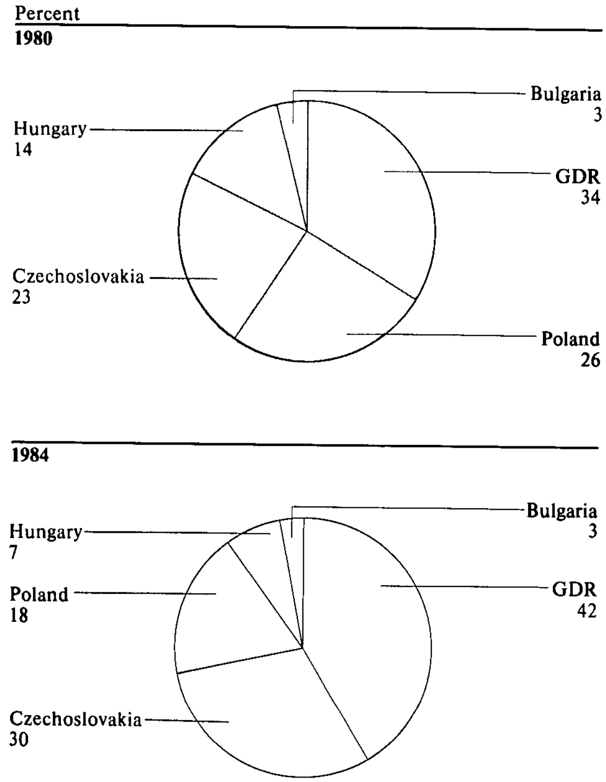
Figure 6
Shares of Total East European IC Production by Country, 1980 and 1984



[redacted]
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yearbooks published by the countries. Czechoslovak IC output was estimated by using published production growth rates to extrapolate a single data point provided by a knowledgeable source. Bulgarian IC output was estimated by taking published figures on semiconductor production and attributing a percentage of this to IC devices (using the semiconductor-to-IC ratio of other East European countries as a rough guide). Romania is not included in this table because its IC output is too inconsequential to have any impact on total East European production. [redacted] 25X1

Per capita IC production figures provide a better understanding of the East European countries' position relative to that of the West and the USSR in the production of ICs. We estimate that as of 1984 Poland was producing about one IC per person; Hungary, about two; Czechoslovakia and the USSR, three to four; and the GDR four to five. By contrast, per capita production in the United States and Japan in 1984 was 45 and 57 ICs, respectively. It should be noted, however, that these figures refer only to the quantity of production and not to the quality or technological level of ICs. If these factors were taken into account, the gap would be even wider. The leading CEMA microprocessor and memory ICs currently in full series production—the 8-bit microprocessor and the 16K DRAM, respectively—are based on US chips that were introduced almost 10 years ago. The United States has started full series production of 32-bit microprocessors and a 1-megabit DRAM, and Japan will soon begin series production of 1-megabit DRAM chips. Thus, not only are the United States and Japan achieving a much higher per capita production rate, but they are also producing chips of a higher level of technology than their East European counterparts. [redacted] 25X1

In absolute terms, Eastern Europe's output of an estimated 181 million ICs in 1984 was far below that of Western Europe—2.9 billion—and the United States—10.5 billion (see figure 7). Eastern Europe's share of world IC production has also decreased from an estimated 1.2 percent in 1980 to 0.8 percent in 1984 (see figure 8). Thus, despite some impressive gains in East European IC production since 1980, the gap between the CEMA countries and the West in overall output of integrated circuits is extremely wide and growing wider. [redacted] 25X1 25X1

Eastern Europe's low IC production levels can be explained by a combination of low capacity and poor yield rates. A late start in the production of ICs and the lack of an established electronics production base on which to build have hampered industrial development. In addition, the East Europeans are hindered by

Table 2
East European IC Production by Country, 1980-85

Million ICs

Country	1980	1981	1982	1983	1984	1985
East Germany [a]	37.7	47.0	55.4	59.0	72.2	97.0
Czechoslovakia [b]	25.0	29.0	35.0	42.0	52.0	67.0
Poland [a]	28.3	22.8	21.6	27.5	32.2	37.0
Hungary [a]	15.6	15.6	11.4	10.9	19.0	23.0
Bulgaria [b]	4.0	4.1	4.1	4.6	5.1	6.0
Total [c]	**111.0**	**119.0**	**128.0**	**144.0**	**181.0**	**230.0**

[a] Reported in national statistical yearbooks.
[b] Estimated.
[c] Columns may not add to totals given because of rounding.

[redacted] 25X1

longstanding problems at the plant level that have contributed to low yield rates—especially for the more advanced circuits. Primary problems include:

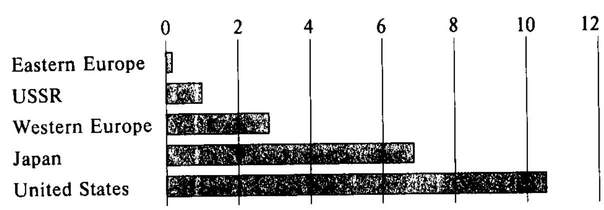
- Poor-quality—and often outdated—production equipment.
- Low-quality raw materials used in wafer processing, including electronics-grade silicon, industrial chemicals and gases, and deionized water.
- Shortages of skilled labor. [redacted] 25X1

Western IC industries have paid great attention to developing precise environmental and process controls—not only to increase product yield rates, but also to ensure plant safety. Microelectronics fabrication requires the use of pressurized gases as well as chemicals that are toxic, explosive, or both. Strict observance of safety procedures is thus extremely important. Inadequate safety and process control, as well as possible building design flaws, can have catastrophic consequences, as evidenced by the recent fires at IC plants in Czechoslovakia, Romania, and Hungary (see inset). [redacted]

[redacted] even East Germany is suffering low yield rates on its microprocessor chips. As of April 1984 the East German VEB Karl Marx Plant in Erfurt was achieving a yield rate of 11 to 12 percent using 3-inch wafers for the U880 microprocessor (a copy of the Zilog Z-80 chip, introduced in the United States in 1978). The early yield rate for the GDR's next generation of microprocessor, the 16-bit U8000, was 2 to 3 percent for initial production lots at the Erfurt plant.[7] By contrast, Western IC

Figure 7
IC Production by Major World Region, 1984

Billion ICs



[redacted] 25X1

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[7] Production of the U880 using 4-inch wafers was to start at the new plant in Erfurt Southeast in May 1984, so these yield rates have probably dropped somewhat while technical problems involved in the switch to the larger wafer size are worked out. [redacted]

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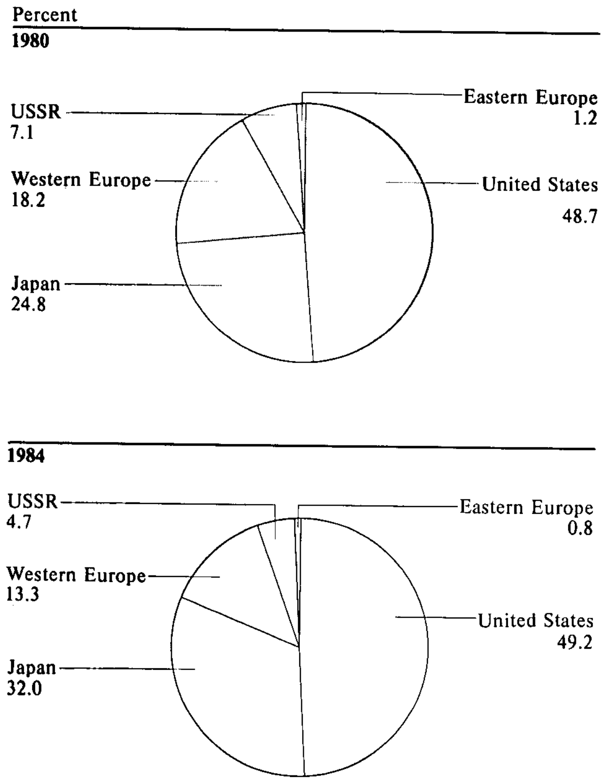
Figure 8
Share of World IC Production by Country or Region, 1980 and 1984



[redacted]
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manufacturers typically cannot afford to mass-produce a circuit unless they can achieve at least an 85-percent yield rate. At rates below this, a firm would not be able to offer the chip at competitive prices. Czechoslovakia has also been plagued with quality problems in the manufacture of ICs. [redacted] the Tesla Piestany Plant was achieving a yield rate of only 5 to 10 percent in 1982 on its copy of the US Intel 8080 microprocessor. [redacted]

The Impact of Inadequate Safety Standards: The Hungarian Industrial Accident

On 26 May 1986 a fire destroyed Hungary's largest and most advanced integrated circuit producer—the main Microelectronics Enterprise (MEV) plant in Budapest. This plant was considered a showplace facility, and General Secretary Gorbachev reportedly was to visit it in June 1986. The Hungarians have estimated total damages from the fire at $30-45 million, including the cost of two recently acquired Soviet IC production lines. Although authorities are still investigating the cause of the fire, we believe it may have resulted from inadequate safety and process control—an area in which the East European microelectronics industries have historically been weak. [redacted] 25X1

At the time of the fire, MEV was stepping up production on the two Soviet lines—each of which had a rated annual capacity of 10 million ICs—and was constructing a new production building that was intended to produce chips of even greater sophistication. We estimate that in 1985 Hungary produced about 23 million ICs, and we believe that output may now drop 50 percent as a result of the fire. Hungary's two other IC plants probably will not be able to make up for the lost production, and the country will be hard pressed to meet domestic demands—especially in the computer, telecommunications, and industrial machinery industries. [redacted] 25X1

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Within days of the fire, the Hungarians began contacting officials in the USSR, East Germany, and Czechoslovakia, as well as West European firms, to negotiate joint ventures and equipment-leasing schemes to replace equipment destroyed in the fire and to obtain ICs to help meet domestic requirements. Nevertheless, we estimate that, even with large-scale government support, it will take the Hungarians a minimum of two years to rebuild the plant, acquire new production equipment, and gear up to previous production levels. This accident has severely set back Hungary's electronics development program and will hurt its long-range economic plans to become a major exporter of microelectronics-based equipment by 1993. [redacted]

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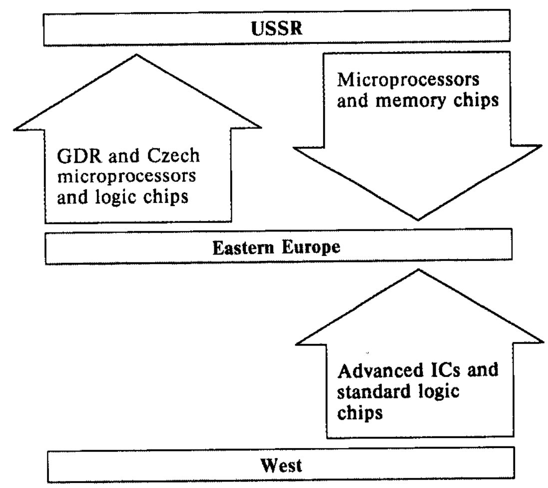
Overall, we judge that Eastern Europe's IC production capabilities lag those of the United States and Japan by at least six to eight years and Soviet capabilities by one to two years. We use as an East European benchmark the capabilities of the region's most advanced industry—the GDR's—and we measure progress in two key device types, memory circuits and microprocessors (see inset). Czechoslovakia lags the GDR by two to three years, and the other East European countries are five to 10 years behind the GDR. [redacted] 25X1

Reliance on Western ICs

The East European countries import large quantities of ICs from the West to augment domestic production. These imports, which we believe to be larger than Soviet deliveries, include advanced circuits used for reverse engineering and for direct use in domestic computers and automation equipment, as well as large numbers of standard logic chips (see figure 9). We estimate that the Soviet Union and Eastern Europe now obtain over 100 million ICs annually from the West. One of the several important Western sources for these circuits has been the Swiss firm Allimex, which, [redacted] has been offering increasing numbers of US and Japanese ICs to the GDR since at least September 1983. Earlier shipments by Allimex were relatively small, but allegedly contained COCOM-controlled chips. In 1984 Allimex increased the quantities and the level of sophistication of ICs offered to the East Germans. The quantities shipped that year totaled in the millions and included advanced 16-bit microprocessors. The Swiss firm has also sold hundreds of thousands of COCOM-controlled memory circuits to the GDR, including sophisticated 256K EPROMs, 256K DRAMs, and 64K static RAMs. [redacted] 25X1

Other evidence of CEMA's increased use of Western ICs and equipment is provided by a recent article on the Hungarian IC industry in a British journal. According to the article, Hungarian IC imports from the United States, Japan, and West Germany more than doubled (in value terms) in 1984 from the previous year. More than 70 percent of Hungarian semiconductor imports now come from hard currency sources. This trend is likely to continue as Hungary attempts to make up for lost production capacity as a result of the fire at its leading IC plant. [redacted]

Figure 9
IC Imports and Exports for Eastern Europe



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[redacted] 25X1

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Relations With the Soviets

There is a substantial flow of microelectronic devices from Eastern Europe to the Soviet Union, and the level of support has increased significantly in recent years. Although the total quantities involved do not represent a large proportion of total Soviet IC consumption, they fill an important niche in providing circuits that, [redacted] go primarily into civilian applications. This allows the Soviets to concentrate scarce development and production resources on higher priority IC projects—including those for which the Soviets cannot rely upon foreign

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Comparative Levels of East German, Soviet, and US IC Technology

Memory and microprocessor integrated circuits are generally the trendsetters for microelectronics advances, and production technologies developed in these fields are usually applied to other types of ICs. Memory ICs store large volumes of information in the form of electrical charges, while microprocessors are ICs that provide, in one chip, functions equivalent to those contained in the central processing unit of a computer—arithmetic capabilities and some memory. To understand more fully the differences in microelectronics state of the art between the United States, the Soviet Union, and East Germany, it is useful to compare these technologies individually.

The 64K DRAM is the most advanced memory device serially produced in the Soviet Bloc. Initial production of this device began in the United States in 1978, and full series production started in 1980. The Soviets achieved initial production of a 64K DRAM in 1979 and began small-scale series production prior to 1984. The Soviets probably have sufficient quantities of these chips to satisfy high-priority military requirements, but we believe that production problems have prevented their widespread use in civilian applications. The East Germans achieved initial production of their version of the 64K DRAM in 1982 and began low-volume series production at the Erfurt Southeast Plant in 1985. Thus, the Soviet Bloc lags the United States by two to four years in 64K DRAM production. The gap is even wider when the higher quality and quantity of US production are factored in, and the United States is increasing its lead in the development of more advanced DRAM circuits. The United States achieved series production of the 256K DRAM in 1984 and recently started full series production of a 1-megabit chip. Neither the USSR nor East Germany is known to have achieved even small-scale production of either chip, and they will probably have to either produce or acquire more advanced production and testing equipment and overcome problems in quality and process control and materials purity to master the complexity of advanced VLSI production. 25X1

The 16-bit device is the most advanced type of microprocessor produced in volume in the Soviet Bloc. The USSR probably achieved limited series production of its 16-bit microprocessors by the early 1980s. These products—the K581, K586, and K588—include indigenous and copied Western architectures. The most advanced Soviet 16-bit microprocessor, the K1810—based on the US Intel 8086 chip—entered initial production in 1983 and may now be in low-volume series production. The East Germans took a different approach from the Soviets, copying the US Zilog Z8000 16-bit microprocessor and achieving initial production of their U8000 in 1984. As of early 1985 the East Germans were producing pilot lots of 1,000 of these devices a month at the Erfurt Microelectronics Plant. The US firm Intel achieved initial production of its 16-bit 8086 microprocessor in 1977 and started full series production in 1978. Thus, the Soviet Bloc lags the United States in the production of 16-bit microprocessors by six to seven years. The US lead over the Bloc countries is even wider when the development of more advanced microprocessor devices is factored in. The United States achieved series production of 32-bit microprocessors in 1985, whereas the Soviets and East Germans are not known to have achieved even initial production of an equivalent device. Microprocessors are much more difficult to design and produce than memories, and this field is even more dependent on computer-aided design systems—an area in which we believe the USSR and East Germany are at least 10 years behind the West.

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sources of supply. In general, East European contributions to Soviet microelectronics capabilities take three primary forms:

- Reexport of Western ICs and IC manufacturing equipment.
- Shipments of electronic products such as radios, computers, computer peripherals, robots, and numerically controlled machine tools that incorporate ICs.
- Direct shipments of domestically produced integrated circuits.

The East European countries rely on the Soviet market to sell their ICs and related products to help offset their purchases of Soviet goods such as energy and raw materials. Despite the increased reliance, however, we do not believe that the Soviets have become dependent on Eastern Europe for any critical integrated circuit types. We have no evidence that Eastern Europe produces any major IC type that the Soviets do not manufacture themselves. [redacted] 25X1

Although information in this area is insufficient to make hard judgments, we believe that the most significant East European contributions to Soviet microelectronics capabilities come in the first two categories. Although the East European countries—struggling to build up their own industries rapidly—use much of the technology acquired from the West for their own development activities, we believe that they funnel significant amounts of Western technology directly to the Soviets for reverse engineering and other purposes. In addition, the East Europeans incorporate Western ICs in their computers and other electronics-based products to increase the quality and reliability of these goods, many of which are shipped to Soviet users. Thus, the Soviets benefit from these cooperative arrangements through the increased access to Western technology and the delivery of more reliable East European machinery and equipment imports. The East Europeans, in turn, gain from greater access to Soviet markets and technology, which allows these countries to develop their IC industries more rapidly than they would be able to do on their own. [redacted]

Eastern Europe as a Conduit for Western IC Technology

Eastern Europe is becoming an increasingly important source of Western microelectronics technology for the Soviets. The primary forms that these transfers take include:

- Export of indigenously manufactured products containing Western IC technology.
- Reexport of Western ICs and IC manufacturing technology as part of Soviet clandestine acquisition and trade diversion programs. [redacted] 25X1

East European computer equipment, machine tools, robots, and other microelectronics-based products imported by the Soviets contain varying amounts of Western circuits and technology. [redacted] 25X1 [redacted] Bulgaria and Hungary still rely almost exclusively on Western circuits and other technology in the production of this equipment. [redacted] 25X1 25X1

[redacted] 25X1

East European foreign trade organizations are also active in acquiring ICs and related equipment for the Soviets. [redacted] 25X1 [redacted] the Hungarian trade organization Elektromodul reexports almost half of the electronic parts it 25X1 25X1

[8] USSR–East European joint development of Ryad mainframes and SM minicomputers resulted from CEMA cooperative programs begun in the early 1970s. [redacted] 25X1

acquires to the Soviet Union and other CEMA countries. Bulgaria, [redacted] tried to purchase 500 IBM PC/XT personal computers in 1985, most of which were to go to users in Czechoslovakia, Hungary, and the USSR. [redacted]

A primary purpose of the CEMA-wide efforts to acquire Western technology has been to exploit a wide variety of Western IC technology to determine what designs best meet the needs and production capabilities of the individual countries. The Soviet Union and Eastern Europe have been very successful in exploiting this technology to produce copies of Western circuit designs. [redacted] the Soviets have been pressing their allies to standardize in key IC areas but are meeting resistance from some East European countries that have expended significant resources in developing programs based on alternate technologies. [redacted]

Products Incorporating East European ICs

As part of CEMA's cooperative program to develop and produce a compatible family of mainframe computers and minicomputers, each East European country ships computer systems or peripheral units to the USSR (see figure 10). According to a recent Soviet journal article, the volume of computer trade within CEMA rose by a factor of 32 from 1970 to 1983. This equipment is produced using a combination of Soviet, East European, and Western ICs. For example, [redacted] Poland's highest quality floppy disk drive and printer are produced exclusively for the Soviet Union and are not available to Polish users. In addition, approximately 90 percent of the Polish-made Mera-60 minicomputers are shipped to Soviet users. The Mera-60 is built with a Soviet processor and logic chips as well as some Czechoslovak ICs. However, the Poles are now using more and more chips from the US firm Texas Instruments, which, [redacted] can often be purchased at "half the price" of Soviet ICs. [redacted]

According to an East German journal, 60 percent of the total exports of the GDR's Robotron Combine go to the USSR. These shipments have included over 450 mainframe computers since 1975. Of the 322 ES-1055 and ES-1055M mainframe computers—the GDR's latest models—produced by the end of 1983,

Figure 10
Intra-CEMA Flow of Computer Equipment

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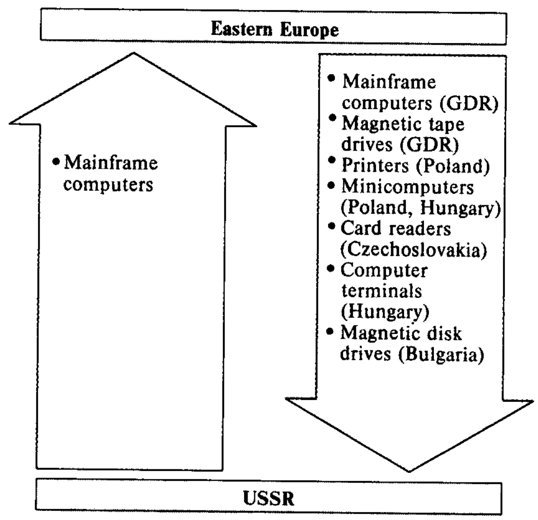

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almost 90 percent were exported, mostly to the USSR. The GDR has also started exporting personal computers to the Soviets. According to an East German open-source article, the first of 5,000 PCs destined for the USSR was delivered in May 1986. Czechoslovakia shipped over $750 million worth of computer equipment to the Soviets during the period from 1981 to 1985, including photoelectric punch tapes and disks, card punch units, digigraphs, keyboards, plotters, and other computer hardware. [redacted]

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Eastern Europe also exports to the Soviets a wide variety of other electronic equipment that incorporates ICs. Two of the most important examples are radio and television transmitters and digital controls

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for machine tools. As of early 1981 more than 800 radio and TV transmitters produced by Czechoslovakia's Tesla Hloubetin Plant were operating in the USSR. According to a Czechoslovak trade journal, the latest transmitters contain semiconductor devices throughout, including ICs. As an example, the new Tesla SRV 10 medium-wave transmitter employs the MDA 2020 amplifier IC produced at the Tesla Roznov Plant. [redacted]

Eastern Europe has been a major exporter of machine tools but, in the past decade, has encountered problems competing because control systems produced in the region were viewed as below world state of the art. In response to this problem, the East European countries have focused more attention on the design of such systems and the need for incorporation of microelectronic devices. Eastern Europe still lags considerably behind the West in this area, but, according to reports in various East European journals, several countries have developed microprocessor-based control systems in recent years, some of which have been delivered to Soviet users:

- Poland has developed a microcomputer (the SM 50/40) that is reportedly suitable for controlling machine tools.
- The Czechoslovak firms ZPA Kosire and Tesla Kolin, working in conjunction with the Tesla VUST and VUOSO Prague research institutes, have developed the NS series of CNC control systems based on the Intel 8080A microprocessor.
- The Romanian firm ITC Cluj-Napoca is offering its three-axis SPL-400 machine tool with a control system based on the Intel 8080 chip.
- The East German firm VEB Numerik Karl Marx produces the CNC 600 numerical control system, which uses a multiprocessor structure based on the U880 microprocessor.
- Hungary's Electronic Measuring Instrument Works produces the Hunor line of microprocessor-based CNC control systems. Hunor control systems have been exported to a number of countries, including the Soviet Union.
- Bulgaria has a licensing agreement with Fanuc/Fujitsu of Japan to produce CNC controllers. In fact, Bulgaria provides full service for all Fanuc controllers sold throughout CEMA. [redacted] 25X1
[redacted] Bulgaria supplies 40 percent of CEMA's electronic controls requirements. Bulgaria also has a license with the US firm Prab to manufacture robots and has developed a capability to produce 1,000 robots annually, many of which are shipped to the Soviets. [redacted] 25X1 25X1

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We believe the East European countries are running an overall trade surplus with the USSR in the areas of computers and other microelectronics-based products. Eastern Europe uses these exports to offset purchases of Soviet energy and raw materials. The surplus in this trade category is likely to increase over the next five to 10 years as CEMA-level cooperative efforts expand in other areas dependent on microelectronics, such as robotics and flexible manufacturing systems. [redacted] 25X1

On the basis of reported East European shipments of computer equipment to the Soviet Union, we estimate that as much as 75 percent of the region's ICs end up in products exported to Soviet users. This figure differs, of course, by country. Those CEMA members that are heavily oriented toward the Soviets, such as Czechoslovakia and Bulgaria, probably export an even higher percentage of their IC output. The East Germans, who use relatively more indigenously developed IC technology for domestic applications than other East European countries, probably ship a lower percentage of their ICs to the Soviets. [redacted] 25X1

Integrated Circuits

We estimate that direct exports of integrated circuits constitute only a small portion of total East European IC output. We believe that only the GDR and Czechoslovakia currently are producing ICs for direct use in the Soviet market. Although data on shipments are sparse, the overall volume of exported ICs is probably less than 10 percent of total East European output. [redacted] a large number 25X1
of the ICs produced in East Germany either are exported directly to the USSR or sent there as

components in other GDR-manufactured equipment. For example, more than 70 percent of the MOS circuits [9] produced in the GDR are exported to the Soviet Union. The quantities involved represent only a small percentage of total Soviet IC consumption. [redacted] the East Germans shipped from 6 million to 12 million ICs to the Soviets during 1984. This equates to less than 1 percent of estimated Soviet IC production that year. [redacted]

[redacted] the Soviets have been exerting considerable pressure on East German and Czechoslovak IC producers since the second half of 1984 for a significant increase in the delivery of ICs. The East German VEB Microelectronics Karl Marx Plant in Erfurt and the VEB Halbleiterwerk in Frankfurt-Oder were asked to quadruple deliveries to the USSR in 1984, for a total shipment of 6 million devices. The ICs that are probably involved in these deliveries include the U880 microprocessor made at the Erfurt plant and low-power Schottky transistor-transistor logic (LSTTL) devices produced at the VEB Halbleiterwerk Plant. [redacted]

[redacted] the GDR and the USSR have an agreement stipulating that the East Germans will develop LSTTL devices, while the Soviets would develop complementary metal-oxide semiconductor (CMOS) chips. The GDR shipped 4-6 million LSTTL ICs to the Soviets in 1983, but in 1984 was informed that the Soviets had developed their own LSTTL capability and therefore needed only 3-4 million pieces. This requirement was later raised to 12 million when the Soviet devices proved to be markedly inferior to those produced in the GDR. [redacted]

To bolster domestic IC consumption, East European countries import a substantial number of chips from the USSR. Most East European countries do not manufacture the full range of ICs needed for the production of computer systems and peripherals, and they therefore purchase microprocessors, 16K DRAMs, and other circuits from the Soviets. For example, [redacted] the GDR obtains about 50 percent of the chips it uses from the Soviets, including a 16-bit microprocessor that the East Germans plan to use in their latest personal computer, the A7100,[10] which was displayed at the 1986 Leipzig Spring Fair. In addition, the Czechoslovaks rely on Soviet 16K DRAMs and other LSI memory chips in the production of their SM-4 minicomputer. [redacted] 25X1 25X1 25X1 25X1 25X1

Implications and Outlook

The East European countries will increase their microelectronics production capacities through capital investment and imports of manufacturing and test equipment and technology. We believe, however, that production of ICs in Eastern Europe will not be sufficient to fulfill the rapidly growing requirements of computer and automated equipment producers throughout CEMA, at least over the next 10 years. While the goal of reducing the dependence on Western IC technology is still part of the CEMA development program, acquisitions are likely to rise, at least over the next five years or so, as the East European nations struggle to raise the quality and increase the quantity of their IC production. Stricter adherence to COCOM regulations by the Western allies could limit Eastern Europe's access to this equipment, however. Limited availability of advanced technology from the West may force the countries to increase their reliance on the USSR and to improve their own R&D efforts and production technology to keep up with increasing domestic and Soviet demands. [redacted] 25X1 25X1 25X1

Within Eastern Europe, the microelectronics industries of each country have progressed quite differently and must be viewed separately to anticipate future 25X1

[9] These include the GDR's U880 microprocessor and the U256 16K DRAM chips. [redacted] 25X1

[10] This PC is not yet in serial production and, [redacted] the East Germans may be forced to use the US 8086 chip because of expected shortfalls in both the quantity and the quality of the Soviet version. [redacted] 25X1 25X1 25X1

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developments and problems. By 1990, we expect the following for the six countries:

- *East Germany*. The recent push to increase microelectronics production will be intensified. If plans to add three new production buildings to East Germany's most sophisticated IC plant are realized, the country's capability for producing advanced devices will at least triple. Although the GDR will continue to lag behind the USSR in IC technology, the rapid progress of its microelectronics industry will make East German products increasingly attractive to the Soviets—possibly for military use. East Germany will probably pull further ahead of the other East European countries and continue to dominate development and production in the region.

- *Czechoslovakia*. Resources earmarked for industry improvement will need to be diverted to repair the Tesla Piešťany Plant—severely damaged in an August 1985 accident. This will hamper Czechoslovakia's IC design capabilities for the next few years and will divert resources that could have been used to upgrade IC production.

- *Poland*. Antiquated plants and production equipment will make it difficult for Poland to improve its technological base. Hard currency shortages will make it impossible to modernize its industry substantially in the near term, causing Poland's technological level to continue to slip relative to levels in the West, the USSR, the GDR, and Czechoslovakia.

- *Bulgaria*. Bulgaria has recently doubled its IC production floorspace and has embarked on a plant modernization program that includes purchases of Western equipment to increase production capacity and improve IC reliability. Past efforts to incorporate Western technology have met with little success, however, and we do not foresee a significant increase in domestic capabilities until at least 1990.

- *Hungary*. Hungary's early lack of commitment to its IC industry will force it to play catchup with the Bloc and the West. Although recently purchased Soviet production lines may increase production nearly 200 percent over 1982 levels, device sophistication will remain relatively low. Moreover, a fire in May 1986 at Hungary's Microelectronics Enterprise seriously damaged manufacturing capabilities there, and Budapest has been seeking Soviet and Western assistance to offset production shortfalls. We believe, therefore, that Hungary will be forced to continue importing large quantities of more advanced ICs from the West to fill domestic demands.

- *Romania*. Romania's inability to foster independent R&D efforts, and its strong reliance on Western technology, will ensure its last place standing in Eastern Europe in IC production. Furthermore, because of its poor economic situation, Romania will have great difficulty replacing the equipment for MOS large-scale IC production that was destroyed in the recent fire. As a result, we do not foresee Romania gaining an LSI capability by 1990.

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We believe that, as a whole, Eastern Europe will be able to maintain its IC production growth rate at levels similar to those achieved during the first half of the 1980s. The GDR and Bulgaria will probably show the greatest growth in production because of recent investment programs. The dominance of East Germany and Czechoslovakia in overall East European IC output will probably start to fall as they shift production to the next generation of microprocessor and DRAM memory chips and as the new production programs accelerate in Hungary and Bulgaria.

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To increase production and improve the quality of its ICs, Eastern Europe will remain dependent on the West both for equipping existing plants and for developing specialized buildings for VLSI production. Eastern Europe's lack of standardized IC production facilities may hinder its ability to diffuse technology and produce VLSI devices. Western industry has found it necessary to develop completely new building types with improved clean-room design and vibration control for these types of circuits. East Germany's new building design at the Erfurt branch plant may consequently become the standard for the region as other countries begin production of VLSI devices.

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We expect continued and possibly increased Soviet demand for East European microelectronic devices. Eastern Europe may grow increasingly reluctant to part with its ICs because of growing domestic demands and industrial modernization efforts. Despite CEMA's endorsement of the Soviet-sponsored S&T 2000 program, the East European countries may resist strong Soviet management of domestic R&D programs in an effort to maintain some autonomy over the development of their own industries. 25X1

We expect that the delivery of computers and other microelectronics-based products will continue to be the dominant East European electronics-related contribution to the Soviets. CEMA cooperative computer production programs are expanding rapidly, and East European shipments are likely to continue growing in this area. In addition, the Soviets are pushing their CEMA allies for increased cooperation in other areas such as robotics and the development of flexible manufacturing systems that will require heavy contributions from East European IC producers. These developments probably will push the Soviet-East European trade balance for these products even further in favor of Eastern Europe. The Soviets' own output of ICs and related products will be increasingly needed to support Gorbachev's ambitious modernization program and therefore will not be widely available for export. 25X1

CEMA cooperation efforts have enhanced the IC production capabilities of the East European countries by allowing them, through increased specialization, to concentrate their limited resources on a narrower range of development and production activities. Intra-CEMA trade in microelectronics equipment has risen steadily as countries increasingly enter into bilateral production and reciprocal trade agreements. On the negative side, however, the wide disparity in the technical levels of the East European countries has offset some of these benefits, as the less developed countries have not always been able to supply their trading partners with reliable equipment and ICs. The effectiveness of CEMA cooperation efforts has also been constrained by the unwillingness of the Soviets to share their own technology fully with their East European allies. Soviet and East European statements, the ambitious goals of the S&T 2000 program, and the increasingly costly challenge of keeping pace with Western developments all suggest that CEMA microelectronics cooperation and specialization will intensify. It is doubtful, however, that these efforts will enable these countries to close the gap with the West in IC development and production. At best, we believe that the cooperative efforts of the CEMA countries will serve to keep the gap from getting wider and that most of the region will remain heavily dependent on Western ICs and production technology throughout the 1980s. 25X1

Appendix

Plant Data on East European IC Producers

Country	Plant Name/Geographic Coordinates	Alternate Name (Production Association)	IC Product Lines [a]	Total Production Building Floorspace (*square meters*) [b]
Total				**224,519**
Bulgaria (Ministry of Electronics and Machine Building)				
Botevgrad	Botevgrad IC Plant 4254 15N 0234730E	Botevgrad Science Production Combine for Semiconductors	MOS, 4K RAM, 4k DRAM	11,324 2,872 U/C
Stara Zagora	Computer Memory Disk and IC Plant [c] 422529N 025391E	OZZU/Association of Plants for Memory Devices		8,389
Czechoslovakia (Ministry of Electrical Engineering)				
Lanskroun	Tesla Lanskroun 495438N 0163609E	Tesla Combine	HY	7,122
Piestany	Tesla Piestany [d] 483540N 0174920E	Tesla Combine	CMOS, 16K DRAM NMOS, 8-bit MP	9,323
Prague	VUST/A. S. Popov Research Institute for Communications Equipment 500145N 0142553E	Tesla Combine	CMOS, SSI, MSI, LSI	827
Roznov	Tesla Roznov 492743N 0180739E	Tesla Combine	RAM, ROM, MP, TTL, MOS, BP, LSI	18,800
East Germany (Ministry of Electrical Technology and Electronics)				
Berlin	VEB Television Electronics Plant 522724N 0133157E	Microelectronics Combine	HY, OE	12,855
Dresden	ZFTM/Center for Research and Microelectronics Technology 510805N 0134645E	Formerly Institute for Microelectronics, Dresden Microelectronics Combine	16-bit MP; 64K, 16K, and 4K RAM; VLSI	5,099
	ZFTM Branch/Center for Research and Microelectronics Technology 510743N 0110053E	Microelectronics Combine		5,280 [c] 3,188 U/C

Footnotes appear at end of table.

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Plant Data on East European IC Producers (continued)

Country	Plant Name/Geographic Coordinates	Alternate Name (Production Association)	IC Product Lines [a]	Total Production Building Floorspace (*square meters*) [b]
Erfurt	VEB Mikroelektronik "Karl Marx" Erfurt 505826N 0110053E	Formerly Funkwerk Erfurt Microelectronics Combine	MOS, CMOS, MP, EPROM, RAM, ROM	10,525
	VEB Erfurt Sued Ost (ESO) 505700N 0110503E	Microelectronics Combine	MOS, LSI, 16K/64K DRAM, 8/16-bit MP	6,755 6,755 U/C
Frankfurt-Oder	VEB Halbleiterwerk Frankfurt-Oder (HFO) 521730N 0142825E	Microelectronics Combine	TTL, CMOS, MP, SRAM (over 200 product types)	26,148
Hermsdorf	VEB Ceramics Plant Combine Hermsdorf 505355N 0115100E	Electrical Engineering Combine	HY, IC	1,865
Hungary (Ministry of Industry)				
Budapest	REMIX Radio Engineering Enterprise 472922N 0190748E		HY, IC	7,242
	Microelectronics Enterprise [d] 473442N 0190547E		HY, MP, NMOS BP, OE	5,168 1,350 U/C
Budapest (Ujpest)	Tunsgram/United Incandescent Lamp and Electric Company (EIVRT) 473455N 0190430E		4K DRAM, TTL, 4K PROM, LN	9,702
Poland (Ministry of Metallurgy and Machine Building)				
Krakow	Krakow Unitra-Telpod Electronic Works 500255N 0195750E	Scientific Production Center of Hybrid Microelectronics and Resistors	LSI, HY	29,356
Warsaw	Plant Ratuszowa 521531N 0210152E		IC	6,655
	Tewa Semiconductor Factory 521054N 0210008E	CEMI, Unitra	MP, BP, MOS, TTL, LSI (8080 MP)	10,908
Wrocław	Unitra-Dolam, Research and Production Center for Electronic Components and Equipment 510537N 0170348E		HY	5,329

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Plant Data on East European IC Producers (continued)

Country	Plant Name/Geographic Coordinates	Alternate Name (Production Association)	IC Product Lines [a]	Total Production Building Floorspace (*square meters*) [b]
Romania (Ministry of Machine Building Industry)				
Bucharest	Electronics Parts Plant 442631N 0260915E		IC, MP	2,651
Bucharest/Baneasa [e]	1. Radio and Semiconductor Plant Baneasa (IPRS)	All organized under the Industrial Center for Electronics and Computer Techniques	TTL, LN, BP (over 200 types)	4,327
	2. Microelectronica [d]		MOS, LSI, OE	9,821
	3. Center of Scientific Research and Engineering Technology for Semiconductors (CCSITS) 443101N 0260656E		RAM, ROM, LSI	6,176

[a] IC Product Lines
BP — bipolar integrated circuit
CMOS — complementary metal-oxide semiconductor
DRAM — dynamic random access memory
EPROM — erasable programmable read-only memory
HY — hybrid integrated circuit
IC — integrated circuit, specific device type unknown
LN — linear device
LSI — large-scale integration IC
MOS — metal-oxide semiconductor
MP — microprocessor
MSI — medium-scale integration IC
NMOS — N-channel metal-oxide semiconductor
OE — optoelectronic device
PROM — programmable read-only memory
RAM — random access memory
ROM — read-only memory
SRAM — static random access memory
SSI — small-scale integration IC
TTL — transistor-transistor logic
VLSI — very-large-scale integration IC

[b] U/C—Indicates new production building under construction.

[c] Plants externally complete, but work in progress on clean rooms and air purification systems.

[d] Building destroyed or damaged by fire.

[e] IPRS, Microelectronica, and CCSITS are one plant and are collocated. The Romanians, however, refer to them as three separate entities.

NOTE: The following cities reportedly have IC production plants, but the plants have not been confirmed on imagery:

Bulgaria — Stara Zagora
Czechoslovakia — Blatna, Hradec Kralove, Liptovskiy Hradek
East Germany — Berlin
Poland — Gdynia

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