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DIRECTORATE OF
INTELLIGENCE

Intelligence Memorandum

Soviet Need For US And Western Electronics Technology

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CENTRAL INTELLIGENCE AGENCY
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INTELLIGENCE MEMORANDUM

Soviet Need For US And Western Electronics Technology

Introduction

The capability to produce large numbers of integrated circuits (ICs) has permitted the United States and other nations of the Industrial West to enter a stage of electronics technology that is still essentially closed to the USSR and Eastern Europe. The strategic and economic advantages of ICs come from their ability to increase the reliability and dramatically to lower the size, weight, power consumption, and cost of complex electronics equipment. Moreover, the reduction in total circuit length in computers equipped with ICs materially increases computational speeds.

The mass production of the integrated circuit is the most recent stage in the rapid advance of US electronics component technology. The production process for monolithic ICs embodies a refinement of the planar and epitaxial growth techniques developed originally for the production of silicon planar epitaxial transistors. Silicon crystals rather than those of germanium are used in this process because of the possibility of forming insulation layers of glass on the active silicon surface by oxidation.

Today, ICs are extensively applied in the United States in computer circuits, industrial controls, avionics, communication equipment,

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consumer entertainment products, and desk calculators. This technology made important contributions to the US moon landings. The still more advanced instrumentation packages to be carried by US space probes in the 1970s and 1980s will incorporate IC technology.

Mounting evidence indicates that the lag of the USSR behind the United States in the technology of integrated circuits production is at least five years. The USSR seeks to reduce its lag in this strategic industry by importing Western technology. Manufacturers of electronics production equipment in several West European countries now have the capability and appear willing to give technological assistance to the USSR and Eastern Europe in the field of IC production. Such assistance would require the unanimous consent of the other participating countries in COCOM because IC technology is currently under multi-lateral trade embargo. It is expected that an "advanced state-of-the-art" in IC production in the USSR and Eastern Europe will be alleged increasingly by those participating countries who wish to obtain exceptions to existing COCOM regulations on IC technology.

This memorandum assembles the available evidence and draws conclusions respecting the ability of the USSR and Eastern Europe to produce integrated circuits on an industrial scale. No statement in this memorandum is intended to imply that the USSR lacks the capability to produce limited numbers of custom-made ICs of advanced design for special military or space projects.

The Technological Gap and Its Basis

1. The USSR and the East European countries appear to lag at least five years behind the United States in state-of-the-art in the large-scale production and application of integrated circuits. The lag is not primarily the result of failings of Soviet science. It exists despite the fact that Soviet scientists have experimented for many years with IC devices and with the technological

processes required for IC production and undoubtedly have the capability to produce limited numbers of advanced devices. The USSR has also had available US technical literature, which clearly outlines the properties of IC devices and their potential for advancing electronics technology.

2. The Soviet lag can probably be ascribed largely to the Soviet incentive system. Soviet plant managements are extremely reluctant to introduce major innovations into a stable production program because of the virtual certainty that output (and thus bonuses) will be adversely affected, at least in the short run. This built-in feature of Soviet economic life has slowed the participation of the USSR in every new phase of the technological revolution in electronics during the last 20 years. The lack of Western-developed management and industrial organization techniques has also contributed to the lag.

3. The substitution of transistors for vacuum tubes appears to have been resisted in the USSR by component producers and users alike. Knowledge of the application of semiconductor devices seems to have spread very slowly among rank and file engineers. Designers of electronics equipment continued to specify vacuum tubes which they understood and trusted; users of electronics equipment also preferred vacuum tubes for their reliability.

4. A strong military requirement for transistors did not develop in the USSR at the same time that it did in the United States. The Soviet ground forces standardized on field radios fitted with vacuum tubes. Compact, man-carried radios are fitted with subminiature tubes. Soviet military aircraft were fitted with vacuum tube radio gear long after Free World air forces had shifted to transistorized equipment. Silicon technology for transistor production got its boost in the Free World from the military requirement for devices that would be more reliable under difficult operating conditions than those made from germanium. Because the Soviet military did not demand transistorized equipment, it provided little impetus for the development of silicon devices.

5. The need for small, lightweight, lower power electronic equipment for on-board guidance of Minuteman ICBMs stimulated the development of ICs in the United States in the early 1960s. The feasibility and reliability of the technique was established at that time. A parallel need for integrated circuits, however, was not recognized in the Soviet military/space program. The USSR developed large boosters for ICBMs and space probes, and, because of ample payload capacity early in the program, the Soviet Union was not forced to miniaturize electronics packages to the same extent as the United States.

6. Little was done in the USSR toward establishing an industrial-scale capacity for ICs until the priority need for large numbers of high-speed computers emerged in the mid-1960s. At that time, the Soviet Union found its electronics industries in a very unfavorable position to undertake IC production. Large amounts of high-purity monocrystalline silicon were not available. Little experience had been acquired in producing semiconductors by the planar epitaxial process, and the high-volume production equipment necessary for a rapid buildup of IC output capacity had not been developed. Development of semiconductor production in the USSR was almost certainly retarded by COCOM embargo of both vital raw materials and technology.

7. In the United States, computers probably have been the most important influence leading to high-volume production and low unit cost for ICs. The average unit cost of integrated circuits produced in the United States dropped from $18.50 in 1964 to $1.29 in 1969. During this period, factory sales increased from about $40 million to nearly $500 million and from 2.2 million units to 252.9 million.*

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* *These figures do not include large numbers of ICs which are incorporated into end items by the component producing firm, and hence not reported as IC sales.*

Soviet Progress in IC Production

8. In 1965, when the USSR belatedly recognized the need to establish industrial-scale production of ICs, it apparently did not have an adequate capacity for supplying high-purity monocrystalline silicon. This deficiency arose because the Soviet Union was very slow in adopting silicon as a transistor material. Although some silicon transistors are produced in the USSR, and Soviet planar epitaxial silicon transistors have been made since 1967, almost all transistorized Soviet electronic products contain only germanium transistors, a rather clear indication that progress in applied silicon technology continues to be slow. Delay in shifting from germanium to silicon as the basic transistor material is obviously a fundamental cause of the present primitive state-of-the-art in Soviet IC production. In contrast to the Soviet experience, progress in silicon technology in the United States was rapid. Factory sales of silicon transistors increased from 275 million in 1965 to 935 million in 1969 while factory sales of germanium transistors declined from 334 million to 208 million in the same period.

9. It is significant that silicon planar epitaxial transistors first appeared in Soviet semiconductor catalogs only in 1967, seven years after their annual sales in the United States had reached $100 million. It was, coincidentally, in 1967 that the Soviet Union first offered to export monocrystalline silicon. Although some samples were sold, a major sales effort was not mounted. The substantial purchases of monocrystalline silicon by Hungary from Free World countries in 1969 and 1970 suggests that the USSR still is unable to export significant amounts of adequate purity for IC use. Raw materials of this type still remain COCOM embargoed subject to an administrative note for certain types.

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10. Evidence has appeared from time to time that the Soviet IC production effort has long been stalled in the prototype stage. In early 1966,

the USSR was trying to develop a process for packaging hybrid ICs in large transistor cans, a technique well established in the United States at least three years earlier. At an electronic components show in Paris in April 1969 and again at a show in London in May 1969, the USSR exhibited more than 200 types of ICs. The technical brochures handed out at the shows indicated that, with few exceptions, the Soviet ICs were typical of those in production in the United States four years earlier. Events subsequent to the shows suggest that the USSR had exhibited prototype devices which it intended eventually to produce on an industrial scale.

11. A Soviet representative at the Paris show claimed that 150,000 ICs would be available for export in 1969. Soviet trade officials rejected all purchase orders throughout 1969, however, and later announced that none of the USSR's ICs would be available for export in 1970 because of strong domestic needs.

12. In late 1969 a number of US scientists and engineers visited Soviet semiconductor plants. The most advanced production technology was seen at the Svetlana plant in Leningrad. Svetlana is the USSR's most important component plant. Together with its branch plants it has been given the status of a Main Administration under the Ministry of Electronics. Plant officials indicated that Svetlana has the principal responsibility for providing semiconductors for the Soviet computer industry, and in 1970 the plant apparently is attempting to establish industrial-scale production of digital ICs for new models of computers. Several US visitors were shown samples of ICs, but none of the visitors was shown IC production facilities. One US expert on semiconductors and ICs reported that the ICs shown to him were laboratory prototypes. Some idea of the level of unsolved problems at Svetlana can be gained from the statement of a plant official that the overall yield of usable devices from the plant's production line for silicon planar transistors was only 10% to 15%. This compares very unfavorably with current yields of 80% in the United States. The principal weak spots noted in production technology at Svetlana were the low level of automation and the poor testing

equipment (the USSR has been trying to procure test equipment from the West). It seems likely that efforts are under way to put ICS into production at other component plants as well.

13. In June 1969, during an official reception at the US Ambassador's residence in Moscow, an official of the USSR's State Committee for Science and Technology was asked by an officer of the US Embassy when the USSR would produce "third-generation" computers. He replied, "When integrated circuits become available." This statement is particularly significant because the USSR has announced a RYAD third-generation computer, compatible with the IBM 360 series, which currently is based on ICs, although early models were not. In the meantime, IBM has gone to a 370 series embodying a more advanced type of integrated circuit -- the LSI or large-scale integration development.*

14. Thus in 1970 the USSR is attempting to move ICs from production on an institute or laboratory scale onto the industrial production line. The production of major items of electronics equipment incorporating ICs, and the quality and number of items, will depend on the success of the new Soviet IC production facilities now being established.

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* *LSI depends for its successful implementation on metal-insulator-semiconductor (MIS) technology. This most recent development in microcircuitry permits significant simplification in the production process for microelectronic circuits. Should the USSR decide to introduce this form of circuitry widely, it could satisfy a large part of its needs for microelectronic circuits. The USSR is aware of MIS technology but so far has shown no intentions of introducing it rapidly on an industrial scale as it is attempting to do with monolithic ICs. The substitution of MIS circuitry for ICs would entail a considerable redesign of electronic products which have been designed for monolithic ICs. Moreover, a number of the difficult problems associated with production of monolithic ICs are also present in the production of MIS circuits.*

Production of Advanced Semiconductors Lags in Eastern Europe

15. The East European countries have been slow in developing advanced semiconductor production technology. The slow pace of development may be explained, in part, by a lack of cooperation among the East European countries, and by the Soviet failure (or inability) to honor its technical aid commitments. In theory, the Council for Mutual Economic Assistance (CEMA) directs cooperation in semiconductor development and production throughout Eastern Europe under the leadership of the USSR. Under CEMA, the Academies of Science of the member countries have working agreements for the exchange of research results and production technology. In practice, however, the exchange of information between East European countries takes place only when it is mutually desired. Moreover, Soviet practices have discouraged rather than encouraged cooperation. For example, the USSR not only has failed to provide CEMA members with promised guidance and technical assistance, but also has made a practice of exploiting the best results obtained by the other member countries and has assigned such tasks to them as will benefit the Soviet semiconductor program.

16. Czechoslovakia and East Germany are the only East European countries that have made tangible progress in advanced semiconductor production. Czechoslovakia has developed a small range of linear and digital (monolithic) ICs which are now being produced in small quantities. The East Germans are producing miniaturized silicon planar epitaxial transistors and have developed a variety of linear and digital microcircuits using thin-film passive and discrete active components. However, despite the Czech and East German gains, production on a commercial scale of advanced semiconductors (particularly monolithic ICs) in any East European country probably will not be achieved in the next few years without equipment and technology from the West.

Soviet and East European Strategy to Obtain US Technology for IC Production

17. In recent years the USSR has become very conscious that the "technology gap" between itself

and the industrially advanced countries of the Free World has probably been widening. In addition to a rather ineffective "scientific reform" program, which is intended to speed up the introduction of innovation in industrial production, the USSR has mounted a campaign to obtain advanced technology from the Free World. A major result of the campaign is the conclusion of agreements with the United Kingdom and France for scientific cooperation and exchange of technological information. Within these agreements the USSR will develop strong pressures for the acquisition of advanced technology that is not presently available to Communist countries, because of COCOM controls. For example, the agreement on technological cooperation between the UK Ministry for Technology and the USSR State Committee for Science and Technology calls for cooperation in the field of numerical control and computer control of machine tools. Modern Free World numerical control equipment typically embodies integrated circuits. Such cooperation by UK firms probably would require exceptions to COCOM regulations because the more advanced forms of numerical control (continuous path control) are embargoed. However, integrated circuits embodied in non-embargoed equipment can now move to the USSR and the East European countries.

18. In 1968 the USSR plainly showed its interest in obtaining massive Western assistance for its lagging computer and semiconductor industries when it discussed an industrial and technical cooperation agreement with the United Kingdom which would license the Soviet computer industry to produce the ICL-4 series of computers (third-generation computers, compatible with the IBM-360 series) together with the necessary components, including integrated circuits. However, the agreement was not consummated, and the USSR developed plans to produce the Soviet-designed RYAD series of computers (also compatible with the IBM-360 series) with participation in the production program by all the CEMA countries. The RYAD program provides for Western participation also, primarily in the area of production of peripheral equipment and provision of software.

19. The RYAD program is lagging, and inadequate production of ICs is a major reason for the lag. This fact was reconfirmed in 1970 when senior officials of IBM visited the USSR at the request of J.M. Gvishiani, Vice-Chairman of the State Committee for Science and Technology of the USSR. The USSR was interested in receiving assistance from IBM for its computer industry and proposed to pay IBM in ICs, providing the firm would assist the USSR in establishing a semiconductor facility. IBM officials left the USSR with the judgment that the Soviet Union lagged far behind the United States in all stages of computer manufacturing.

20. The technology of semiconductor ICs is a uniquely American development. The rapid spread of this technology to the major industrialized nations of the Free World has been achieved largely through license agreements and through subsidiaries of US firms abroad. Although several Free World countries are now making progress in developing an indigenous IC capability, all these countries continue to rely on US firms for some types of IC production equipment.

21. Since the early 1960s the East European countries have sought semiconductor production technology in the West. In 1969, for the first time in COCOM, approval to export equipment and technology to Poland for the production of silicon planar epitaxial transistors was granted in response to a French request. Some items, useful in such production, are now approved for export to Eastern Europe on an ad hoc exceptions basis. Romania has been seeking IC production technology from British and US firms, and there are indications that Romania may have recently acquired some US integrated circuit production equipment through illegal transactions.

22. The continuing lag of the Soviet and East European countries in reaching commercial-scale production of ICs and their mounting concern over the consequences of further delays have made these countries more active in seeking Western assistance. This has created a very attractive potential market for Free World countries -- so attractive, in fact,

that despite the strategic importance of this technology and its embargo status under COCOM, several West European countries are exerting strong pressure in COCOM for permission to export IC production technology to Eastern Europe. For example, in June of this year, France submitted an exceptions request to COCOM for the export of IC production technology to Poland, and in July the UK submitted a request to export part of a small-scale IC production line to Hungary. Recently, West Germany asked the United States for its reaction to a contemplated German request to export IC technology to Poland.

23. Approval by COCOM of the French and British requests would have important immediate as well as long-run implications. Initially, it would almost certainly lead to additional requests to export such technology to Communist countries. It would insure a reduction in the technology gap between the Free World and the Communist countries in advanced semiconductor technology, particularly since most of the contract proposals call for continually updating technology. Furthermore, once the technology goes, most COCOM countries insist there is no further case to maintain COCOM controls on equipment in which the technology is embodied. Most importantly, it would probably lead to significant improvements in the quality of strategic Communist items that are electronics intensive. In short, Free World export of IC technology to the Communist countries would supply them with a fundamental capability, the lack of which contributes to the Communist lag in important areas of advanced electronics.

Conclusions

24. The USSR is only beginning to establish industrial-scale production of integrated circuits and recognizes that it is far behind the United States and other Free World countries in design and production. This gap could widen unless the USSR can get technological assistance from the Free World, either directly or through Eastern Europe.

25. The persistent efforts of the USSR to obtain technical assistance in the production of computers and integrated circuits from the Free World reflects the Soviet belief that COCOM embargoes of strategic goods can be broken down through commercial pressures.

26. The technology the USSR seeks is available in Western Europe. Much of the technology is of US origin and still controlled by licenses granted by US firms. If the USSR and East European Communist countries are successful in their current drive to obtain IC technology from the West, along with agreements to keep this technology up-to-date, they will have solved one of their major strategic and commercial problems.