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TITLE: The Partial Integration of the CEMA Computer Industries

AUTHOR: Seymour E. Goodman

CONTRACTOR: The Arizona Board of Regents,
University of Arizona

PRINCIPAL INVESTIGATOR: Seymour E. Goodman

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ABSTRACT

For over thirty years, the member countries of the Council for Mutual Economic Assistance (CEMA) have been extolling the virtues of socialist economic and technological cooperation and integration. Although official lists of cooperative projects are long, most of these undertakings have been very limited, bilateral rather than multilateral, and of questionable success. Effective cooperation and integration are hindered by many political, social, and economic difficulties.

The lack of general success in CEMA integration, and Western analyses of communist computing capabilities that concentrate on the USSR and narrow technical comparisons with the US, have overshadowed the substantial development and integration of the CEMA computer industries that have taken place during the last dozen years. Assorted economic and technological factors seem to have been more effective in bringing this about than Soviet political pressure. Although involving a massive transfer of technology from the West (here defined to include Japan), CEMA progress in the computer field has been impressive relative to its own past and in terms of some important milestone accomplishments.

The CEMA computer development program is a notable achievement in the history of international technological development because of the sophistication of the technology, the scope of the undertaking, its reasonable success in the face of considerable difficulties, and a framework that some might see as an alternative to Western multinational corporations.

In 1971, the 25th Session of CEMA came forth with its "Comprehensive Program for the Further Extention and Improvement of Cooperation and the Development of Socialist Economic Integration by the CEMA Member Countries". This program and its follow-up literature discussed a number of goals that we use to define "socialist economic and technological integration". These apply to the joint computing undertakings, which formally began in 1969, and their achievement was expected to take place over the next 15-20 years. It has now been over ten years since they were first proclaimed, and more than a dozen since the start of the cooperative computing efforts. It is reasonable to test these goals against what has been achieved so far. A secondary framework will consider three characteristics of Western-style integration used to define an "integrated multinational corporation" (IMNC), and views the cooperative CEMA program in this perspective.

The pre-1970 era of East European computing is usefully partitioned into two subperiods. The 1950s were characterized by the construction of several experimental machines of somewhat original design. Developed for the most part in academic environments, these early computers rarely managed to make it out of the laboratory into limited

production. In the 1960s, the East Europeans were forced to recognize an increased need for equipment for data processing and process control, along with their own inability to produce sufficient quantities and mixes of such equipment domestically. Not surprisingly, the 1960s were characterized by a greater reliance on Western and Soviet machines, and by 1969 the proliferation of incompatible computer models and continuing shortages had come to be perceived as a serious problem. During neither subperiod is there evidence of serious multilateral integration.

By the early 1980s some important and necessary steps had been taken toward a form of technological integration. All of the participating members have built stronger and more cohesive national computer industries, although serious problems remain. Several major programs had been started with varying levels of success. Hardware interoperability and software compatibility had become realities to varying degees. A CEMA level organization, the MPKVT, has been established and appears to be functioning fairly well as a coordinating institution.

In terms of progress in international specialization and division of labor, computing is something of a CEMA showcase. Each of the participating countries has acquired a fairly distinct technological role. The GDR, Bulgaria and Hungary have been the most active and aggressive participants, and their computer industries have shown the most dramatic improvements. The comparative reluctance of the Czechs and Poles to actively join in the cooperative efforts resulted in a serious relative decline of the industries of these two countries. Cuba and Romania remain on the sidelines. These roles are evolving in time. The overall trend seems to be towards greater integration, but this trend is certainly not uniform. Our impression is that the division of labor among the CEMA computing industries has evolved naturally at least as much as it has been consciously planned or forced by the Soviet Union. What has developed is primarily a result of de facto achievements, the distribution of pockets of expertise, the influence of domestic market size and character, the ambitions of the national industries and their abilities to haggle for what they want within the MPKVT and other CEMA forums. With few exceptions, the USSR seems content with this dynamic, as long as everyone is at least officially involved in the integration effort. Part of this tolerance is probably due to Soviet sensitivities about ramming too much down East European throats, but other factors include the lack of serious Soviet dependence on East European computer products and the reasonable successes and positive trends the cooperative effort has enjoyed.

The volume of computer related trade among the CEMA countries has grown fairly impressively compared to the levels that existed 15 years ago. Growth rates have been respectable, although absolute volumes are still small by Western standards. There have been improvements in the conduct of this trade, but these are harder to assess and many problems clearly remain. Various serious systemic factors continue to severely limit the scope and practice of technology transfer among the CEMA countries.

The CEMA cooperative computing efforts have made notable progress toward almost all of the proclaimed goals that we used to define "socialist economic and technological integration". However, in many cases, such progress still leaves them far short of what they might want or what has been achieved in the West.

The cooperative program that has brought about this progress satisfies the definition of an INMC, a definition that has been used elsewhere to characterize IBM. To be sure, there are significant differences between IBM and the CEMA program, but there are some striking parallels in terms of features such as the rationalization of tasks within a contentious system, and the naturalization of subsidiaries. Unlike some of the CEMA hardware and software, the implementations of these features were not closely copied from IBM, but evolved in their own way. It would appear that the CEMA countries have effectively established an INMC of their own for computer technology.

CONTENTS

1. INTRODUCTION

For over thirty years. the member countries of the Council for Mutual Economic Assistance (CEMA) [1] have been extolling the virtues of socialist economic and technological cooperation and integration. Although official lists of cooperative projects are long. most of these undertakings have been very limited. bilateral rather than multilateral. and of questionable success. Effective cooperation and integration are hindered by many political, social. and economic difficulties [2].

The lack of general success in CEMA integration. and Western analyses of communist computing capabilities that concentrate on the USSR and narrow technical comparisons with the US. have overshadowed the substantial development and integration of the CEMA computer industries that have taken place during the last dozen years. Assorted economic and technological factors have been more effective in bringing this about than Soviet pressure. Although involving a massive transfer of technology from the West (here defined to include Japan). CEMA progress in the computer field has been impressive relative to its own past and in terms of some important milestone accomplishments.

The CEMA computer development program is a notable achievement in the history of international technological development because of the sophistication of the technology, the scope of the undertaking, its reasonable success in the

face of considerable difficulties. and a framework that some might see as an alternative to Western multinational corporations.

The objectives of this study are to describe and analyze:

1. The history and recent achievements of the CEMA member countries in the field of computer technology.

2. The CEMA international division of labor for the development. production. and support of computing.

3. Computer trade and technology transfer among the CEMA members. and with other parts of the world [3].

4. The extent of integration. by measuring achievements and trends against the proclaimed goals of "socialist economic integration" and some of the characteristics of Western-style technological integration.

The Soviet Union presents us with an awkward problem. In terms of production capacity. user base. support base in other technologies. and range of applications. the USSR makes any of the other CEMA countries look unimportant. We will limit our interest in the Soviet Union to those aspects of its efforts which relate directly to the East Europeans.

Intra-CEMA activities will be of more interest than East-West relations. Constraints on the length of this article are such that it is not possible to give proper attention to both. We chose to concentrate on the former since it receives less attention in the US literature. These constraints have also caused us to essentially ignore important related industries: electronic components, instruments, robotics, and telecommunications.

A few words on sources are necessary. There is a large volume of oral and written information on CEMA computing. What is available is extremely fragmented and needs to be filtered for the useful content buried in the "low grade ore". Much of the best information is technical, and may be used to make inferences and conjectures regarding policy and economic issues about which we have less direct information. For example, the fact that equipment from different CEMA countries operates together using standard IBM interfaces may tell us more than litanies on "fraternal socialist cooperation."

It is neither possible nor desirable to go into much technical detail in a paper of this length and intended audience. It also makes little sense to list well over a thousand fragmentary sources in a bibliography. A first level aggregation of part of this data exists as a long intermediate report [4]. The present study builds a second level analysis and synthesis.

It is assumed that the reader has some knowledge of computer developments in IBM and the USSR since 1960. The necessary minimum background may be obtained from either of two articles [5].

A recent survey of research on CEMA integration identified four areas that need further work [6]. This study is intended to contribute to two of these by looking into the integration of a specific industry, and by helping to improve our understanding of the relationships between technical progress and integration.

2. WHY COMPUTERS?

The CEMA countries are divided by language barriers, poor communications systems, the lack of fluid and flexible international financial institutions and arrangements, national pride, and assorted bad feelings that go back centuries and which have been revived with some regularity in modern times.

Computing is an extraordinary array of products and technologies forcing active involvement by users to an extent that does not exist for any other technology of comparable importance. Computer hardware and software components and subsystems, and the interfaces and understanding used to build them up into a fantastic variety of useful systems, are among the most complex and delicate entities in widespread use.

It is difficult to imagine a more sophisticated and risky joint technological venture for a set of countries with the problems of CEMA. Even IBM. the world's most powerful and experienced computing multinational, had enormous problems building what would be the model for part of the CEMA effort [7]. Thus the basic question: Why would CEMA choose computing as a major cooperative undertaking?

Briefly. the answer may be stated as a list of several important needs. opportunites. and problems:

1. Current and potential applications of computerized systems are so pervasive. and are moving so far beyond the cost/performance capabilities of all-human systems. that no modern economic or military establishment will be able to function efficiently or competitively without them.

2. Computers are high value-added products. Production consumes little natural resources. This is a good technology for resource poor, industrialized countries to pursue.

3. Each East European CEMA country has a need to export to the Soviet Union that is closely and negatively correlated with its degree of energy self-sufficiency. Computer products are well suited as exports to the USSR.

4. The range of computing technologies is such that no small country can cover much of this spectrum. Talent and capital requirements are high. and the internal market is too small to permit good returns on investment.

5. None of the East European countries has the hard currency to import all of its computing needs from the West. although much of this would clear export controls. Such dependence would not be economically. politically. or militarily acceptable to the communist governments. This does not preclude equipment purchases or technology transfers for selected applications or to help build indigenous capabilities.

The East European members of CEMA have several options:

a. They can do without much computing resources.

b. They can look for what they need in the West.

c. They can look to the USSR.

d. They can each attempt to develop an independent and self-sufficient industry.

e. They can try to undertake a cooperative effort. with a partition of the necessary technologies.

Our discussion makes a combination of options c and e, with selections from b, look like an obvious necessity. However. students of East European affairs know that "obvious" solutions are rarely easily adopted in that part of the world. The current state of this obvious solution is not perfect. and not all the CEMA members share exactly the same perceptions.

3. AN ANALYTIC FRAMEWORK

We intend to describe and analyze the extent to which the CEMA computer industries have integrated in terms of:

A. The achievement of the proclaimed goals of CEMA. This will be split into two parts: the extent of integration attained before 1970. and progress since then.

B. Some of the characteristics of Western multinational integration associated with IBM.

Two important events that occurred around 1970 make that year a useful separator of the assessments under A. In December 1969. the USSR and five East European countries signed the multilateral agreement on collaboration in the area of the development. production and utilization of computers [8]. In 1971. the 25th Session of CEMA came forth with its "Comprehensive Program for the Further Extension and Improvement of Cooperation and the Development of Socialist Economic Integration by the CMEA Member Countries" [9]. The integrated computer effort was to be an important

project within this Comprehensive Program.

The 1971 Program and its follow-up literature discussed a number of goals that we will use to define "socialist economic and technological integration". These apply to the joint computing undertakings, and their achievement was expected to take place over the next 15-20 years It has now been over ten years since they were first proclaimed and more than a dozen since the formal start of the effort in computing. It is reasonable to test these goals against what has been achieved thus far. We list 16 goals [10]:

1. A more rapid development of the productive forces in all the CEMA countries.

2. Achievement of the highest scientific and technical levels.

3. A steady rise in the technical equipment of branch industries [industrial sectors].

4. The introduction of progressive technology in accordance with the requirements of the Scientific-Technological Revolution (STR).

5. Satisfaction in the long run of the national economic requirements of countries for... modern equipment... mainly through the production and rational utilization of the resources of the CEMA member countries. [This will be interpreted as the desire to eliminate dependence on non-CEMA countries for critical items.]

6. The gradual drawing closer together and evening out of the economic development levels of the CEMA member countries.

7. The growth of the capacity and stability of the socialist world market.

8. The strengthening of the defensive capability of the CEMA member countries.

9. To avoid the duplication of research and development work. To provide checks against work done elsewhere.

10. To develop specialization in the smaller countries. This will be made possible by the availability of the full CEMA market [especially that of the USSR] to provide for enough exports to permit efficient large scale production within the smaller economies.

11. The coordination of national economic plans and reciprocal deliveries.

12. To build a qualitatively new form of scientific and technical cooperation based on the three principles of: (i) voluntary participation; (ii) full equality of participants; and (iii) mutual benefit and comradely mutual assistance.

13. The national achievements and experience of individual countries in the field of science and technology becomes the property of all the members of the socialist community

14. The formation of modern. highly effective, national economic structures.

15. Priority now will be given to forms and methods of the division of labor... linked to technical progress... [to] enable all the socialist countries to raise the technical levels of production and make their products competitive on world markets.

16. Improvement of the forms and methods of cooperation in foreign trade and standardization.

Although we will judge the integration of the CEMA computer industries primarily in terms of these 16 criteria, it is also of interest to make some comparisons with IBM. We now establish this secondary framework for analysis.

A definition of a multi-national corporation (MNC) that is particularly relevant to this study is taken from a report on IBM commissioned by the Canadian Government [11]. This definition focuses on the multinational affiliates and their relations within the global organization. and characterizes a computer company whose size and scope are comparable to those of the joint CEMA effort. Since the definition may not include all the companies commonly

considered MNCs, we use the term "integrated MNC" (IMNC) to refer to a large organization with the following characteristics:

i. The Internationalization of Markets. An IMNC considers many countries to be within its market.

ii. The Rationalization of Tasks Within a Contentious System. Although there may be considerable central control, there exists a competitive and contentious system among the international affiliates. Within this system, there is a political process under which the affiliates bid for and develop their roles and workloads.

iii. The Naturalization of Subsidiaries. Within each country, the affiliate behaves as an organizational "citizen" of that country. Most of the people who work for the affiliate, at all levels including top management, are citizens of the host country.

This definition conveys three senses of integration. First, that a respectable part of a world market is integrated under an IMNC's influence and activities. Second, that the activities of its international affiliates are integrated in a way that still leaves these affiliates considerable freedom to stake their own claims. Third, that the affiliates are integrated within their host national environments. We believe it is accurate to describe IBM as an IMNC, and will try to show that the CEMA countries have effectively established an IMNC of their own for computer

technology.

These goals and characteristics should be kept in mind while reading Sections 4-7. Section 8 will be a complete review and summary.

4. A SHORT HISTORY OF EAST EUROPEAN COMPUTING [12]

The pre-1970 era is usefully partitioned into two subperiods. The 1950s were characterized by the construction of several experimental machines of somewhat original design. Developed for the most part in academic environments. these early computers rarely managed to make it out of the laboratory into limited production. In the 1960s. the East Europeans were forced to recognize an increased need for equipment for data processing and process control. along with their own inability to produce sufficient quantities and mixes of such equipment domestically. Not surprisingly. the 1960s were characterized by a greater reliance on Western and Soviet machines. and by 1969 the proliferation of incompatible computer models and continuing shortages had come to be perceived as a serious problem. During neither subperiod is there evidence of serious multilateral integration.

The 1950s: Academic Beginnings

The honor of having produced the first electronic digital computer in Eastern Europe is claimed by Poland. This machine, the EMAL, never became fully operational, but it was followed by three other experimental machines which did. All four developments took place in academic settings. Although features were borrowed from Western predecessors, it is fair to say that early Polish efforts were independent and somewhat innovative. None of these machines went into production, but they provided valuable experience for Polish designers and programmers.

In Czechoslovakia, computing took root in an academic environment under the leadership of Antonin Svoboda and his students. Two original and innovative models were developed during the 1950s, and one achieved limited production. It might be argued that Svoboda's group of computer engineers was one of the best on continental Europe.

The first East German computer, the Oprema, was built in 1955 by the Academy of Sciences with help from the Karl Zeiss industrial firm. While most early East European computers suffered considerable delays from start to completion, the Oprema was built in nine months and saw at least four years of three-shift operation. It may have been the first fully operational computer in East Europe. Oprema's successor was built by Zeiss and a version may have gone into limited production in 1959.

By the early 1960s, Romania had built an experimental research computer, and Hungary had copied a small Soviet machine. Hungary had also established a respectable communications equipment industry. There were no serious digital computer developments in Bulgaria.

By the end of the 1950s Eastern Europe had demonstrated the ability to construct prototype electronic digital computers based on a variety of architectures. Some were doing reasonably well, given their sizes and post-World War II economic and political conditions. But none had succeeded in building a computer industry. Computing-related contacts between countries were weak.

The 1960s: Growing Foreign Dependence

The need for much improved computing resources gradually became apparent to the East European countries during the 1960s. Each would try to blend its own mix of domestic production and imports from the West and the USSR. Attempts to master the full range of computing technologies suffered from systemic economic weaknesses, and efforts to build domestic capabilities grew increasingly dependent on foreign technical assistance. By the end of the decade, most of these mixes had failed.

Poland followed the most ambitious program of domestic production. The Elwro enterprise, founded in 1959 and later to become a cornerstone of the MERA association, had completed its first computer by 1962 and its hundredth by 1967. Three lines account for the bulk of Polish production, with the Elwro ODRA line being the most important. The early ODRAs were based on a Univac design, but by the end of the decade, Elwro had established good relations with England's International Computers Ltd. (ICL). In 1969, the ODRA 1304, based on the ICL 1900 series and using British systems software, was in production. It was a popular machine and undoubtedly accounted for some of Poland's reluctance to participate actively in the early stages of the joint CEMA effort. Of the three machine lines of the 1960s, the ODRAs had the least direct connection with the pre-1960 designs. The others were production variants of two of the followers of the EMAL. Neither was as successful as the ODRA. The production of indigenously designed computers gradually faded.

Czechoslovakia also pursued a policy that combined the continued development of indigenous models with the production of foreign machines under license. The Tesla enterprise began the licensed production of a second-generation French Bull machine in 1965. In that same year, in an effort to consolidate the Czechoslovakian organizations working on the research, development, production and support of computers, a number of enterprises

were combined to form the Instrument and Automation Works (ZPA). ZPA would grow to dominate the Czech computer industry, as MERA would dominate the Polish industry. Four years later, it began production of a model based on one of Svoboda's designs. By this time however, Czechoslovakian research and development had lost much of its vitality with the defections of Svoboda and other key designers.

In surprising contrast with the decade-long Polish and Czech efforts to establish domestic production capacities, there was a relative lull in the GDR. For most of this time the East Germans were content to produce calculating machines and typewriters. This changed significantly by 1969, with the appearance of the R-300, made by a new enterprise that would become the most technically and managerially capable of the CEMA computer manufacturers: the Robotron Combine. The R-300 was based on the IBM 1401 and was manufactured in respectable numbers. It is important to note that, unlike the Polish and Czech arrangements with ICL and Bull, the R-300 was not produced with the cooperation of IBM. Robotron's success here was to set a precedent for the future, and it helped to establish a leading role for the GDR in forthcoming joint CEMA efforts.

In the late 60s a sequence of TPA machines, based on the US Digital Equipment Corp. (DEC) PDP minicomputer models, emerged from the Hungarian physics research community and went into limited serial production. The Hungarians (and Romanians) would end the decade in pursuit

of licenses from France.

The internal production of computers was inadequate to fulfill the needs of the East European economies during the 1960s. So it is not surprising that increasing numbers of Western computers were imported during the same period. A useful partial summary of these imports is given in [13] (notably missing are some imports from IBM). These data show that at least 223 Western machines were imported during the decade. Almost half of these came from the UK. Despite periodic problems with export control, Elliot and ICL established solid trading links with Bulgaria, Czechoslovakia. Hungary. Poland. and Romania. The US was the second largest source of imports. with Univac. Honeywell. NCR. General Precision. and IBM supplying well over 76 computers. Bull-GE of France exported 27 machines to Eastern Europe during the decade. while companies in Denmark, Italy. West Germany. and Japan account for the remainder.

There was no coordinated strategy behind these imports. and each country followed its own course both as to the number of machines imported and the sources from which they were purchased. Czechoslovakia was the largest importer, with 88 machines; next came Hungary (56). then Poland (36). East Germany (19), Romania (16). and Bulgaria (8). Czechoslovakia also imported the widest range of equipment; of the seventeen firms exporting computers to the area. fourteen were represented within its borders. The GDR

imported rather heavily from the US. and other technology transfers across the border with the FRG were not uncommon. Poland and Bulgaria imported primarily from the UK, while Hungary and Romania also bought French products.

By 1966 this proliferation of small quantities of a large variety of incompatible machines had begun to cause maintenance and support problems. In Czechoslovakia, where the problem was most acute, there was an effort to consolidate imports, concentrating on Minsk units from the Soviet Union and ODRAs from Poland. Nonetheless, the flow of Western equipment into the area continued.

East European imports of Soviet computers were surprisingly small during this period, perhaps numbering around 200 machines. Most of these were small, early Minsk and Ural models. Czechoslovakia was the largest importer, taking over 50 Soviet machines. Hungary imported a fair number, but probably fewer than she bought from the West. Poland was more self-sufficient than the others, although some Soviet machines were purchased. Among its imports from the USSR, the GDR included two large scientific computers. Bulgarian needs were so limited that imports from the USSR may not have greatly exceeded those from the West. Romania was the most reluctant to buy Soviet computers

Although not yet a member of CEMA. Cuba made the decision to build an indigenous computer industry in 1967. Its first machine. a minicomputer whose design was based on the DEC PDP-8, appeared in 1970. Before Castro took power, a small IBM affiliate had existed and its demise left Cuba with at least one old computer and a stock of office equipment. During the 1960s. Cuba managed to import one computer from the UK and at least two. plus some technical assistance. from France. As far as is known. Cuba had not purchased any Soviet or East European machines by 1970 [14].

The Extent of Integration in 1969

Almost no progress toward integration had been made before 1970. Of course the goals of 1971 had not yet been formally proclaimed, but it is nevertheless striking how little had been achieved in the preceding twenty years.

The three countries that were technically most advanced before World War II. Czechoslovakia. Germany. and Poland. had developed computer industries that could not meet their own internal needs. Innovation that existed in the 1950s faded away. and by 1969 most of the domestically manufactured machines were copied from the West. There was little trade between the East European countries. although some ODRAs and R-300s had been exported by 1970. and the Czechs. Poles. and East Germans sold small quantities of peripheral equipment to other CEMA members. Only a trickle of people crossed intra-CEMA borders for computer related

purposes. e.g. conferences. training, equipment servicing. Bulgaria. Cuba. Hungary. and Romania had accomplished little.

Between them. these seven countries had over 1000 computers in 1969. Almost all were small machines and. except for some Western imports. suffered from deficiencies that made them difficult to use. These included the lack of good peripherals, vendor hardware maintenance, and software support. So the computers that did exist were often underutilized in quiet and desperate isolation by their owners. This situation was compounded by the large number of different computer models. making for poor compatibility; shortages of spare parts and trained personnel. To make matters worse. different units of the same Soviet and domestically produced models were often incompatible.

The Soviet role in all of this was less than spectacular. The USSR may have exploited some East European developments. There also may have been Soviet overtures for greater cooperation in developing this technology, but they were apparently resisted. Although arguably the second largest computer producer in the world. the USSR seemed reluctant to sell its machines abroad and pushed for hard currency credits in payment. The quality and reliability of Soviet equipment was poor. spare parts and service were very difficult to obtain. and the delays and aggravation involved in dealing with the Soviets were great. One story will illustrate the extremes to which some Polish purchasers of

an early Ural model were driven. This computer used Soviet vacuum tubes that were performance compatible with Western tubes. but which used different sockets. The Soviet tubes were so unreliable and replacements took so long to arrive. that the Polish engineers went to the extraordinary effort of replacing the tube sockets on their Ural so that they could use Western equivalents. More positively. a notable Soviet technology transfer was the design of a small computer (the M-3) that could be built by some of the less sophisticated industries. This machine was reproduced in at least three countries: Hungary. Romania and China.

5. STEPS TOWARD TECHNOLOGICAL INTEGRATION

In part. the almost total lack of integration among the CEMA computing communities by the late 1960s was a reflection of general deficiencies such as inconvertability of currencies. use of the Stalinist economic model. and restrictions on travel. But the situation in computing was worse than that in many other industries.

A large part of the problem was the weak perception of the economic value of computing that existed in CEMA. This changed as the East European economies began to suffer slowing growth rates. decling productivity. and increases in the complexities of planning and administration. The political and economic leaderships of the CEMA countries began to seek solutions to these problems via reforms that stressed the development and application of technology.

These concerns were accompanied by the creation of considerable theory and rhetoric in the form of the Scientific-Technological Revolution (STR) [15]. to provide ideological justification for the reforms and exhortations intended to improve the real performance of the working elements within the CEMA economies. The potential applicability of computing to all aspects of economic development made it a natural centerpiece technology for both the practical and ideological efforts.

The ES-I Joint Program [16]

The West influenced further developments in two critical ways: by providing an experience base that helped change CEMA perceptions of computing, and by providing explicit models for practical efforts. Since the late 1950s. some countries had been using computers on a large scale to improve productivity and to help alleviate difficulties similar to those being experienced in CEMA. Western industrial and commercial environments were much more hospitable to practical technological innovation. diffusion and utilization. The computer industry itself, and computer use in general, were rapidly becoming a bright feature on the Western economic scene. Of particular importance was the announcement and start of production of the IBM S/360 family of upward compatible computers in 1964-65. In terms of range of computing power, repertoire of peripherals and software. and volume of production. the

S/360 dwarfed anything that then existed anywhere in the world. By 1970 around 35,000 of these machines had been produced, in addition to at least 15.000 other IBM computers made before the mid-1960s. Other Western companies were making a broad spectrum of machines and peripherals; a wide range of software products was being developed and disseminated; and the fledgling minicomputer sector was starting to claim an important place in the industry.

Although their indigenous computing efforts were lagging, most of CEMA was not oblivious to developments in the West. Conservative, risk averting leaderships could see Western implementations of fairly successful solutions to problems similar to the ones they were experiencing. The ideology of the STR owes much to Western influence, not least through work in Eastern Europe, particularly Czechoslovakia. The CEMA countries were following Western leads in the application of computers. Most of the programming in higher order languages (HOL) was done on translators for Western-developed HOL or variants of these languages made more suitable for less advanced East European hardware. The success of Western hardware development and production did not go unnoticed. The GDR had started work on an IBM S/360 compatible mainframe. The USSR made two efforts to produce upward compatible families, one an indigenous design and the other a copy of the S/360, but both were essentially failures.

One approach toward improving the overall CEMA computing situation would involve a radical reconfiguration based on regional cooperation -- the sort of solution that would be regarded with suspicion by more than a few East Europeans. Within this approach. a key project that could take them well beyond rhetoric would be the joint development and production of a respectable common hardware base. particularly an upward compatible family of computers and peripherals.

The leading role for any such effort would necessarily belong to the USSR. It was the only CEMA country whose computer industry had anything like the capacity and cohesion to undertake the task on its own. and it was the only country that could possibly coordinate the efforts of the other members. Its two earlier failures also provided valuable experience.

The Soviets had made some early and unsuccessful overtures for cooperative efforts in the development of computing technology. A joint CEMA committee on computing had existed for years but without any appreciable effect. The interests of the USSR in a major joint undertaking were reasonably clear: to draw on some of the expertise and workmanship of the East Europeans. to turn the East Europeans away from looking westward for this technology. to tighten economic ties. and to provide technical standardization for Warsaw Pact and other applications. Substantive cooperation had to await a spectacularly

successful Western model. improved perceptions of need and opportunity. and the recognition by some of the East European countries that they would not be getting far on their own.

During 1967-69. these conditions had been met to the extent that the Soviets were successful in enlisting the offical participation of five other CEMA members in a third Soviet effort to build an upward compatible family. This undertaking formed the basis for the 1969 multilateral agreement. The GDR seems to have played a major role in formulating the overall strategy [17]. It was the leading advocate of the policy to make the CEMA family. known officially as the Unified System (ES) and more popularly as Ryad. a functional duplication of the IBM S/360. Most of the East European countries had more experience with IBM equipment than the Soviets. and had been favorably impressed. They had less than favorable experiences with Soviet computing equipment and were probably wary of any Soviet design effort.

There were good technical and economic reasons for adopting this strategy. The project had very high level backing. and considerable resources were being poured into it. The acquisition of functional capability was far more important than achieving or surpassing the then world state-of-the-art. The lack of experience and imagination in CEMA. plus the fact that there was no need to compete on the world market. made copying a proven system an obvious

choice. Another obvious choice was the S/360. the West's most successful system. and probably the only one they could agree on. Furthermore. there was precedent that the IBM system could be successfully duplicated. For example, RCA had done so shortly after the IBM originals appeared. Finally. one of the great CEMA shortcomings was in software -- both systems and applications software. and both development capability and inventory -- so the prospect of building machines that could directly use the billions of dollars worth of programs that IBM and its competitors and customers had developed must have been appealing. Thus CEMA had reason to hope that time and risk could be saved early in the undertaking by using a well established design. and after production started. by using Western systems and applications software.

In terms of technical achievement and integration. the ES-I equipment was more successful than most analysts and participants might have expected. Between 1972 and 1975. several small and medium scale ES computers and scores of peripheral devices went into production. During 1975-77. some of the earliest models were replaced by higher performance upgrades. and a smaller wave of peripherals appeared. While these developments were hardly without serious technical problems and not all the CEMA countries participated with the same vigor as the GDR (see Section 6). the overall achievement was substantial. Most of the ES equipment functionally duplicated the S/360 in that they

shared a common architecture and machine language. used common data interfaces. and had a considerable degree of IBM software compatibility. Perhaps most significantly, the equipment made by the participating countries was. for the most part. interoperable. Ryad production far outstripped that of other models. and computer centers contained integrated equipment mixes pulled together from the partipating countries.

Several Other Major Joint Programs [18]

By 1974 developments in the ES mainframe project had been encouraging enough to start a similar project for minicomputers. The same basic strategy was to be followed. but in this case the design choice was not so obvious. Each of the CEMA participants had developed its own line of minicomputers. often on the basis of Western designs. and they were reluctant to give them up. (In contrast. the Ryad design decisions adversely affected only Poland and Czechoslovakia.) Although all of the Ryad participants formally signed the minicomputer cooperative agreement. it seems that the Soviets were pretty much on their own initially. A Soviet ministry took the leading technical role, but the two primary research and development institutes involved favored the functional duplication of two different US designs. The result was a compromise partition of the first group of four Small System (SM) models. Two would be based on the Hewlett-Packard (HP)

21xx, and the other two on the DEC PDP-11 series.

Whereas the development and production of the Ryad-I models were distributed across the Warsaw Pact CEMA members except Romania. the initial production (in 1977) of the SM-I models was limited to the USSR. But by 1981 most of the CEMA countries. including Romania and Cuba. had started manufacturing DEC-like SM-I models. The SM machines use most of the ES peripheral hardware. although a growing separate line of SM peripherals has emerged in recent years.

By the second half of the 1970s. the CEMA members thought enough of the two groups of ES-I computers and peripherals to initiate an ES-II undertaking patterned closely after the IBM S/370. which went'into production in the early 1970s. The S/370 was an improved version of the S/360 family that maintained a downward compatibility with its predecessor. i.e. software that could be run on the S/360 could usually also run on the S/370. This was an important consideration for thousands of IBM customers who were expected to. and did, migrate to the S/370. By 1979, most of the ES-II models were at least in the prototype stage, and were shown at the Ryad tenth anniversary exhibit in Moscow. The new computers were accompanied by an assortment of new or upgraded peripherals. By 1982. at least initial batch production had been announced for all the models. and some of the first production variants were being superceded by upgrades.

It is important to note that East European participation in the ES-II project seems to be more uniformly positive than was the case at the start of the ES-I effort. The reluctance that characterized the ES-I partipation of Czechoslovakia. Hungary and Poland is much less apparent now (see Section 6).

An ES-III program was announced in 1978, although little detailed information has appeared since then. Announcements of specific equipment are expected in 1982-83. These machines may follow Western patterns of improvement in components, orientation towards telecommunications. etc.

Another major cooperative computer hardware program is the SM-II group of machines. They are microprocessor-based small computers with several models distributed over all or almost all of the CEMA countries. Processors appear to be based on US designs. In contrast to the initial production of the SM-I models. the East European participants are actively involved from the start. The SM programs have provided a minicomputer hardware base to complement the Ryad mainframes. However. unlike the situation with mainframes. some of the East European countries continue to manufacture non-SM minis, and there remain questions regarding the compatibility of the proliferation of models with each other and their Western predecessors.

During the 34th Session of CEMA in 1980, the eight participants in the ES-SM cooperative programs renewed their commitments by signing a new Multilateral Specialization Agreement on Electronic Computer Technology. The 35th and 36th Sessions in 1981 and 1982 produced additional accords for microprocessors, industrial robots, communications equipment, and other hardware [19].

Initially, many of the microprocessor chips and other microelectronic components (and some equipment and technology for their manufacture) used in Soviet and East European computers and elsewhere were acquired from the West, often in spite of export controls [20,21]. The GDR and USSR have embryonic capabilities for the production of these chips, and many are based on US designs. More generally, all eight of the CEMA participants signed a major 1981 intergovernmental agreement on the creation of a common, standardized electronic components base for computer equipment and other needs, with the proclaimed intention of satisfying the CEMA member countries' requirements for advanced microelectronics. If successful, this cooperative program will have a great impact on all the others [22].

The CEMA countries have also tried to achieve serious technical and limited economic integration in systems and applications software, and in hardware and software training and service. However, whereas they have respectable and fairly pervasive levels of standardization and interoperability in hardware, this is not the case for

software and services. As one moves further from the hardware. standardization and integration become weaker. Thus there is more standardization and widespread use of a common systems software base (much of which was "borrowed" from the West) than is the case for applications software. Similarly, there is more internal cohesion and external coupling for hardware service than is the case for software services. This is to be expected for other reasons. and is also true in the West. But the situation as it exists in CEMA. especially for applications software. is much weaker for fundamental economic and social reasons. For example. the CEMA economies have had serious practical and theoretical problems in resolving questions of software pricing and ownership protection.

Organizational Developments [23]

During the last 15 years an impressive array of computer organizations have developed at both the CEMA and national levels. The highest level CEMA organization that is totally dedicated to computer technology is the Intergovernmental Commission for Cooperation of the Socialist Countries in the Field of Computer Technology (MPKVT). MPKVT is composed of a number of major subdivisions with purview over the ES and SM programs. peripherals, standards, services. production assignments. certification, test and monitoring equipment. systems and applications software. Since its inception. MPKVT has been

headed by M. E. Rakovskiy, a Deputy Chairman of USSR Gosplan. Responsibility for electronic components for computer hardware is in the domain of the Permanent Commission for the Radiotechnical and Electronics Industry, although MPKVT seems to have involvement there as well.

Our research on the MPKVT is incomplete, but some tentative observations are possible. Its effectiveness appears to vary considerably over its domain. The MPKVT seems to have real control and influence in the hardware areas, especially with the ES and SM programs, peripherals, production assignments and standardization. Some progress has also been made in the areas of hardware service and systems software. The MPK role here is much weaker, and most of what has been achieved is only noteworthy relative to the abysmal situation that existed before 1970. The MPK is least effective at the applications levels. Not surprisingly, effectiveness declines as we move from narrowly defined, technical areas that involve fairly isolated economic elements, to areas that involve a larger spectrum of social and economic elements and relations.

By the early 1980s some important and necessary steps had been taken toward technological integration. All the participating members have built stronger and more cohesive national computer industries, although serious problems remain. Hardware interoperability and software compatibility have become realities to varying degrees. A CEMA level organization has been established, and has been

functioning reasonably well as a coordinating institution.

6. AN INTERNATIONAL DIVISION OF LABOR

Western economists consider national product and service specializations in an international network to be a measure of advanced development and economic integration. This applies in particular to modest sized countries who find respectable technological niches in world or regional markets. rather than in the simple export of their natural resources. This viewpoint. with the mandatory Marxist-Leninist embellishments. has become part of Soviet and CEMA ideology concerning economic relations among socialist countries.

In terms of real progress in international specialization and modernization, computing is something of a CEMA showcase. This section is concerned with the post-1969 character. growth. and evolution of the roles of the participating countries. Since each of the participants has defined a fairly distinct place for itself, we shall start with brief national summaries [24]. The section concludes with several broader observations.

Bulgaria

In 1969, Bulgaria had the least developed computing industry of all the East European CEMA countries. While the Bulgarian initial condition should not be surprising to students of Eastern Europe, its present level of achievement might be. Bulgaria is a manufacturer of small computers and computer systems, fairly sophisticated peripherals, and unsophisticated electronic components. The number of different hardware products made by Bulgaria is impressive for a country of its size and economic background [25]. There is no better example to support the claim that the CEMA integration program is raising the levels of the less developed members.

Perhaps the most surprising of the Bulgarian achievements is its specialization in magnetic disk storage. This delicate electro-mechanical technology is one of the most difficult to master in the spectrum of computer hardware, and is a niche the GDR would have been expected to claim. The Germans were working in this area in the early 1970s, although they did not achieve volume serial production, but lost this specialty to the Bulgarians. The Bulgarians are the primary suppliers of disk storage to Eastern Europe, including the GDR.

Another Bulgarian niche is robotics. Stara Zagora is the home of the CEMA robotics research and development coordination center. and Bulgaria does appear to be manufacturing unsophisticated industrial robots. However, this is not an area that will simply be left to them. and other East European countries will pursue active programs of their own.

Since they had nothing to lose. and markets to gain. the Bulgarians were among the strongest early supporters of the joint CEMA computer effort. Within the context of this framework. they have built an indigenous industry and a substantial export business in disk storage and electronic components [26]. Their initial involvement was made easier by relatively strong ties with the USSR and relatively weak links with Western companies.

This discussion of the Bulgarian success story needs to be tempered with some damping observations. The quality of Bulgarian computer products remains considerably below that of contemporary Western counterparts. although they are competitive with some of the USSR's best. Its success as a producer of disk storage within CEMA aside. the gap between Bulgarian and Western achievements in sophisticated. high performance secondary storage technologies is not closing. Complaints about Bulgarian products are not unheard of. Finally. Bulgarian progress in computing is perhaps the most uneven in CEMA. Accomplishments in hardware construction are not complemented by comparable achievements in software.

applications, and service. Successes have largely been the result of the efforts of a small number of aggressive technical people. Adequate numbers of people with similar talents are not available in other fields.

Cuba

Geographically remote, and sharing little of Eastern Europe's technical heritage and connections, Cuba's computing activities have not been impressive compared with those of the other participants. As befits a small country, Cuba builds minicomputers. A relatively late (1973) signatory to the cooperative agreement in computing, Cuba's efforts were outside of the framework of the main CEMA program until the mid-1970s when it centralized and expanded its computing organization, became more involved with the MPKVT, and began active participation by bringing some of its indigenous minicomputer efforts into the SM program. It would appear that essentially all of Cuba's current hardware and software production is consumed domestically.

Czechoslovakia

Czechoslovakia is also contributing to the "evening out" of the levels of achievement among the CEMA computer industries. Since the 1950s its computing community has been displaced from the top spot in Eastern Europe. Czech progress has been decidedly lackluster.

The Czechs were apparently reluctant to participate in the joint effort that began in 1969. No doubt. the political events of 1968 were a factor. but the relative strength of the Czech computer industry and hopes for technical ties with West European companies were probably as important. The Soviet desire to get the Czechs to sign the 1969 agreement is self-evident. In return for this show of fraternity the Czechs were able to keep their distance from the central effort. Their contribution to the ES-I group of machines was a partially incompatible Czech design with an ES designation. Their peripherals specialties were mainly unsophisticated electro-mechanical devices (e.g. punched card equipment and operator consoles). a poor niche. Other countries were not dependent on the Czechs for anything in the same way they depended on the Bulgarians for disks.

Czech hopes of building technical bonds with Western Europe have not worked out spectacularly well. They have not been able to build a broad and powerful indigenous industry. nor have they developed a strong computer export business with either the East or West. While they played in their own puddle. the other CEMA countries claimed the best niches. The Czech industry was more or less left behind. and it became one of the most isolated in CEMA.

The Czechs themselves appear to be increasingly aware of what has happened, and there are indications they would like to get more involved with the others Their ES-II models are to be fully compatible, and they are active partipants in the SM program. They seem to have a greater desire to increase the export of peripherals and components to CEMA, and are actively involved in the software division of labor [27].

But they are going to have an uphill climb. Their low end ES-II models will be squeezed from above and below by ES and SM machines made elsewhere. Few may be purchased outside of Czechoslovakia. The best peripheral niches are already claimed. The joint software program has been, and will continue to be, much less successful than those for hardware.

German Democratic Republic

The East Germans are not overly concerned with leveling the East European industries. They have the outstanding computer industry, and are determined to stay on top. They have one of the best niches -- the mid range mainframes -- and are also developing a respectable microcircuit industry.

The GDR industry is dominated by the Robotron Combine. It is the most cohesive and best managed computer company in CEMA. Robotron's products are well regarded by the other members, and it appears to have the best international

training and repair services of any of the manufacturers. The usual German efficiency arguments aside, a good part of this success may be attributable to the relative freedom it has to organizationally resemble and behave like a Western corporation. By socialist standards, it appears to be inordinately motivated by export and profit. Many Western business executives who have dealt with Robotron and other socialist computer firms regularly make these observations. Another strong manufacturer is Zeiss, which specializes in certain peripherals, notably magnetic tape units.

Having said this, it should also be pointed out that Robotron and Zeiss are nothing exceptional compared to the major US, West European or Japanese computer manufacturers [28].

At one time it appeared that the GDR had decided not to go into the microcircuit business for the usual reason a small country does not take on a high-risk, sophisticated technology on a large scale, i.e. it is not cost effective for a small internal market. This decision now has been reversed, and the GDR is moving to the head of CEMA as a microcircuit manufacturer. We would conjecture that this is a fairly rare instance where there was Soviet pressure to get one of the East European participants to produce something the USSR needed and for which it could not fulfill all its own needs. There is a good match here between German technical capabilities and a large Soviet market.

Hungary

During the last 15 years. the Hungarians have moved from an almost non-existent computer industry to one of the most successful in CEMA. Their progress has been characterized by more style and imagination than that of the other participants.

Like Czechoslovakia. Poland and Romania. Hungary initially demonstrated less than overwhelming enthusiasm for a joint program that was certain to be dominated by the GDR and USSR. Its contributions to the ES-I computer family were minicomputers. made under French CII/SEMS licenses. that were even less compatible with the IBM-like machines than the first Czech model. However. the Hungarians found a good niche in minicomputers. They sold so many of these minis to the other CEMA countries that potential Hungarian users complained about not keeping enough at home.

The Hungarians claimed the lowest model of the ES-II family. which will be fully ES compatible. and are among the leaders in the SM-II program. They have a good peripherals niche in display terminals; produce other useful small peripherals. such as printers under Western license; and build complete systems under foreign contract.

The leading Hungarian company is Videoton. perhaps the most aggressive of the major CEMA computer manufacturers. Like GDR Robotron. it appears to be more motivated by export and profit than the more "traditional" Soviet-style indices of performance. Although it lacks the size and technical competence of Robotron. it makes up for some of this deficiency with hustle. Elsewhere in the industry. the Hungarians encourage and exploit some unplanned innovation and even permit private ownership [29]. This is not to give the impression that the latter two activities are widespread. or that they have a major place in the industry. For example. the first officially licensed. privately owned Hungarian software firm consists of three people. two of whom declined to be named in an interview with a reporter.

Poland

The Polish computer industry is the most disappointing in CEMA. because expectations were once so high and it is an instance of an absolute decline in an area that is so dynamic and rapidly growing elsewhere in the world.

Perhaps more than any of its neighbors. Poland turned to a massive infusion of Western technology to move it into an intensive pattern of economic development. and computing was to have been one of the kingpins of this new strategy. Accordingly. a grand program for computing was adopted at the highest government level calling for an investment of several billion zlotys during 1975-80. Furthermore. the

Poles seemed determined to keep their distance from the joint CEMA effort and to rely instead on indigenous efforts and transfers of Western technology.

However, like so many other aspects of Poland's new economic strategy, the grand plan fell on hard times. For example, the 1974 plan called for the production of 600 medium sized computers during 1976-80, and that half of these would be exported. Production has fallen off from 105 machines in 1976 to an expected output of 35 in 1980. Exports were even further under plan, averaging only about six machines a year during the five year period. Part of this decline was explained by a shift in emphasis of production from mainframes to peripherals, but the Polish industry is clearly having serious problems.

To be sure, the general deterioration of the Polish economy has been a major contributor to the problems of its computer industry and, as such, further discussion would take us far from our main topic [30]. However, the Polish industry has always been fairly isolated from the cooperative computer effort. During the 1960s, the Poles, like the Czechs, had built a respectable indigenous industry. The Poles were understandably reluctant to divert resources from this effort, and their participation in the ES-I project was half hearted at best.

The Poles and Soviets were to co-develop and co-produce a mid-range ES-I model. Originally, it may have been felt that the Soviets would gain most from the joint effort, since the Poles had been making products using ICL technology. However, the Poles only brought out a few prototypes of the first joint model, while the Soviets went into serial production with scores exported. An improved Polish model went into production, but not many have been made, and very few exported. The improved Soviet counterpart is produced and exported in quantity. Much of this goes to Poland's neighbor Czechoslovakia. It seems that the Poles wanted to go their own way, overestimated their own capabilities, and have been outperformed. The two countries are going into another mid-range model together under the ES-II program. Given the recent labor suppression, it is unlikely the Poles will cooperate more closely this time.

Poland's most apparent niche in the ES program was an ICL licensed printer. It also exports ferrite main memory, tape cassettes, and small quantities of other items.

Romania

Although a signatory to the joint CEMA cooperative agreement in computing, Romania's active participation has been almost non-existent. It consists of a little rhetoric and a presence on assorted policy and certification committees. There are some signs of a softening of Romanian

attitudes toward CEMA cooperation and trade in science and technology. but their computer products have not conformed to CEMA standards. with the possible exception of a minicomputer exhibited with an SM designation [31]. They have no CEMA specialty in hardware. and their cooperative role in the joint software program seems stillborn.

The route Romania has chosen to build a viable computing industry is via a highly centralized state enterprise CIETC. and the use of Western licenses and joint ventures (notably with CII and CDC) on a relatively larger scale than the other CEMA members. The net result is fairly satisfactory. at least as far as production for domestic needs is concerned. Romania's ability to pursue this strategy is due to the degree of independence it has from the USSR. and the relaxed export control policies applied by the West.

USSR

Because of its singular military role within CEMA. and because of a domestic market that is larger than those of the other members combined, the USSR is the only participating country whose industry covers the entire range of computing products and services. In this capacity, its domain includes areas not covered by any of the other CEMA countries. e.g. large scale computers and certain areas in electronic components and software.

Several Broader Observations

We start with a short overview of the dynamics of establishing hardware niches. In 1973. at the first major exhibition of ES-I equipment. there was a partition of the Ryad central processing units (CPUs). This division of labor was straightforward. with each country doing almost what it would have done had there been no cooperative program. The USSR covered the full range of machines. The East German and Hungarian programs for medium-scale mainframes and minicomputers were simply and usefully absorbed into the overall effort. Czechoslovakia and Poland expended some rhetoric and a minimum of serious effort to provide an integrated front. but went on with their own CPU efforts (slightly modified). Romania ignored the whole thing. Bulgaria was quite happy with the "franchise" it got from the Soviet Union to build small Ryads.

The situation with regard to peripherals at this exhibition was more interesting. Almost every country announced a fairly broad line of peripherals [32]. But whereas most of the CPUs were in shape for the big unveiling (notably absent were the troubled large Soviet models). many of the announced peripherals did not show and were never to go into extended production. What appeared to have happened is that each of the East European participants realized that it did not have the internal market. know-how. and production capacity to cover the full range of IBM-like peripherals needed for a system like the S/360. In the

ensuing division, most went with their strong suits -- e.g. the Poles with their licensed printer, the Czechs with their expertise in low level electromechanical technology, etc.

During 1973-80, each country tried to consolidate its specialties [33]. For example, the same CPU niches have carried over to the ES-II program, and Bulgaria has continued its disk program by following the IBM trail through improved models. Of note in this period is how well the Hungarians have been doing with display terminals.

Since the late 1970s there has been some tendency away from division of labor specialties, although many of these were formally renewed in the 1980 agreement (fn. 19). Examples include the lack of a clear CEMA-level partition of the SM CPUs, and encroachment on each other's hardware niches. With the growth in internal computer markets that has taken place in all the CEMA countries in the last dozen years, there are now scale incentives for each to try to cover a broader range of its own domestic needs and to seek additional exports.

As noted in Section 5, the cooperative software program has not fared as well as those for hardware. Under the MPK's Council for the Application of All Forms of Computer Technology, an organization with some superficial similarities to the MPK's Councils of Chief Designers for the ES and SM programs, there is a formal division of software responsibilities. Thus, Bulgaria has

responsibility for software used in designing frame and bridge structures. Hungary for accounting packages and systems analysis, the GDR for data base management systems. Cuba for the management of sugar cane production. etc. This division of labor is not a partition of software to anything like the same extent that ES hardware has been partitioned. It represents a small fraction of the software universe. Furthermore, most of the countries seem to be doing a poor job of meeting their commitments [34], and the cross-national use of applications software is not impressively extensive.

None of the CEMA members has committed all of its computer industry to the cooperative projects. In particular. Romania has committed almost nothing, and the USSR has sectors of its industry that we suspect many East European professionals do not know exist. With the important exception of certain software institutes. whose primary function seems to be adapting Western systems software for the ES and SM projects. almost all of the national software efforts could barely be called industries. let alone an integrated group. Roughly speaking, what has been committed are many of the primary hardware research, development and production facilities. some key software and service organizations, and representatives to committees.

Our impression is that the division of labor among the CEMA computing industries has evolved naturally at least as much as it has been consciously planned or forced by the Soviet Union. What has developed is primarily a result of de facto achievements. the distribution of pockets of expertise. the influence of domestic market size and character. the ambitions of the national industries and their abilities to haggle for what they want within the MPK VT and other CEMA forums. With few exceptions. the USSR seems content with this dynamic, as long as everyone is at least officially involved in the integration effort. Part of this tolerance is probably due to Soviet sensitivities about ramming too much down East European throats. but other important factors include the lack of serious Soviet dependence on East European computer products and the reasonable successes and positive trends the cooperative effort has enjoyed.

7. TRADE AND TECHNOLOGY TRANSFER [35]

The Extent of Trade

In 1980. a formal accord was signed that called for intra-CEMA computer trade to be in the 15-17 billion ruble range during the 1981-85 plan period. This would be approximately twice the 1976-80 level [36]. Twenty years ago, computer trade consisted of a few wretched Soviet machines grudgingly sent to Eastern Europe, and a small

trade in components and peripherals.

Trade between the USSR and Eastern Europe probably accounts for at least half of intra-CEMA trade in computing and electronics. At the end of 1978. Soviet exports were growing at the rate of 10-15% per year. and the Elorg FTO (Foreign Trade Organization) could boast that Soviet computers were used in 18 countries [37]. However. all but a few dozen are used in CEMA. The East Europeans typically report that approximately 50% of their exports go to the USSR [38].

The Soviet market is so dominant and important to the joint effort that it is capable of dictating de facto technical standards. Although the Soviets produce almost the full range of CEMA computer products. they do not make as much as they can use. The Soviets are not seriously dependent on imports from Eastern Europe. but they find these products useful and often of higher quality than what they make themselves. However. the East European economies all need more computer equipment than they are getting. and some of the more advanced user communities resent the export of so much of their indigenously produced products to the USSR [39].

The growth cited above is substantial in comparison with the past. but USSR-Eastern Europe computer trade volumes are still small relative to international computer trade in the West. Until recently. Western CPU shipments to

Eastern Europe, especially if Romania is included, may have been comparable to Soviet shipments, although export control and hard currency problems have limited Western sales in the last few years. In both cases, 1978-79 annual levels were on the order of 30-60 medium sized mainframes, and 100-200 small mainframes and mini computers [40]. In the other direction, only the GDR and Hungary send a substantial number of CPUs to the USSR. It is too early to tell if this will change much under the ES-II and SM-II programs.

Trade between the USSR and Eastern Europe in peripherals and components is more extensive, and the balance greatly favors the latter. For example, the Czechs anticipate that they will export 400 million rubles of computer equipment to the USSR during 1981-85, while importing about half that value [41]. Since the Czech ES CPUs have not been viable for export, this trade consists mostly of Czech electronic components and electromechanical peripherals for Soviet mid-range mainframes [42]. All the East European industries send peripherals and components to the USSR, and it is possible that in all cases the value of these shipments exceeds that of the Soviet CPUs and components they receive.

Most of the trade among the East European CEMA members is in peripherals and components. This trade and specialization enable the East Europeans to assemble respectable user computing centers and products without having to build everything indigenously. In contrast, the

East European countries build their CPU inventories from their own production, and imports from the West and USSR. Again, only the East Germans and Hungarians have much of a trade in CPUs, although the Poles once had a fairly brisk trade in ODRAs. We have been able to identify very few Polish, Bulgarian and Czech ES-I models in use outside of those countries. Within Eastern Europe, Czechoslovakia and the GDR appear to be the most active trading partners, although the Hungarians may be as active on a per capita basis [43].

By CEMA standards, an unusually good set of computer trade and industry statistics are available from Hungary [44]. In 1977, 521 general purpose computers were installed, which was 0.07% of the world's inventory. Of these, 23% were made in Hungary, 38% were from other socialist countries, and the remainder from capitalist countries. Breaking the inventory down further: 58% of the minis were from Hungary, 14% from other CEMA manufacturers, and the rest from the West. Within CEMA, Hungary's imports come mainly from the USSR, with the GDR second. The two prime recipients of Hungarian exports are the USSR and Czechoslovakia. Between 1972 and 1978, the Hungarians purchased at least 24 mid-sized machines and 133 minis from the West. By 1979, they had exported almost 300 minis to the Soviet Union. At the end of the 1970s, as a percentage of total computing imports, those from CEMA dropped from 63% to 55%, with most of the change due to increased Western

imports.

Some Hungarian financial trade statistics are given in Table 7.1. Although impressive in some ways. it should be noted that 4354 million forints is only about 114 million dollars. There are single large computer centers in the US whose equipment is worth more than that. It is hard to interpret the balance of payments. because we do not know the extent to which hard currency or commodity trade was used in these sales. Also. a good part of the East to West computer "trade" claimed by Hungary. and other CEMA countries. may be in the form of buy-back arrangements that were part of Western licensing agreements.

In comparison with Hungary, Czechoslovakia and Poland have more extensive dealings with the West. although perhaps not on a per capita basis. Bulgaria and the GDR have less. and their computer inventories and trade distribution are more Soviet oriented [46]. The GDR is thought to be particularly active in the covert acquisition of Western technology. although it has purchased little in recent years. Romania has a very small computer trade with the other CEMA countries. Much of its own production and inventory is through Western licenses.

Table 7.1

Hungarian Foreign Trade in Computer Technolgy [45].

A. Imports

Countries/Regions	1976	1977	1978
Socialist Countries	1860	2266	2403
CEMA	1856	2263	2399
Developed Capitalist	1068	1591	1959
EEC	506	837	1090
Other European	320	394	311
Outside of Europe	243	360	585
Developing Countries	17	11	0
Total (Imports)	2945	3868	4388

B. Exports

Socialist Countries	3102	3619	3942
CEMA	3040	3555	3843
Developed Capitalist	185	193	402
EEC	71	50	153
Other European	113	136	220
Outside of Europe	0	7	29
Developing Countries	3	13	10
Total (Exports)	3289	3825	4354

(All figures are rounded to the nearest million forints.)

A modest computer trade between CEMA and developing countries exists. The most notable connection is with India. where the USSR. the GDR. and Hungary have installed a small number of ES computers. and where there may be a market for SM minis. The Soviet Elorg FTO has established a

maintenance center and a marketing agent with a half dozen branches in India [47]. A scattering of computer equipment is sold elsewhere, mainly to the Mideast. There have been sales to, and systems development for Vietnam; and Vietnamese observers have attended MPKVT meetings [48]. Some trade is carried on with China. The Romanians have developed a small trade with LDCs, including China [49].

The Conduct of Trade

We have a poor picture of how the CEMA countries conduct computer trade. For the most part, it seems to be bilateral and through specialized FTOs. There are some multilateral features, e.g. monitoring and coordination by the MPKVT, and product mixes like the use of components or subsystems from country A in a system built in country B and exported to country C. How much of the latter takes place cannot be judged from the available data, although the volume of trade in electronic devices is high enough to think that this might not be insignificant. What is clear is that thousands of CEMA computer centers contain a multinational mix of equipment, and that considerable coordination and planning at the MPKVT and FTO levels is necessary to make this possible. We do not know how bilateral trade in computing equipment is balanced, but much is probably done at the MPK level. It appears that there is not a close balance in computer products between the USSR and each of the East European countries. The balance

between two East European countries may have to be closer, or at least be closer across the broader product lines covered by the appropriate FTOs. Some hard currency figures into the transactions, but we do not know to what extent.

If there is something close to bilateral barter balance at the FTO product coverage level, and if we accept that none of the East European countries has the resources or market to pursue the entire range of computing products and technologies, then it is possible to argue that hardware interoperability and software compatibility were essentially forced on these countries by technical and economic considerations. No East European industry can make everything, but every respectable computer installation in each country needs a spectrum of equipment that includes some of almost everything. If only part of this can be gotten from the indigenous industry, the rest must come from other CEMA countries or the West. Much as many end users would like, they cannot buy all they want from the West. Given CEMA service and support, anything that is not technically interoperable or compatible is going to be worthless or at least a big problem for most users. Under these circumstances, each country needs something to trade on a bilateral basis or it will have trouble getting what it needs. To be viable, this something has to be what others want but do not produce themselves, and it must work together with everything else they acquire from around CEMA.

Although we lack many details of how CEMA computer trade is conducted, it is clear that the layers of foreign trade bureacracy, the lack of effective monetary, financial, credit and pricing systems, fetishes for security and control, and poor transborder communications separate the end user from its vendors to an extent that severely handicaps both. It is difficult for a potential customer in one country to find out what is offered abroad and get in some serious "shopping around". This practice has been enormously beneficial to Western users, and is an example of opportunities available in the West that are much more limited in CEMA. In theory, some of this is possible in CEMA, and there are scattered examples in practice, e.g. advertisements for the products of one country in the trade journals of another. However, for the most part, CEMA trade practices tend to keep vendors and users separated. This not only limits trade opportunities but, more importantly, it retards the effective utilization of computer technology.

One improvement in trade-related practice that has evolved over the last several years is in the area of service and support for equipment sold abroad. Before then, users who bought equipment from another CEMA country were in deep trouble if they could not take care of it themselves. Now each major exporter has developed programs to train foreign end users and service personnel at centers in both the exporting and importing countries [49]. Each country has established national computer service organizations to

provide maintenance for both indigenously manufactured equipment and imports. Although the quality of training and maintenance varies considerably across CEMA. and most of it falls short of Western practices. it does respresent progress. This was necessitated by the growing complexity of computing systems. making self maintenance very difficult for most users. and the desire to increase exports. Exporters were forced to recognize that they would have to help their customers abroad if they were going to sell much.

CEMA computer sales to developing countries are dependent upon a willingness to trade for services. commodities. and local currencies to an extent that Western vendors will not. One interesting arrangement involved the exchange of Soviet computer equipment for Indian software development on that system [50]. Prospects for licensing production and joint stock companies also may not be too bad in some places. A few CEMA optimists might have dreams of selling large quantities of their computer products to developing countries. thereby providing these countries with adequate technology. and themselves with hard currency earnings (with which to buy more advanced Western technology. upgrade their own products. and continue the cycle). This has not happened to any appreciable extent. A combination of the following reasons may explain why: small markets in developing countries. a technology where Western price/performance dynamics offsets CEMA willingness to discount their wares. and relatively poor CEMA service and

equipment reliability.

Technology Transfer

The volume and levels of computer technology transferred between the CEMA countries is hardly as great as is sometimes advertised by the participants. However, with the much increased availability and use of computing during the last decade. there has come more extensive use of a number of technology transfer mechanisms including joint development efforts. formal training, technical visits. and meetings of various kinds. In particular, multilateral conferences and bilateral projects have become fairly common.

The most striking of the intra-CEMA technology transfers since the advent of Ryad are the bilateral joint development projects involving the Soviets and an East European partner. At the top of this list are the ES-I and ES-II mainframe efforts with the Poles (mid-range machines) and the Bulgarians (low end models and some peripherals). As we saw in Section 6. the undertaking with the Poles. has not worked out particularly well. Examples of other joint technological undertakings include magnetic disk development with Bulgaria. and bubble memory and applications systems with Hungary.

Joint Soviet undertakings with the Bulgarians have developed into the most visible of all the intra-CEMA technology transfer relationships. Some of the effusive Bulgarian rhetoric praising Soviet help may have substance. As we have seen, at the start of the Ryad program the Bulgarians had almost nothing going in computing, and were most eager to enter into arrangements that would transfer technology to their little industry [51]. Of the CEMA countries only the USSR was apparently willing to help.

What seems to be a successful working arrangement has evolved between the major Soviet research, development, and production facilities in Minsk and the heart of the Bulgarian industry, the IZOT Association. The joint effort has enabled the Bulgarians to produce enough of three Ryad models to satisfy much of their own needs. They do not appear to be exporting many machines, but the Bulgarian computers and electronics FTO, Isotimpex, has been advertising in other CEMA countries. The Soviets may also have helped to build up the Bulgarian electronic components industry. It should be noted that these components are not as sophisticated as those made in the GDR, and we do not know the extent to which they are used in computer products, but the Bulgarians are producing and exporting in volume.

For magnetic disks. the story could be a little different. It may be argued that the Bulgarians acquired their initial disk capability through various means from the West and through their own perseverence. with little help from the Soviets. It is also possible that. at least initially. the Bulgarians transferred more disk technology than they received from the USSR. As later generations of Soviet and Bulgarian disk products have appeared (always models closely in line with their IBM predecessors). the Soviets may have become the technically more capable partner (although there is evidence they have not).

The Minsk-IZOT joint development and production cooperation has some resemblance to the IBM "sister plant" arrangement. In the latter. each major US facility has primary responsibility for development and production of certain products. e.g. the IBM plant in Tucson is responsible for the 20.000 lpm laser printer and other products. It has a sister plant in Valencia. Spain which makes the same equipment. The US facility essentially licenses the overseas plant (US IBM owns all IBM technology. even if it was originally developed by one of its foreign affiliates). and sees to it that as much technology as necessary is transferred so that the foreign affiliate successfully manufactures the same products for its market area. As part of this effort. foreign engineers and managers are brought to the US facility. and US technical and management personnel will go abroad to expedite the

transfer. These formal one-to-one sister plant relationships were started at IBM in 1975 and completed by 1977, although similar practices have existed as long as IBM has manufactured products abroad. The Minsk-IZOT "sister-plant" relationship is not as close or effective (and the Bulgarians hardly have free run of Soviet facilities), but it has been in existence since the early 1970s and it is the only widely heralded and successful pairing of major consequence we know of in CEMA. It is not unlikely that certain pairings exist between Soviet and East German firms under arrangements that differ somewhat from the above, i.e. with most of the technology flow to the USSR. Some observers feel that certain GDR firms have unofficial "sisters" in the FRG.

The East European countries continue to be useful to the Soviets as a funnel for computer technology from the West and technology indigenously developed in Eastern Europe. Although the Soviets now offer more in return, they are still in a position to appropriate whatever they want and, with exceptions, they keep much of their own technology off limits to the other CEMA countries. There are good East European computer engineers who fear doing so well in an area of interest to the Soviets that they will find their efforts and themselves "borrowed" for special projects. In some ways, the Soviets are their own worst enemies in these relations. Their arrogance and selfishness are such that they do not always get the East European cooperation that

might be possible if they behaved differently.

Intra-CEMA technology transfers not involving the USSR appear to be limited to product use and maintenance training. conferences. and other low level efforts. We have not been able to identify much in the way of licensing. turn-key plant establishment. etc. These are the more active and effective production technology transfer mechanisms used by the CEMA countries to acquire Western technology. The East Europeans. socialist theories of free and fraternal technical information flow notwithstanding. are less than forthcoming when it comes to sharing their specialty technologies with their brothers. Most are happy to sell products. but not to transfer lucrative technology.

Categories of transfer mechanisms used less effectively by CEMA than the West are those involving extensive, and long term. cross-border flows of people. Computer related travel across CEMA borders has increased greatly in the last decade. but most of this is for short training courses and conferences. The total extent and quality of such travel falls far below levels in Western Europe.

The USSR and its CEMA allies have not found a satisfactory means for pricing or otherwise protecting or compensating for know-how and non-hardware product transfers such as design data and software. For example. does one pay a single fee or royalties based on the number of uses? For many such transfers. it is difficult to determine how much

something will be used until after it is in use. The planned economies and communist economic doctrine have been very slow to come to grips with such questions that are central to improving intra-CEMA and East-West technology transfers. Extensive discussions of legal problems and pointers to the CEMA literature may be found in [52].

CEMA computer technology transfer to the non-aligned countries is very small. As far as we can tell, no turn-key production facilities, etc. have been established. An example of a widely advertised effort is the Hungarian training schools that have students from non-aligned countries (occasionally with Western instructors) [53]. CEMA appears to neither give nor receive much technology (at least not overtly) through these relationships.

8. THE EXTENT OF INTEGRATION

Progress Toward the Proclaimed Goals of CEMA

We now explicitly reconsider the list of integration goals from Section 3. For each, we present a brief summary and assessment of the progress that has been made during the last dozen years.

1. A more rapid development of the productive forces in all the CEMA countries.

The enormous commitments to computing that followed the 1969 and 1971 agreements have brought growth rates to the CEMA computer industries that have been good by world standards. In the early and mid 1970s it was not uncommon to have hardware-electronics production increase by annual rates of about 20% [54]. Growth during the second half of the 70s may have been at a respectable 10-15%. Similar rates are projected for the current Five Year Plan period. Greater hardware availability brought substantial increases in the volume of software and the number of trained people. At this time. it is fair to say that each of the East European CEMA participants has built a nontrivial computer equipment industry.

2. Achievement of the highest scientific and technical levels.

This has not been accomplished. but much higher levels than existed in 1970 have been achieved. While the CEMA countries have closed some of the technology "gaps" with the West. others have become wider. It may be argued that much of the relative catching up has taken place because the CEMA countries have been able to acquire Western technology.

3. A steady rise in the technical equipment of branch industries [industrial sectors].

Considerable progess has taken place here. There is a big difference in the quality of hardware and software between most of the pre-Ryad systems and the ES and SM systems that have been coming out since 1973. Third generation hardware and software is now widely available. The number of computer installations has increased dramatically. and there are many installations within every major branch industry in each of the CEMA countries.

4. The introduction of progressive technology in accordance with the requirements of the STR.

For the purposes of a short statement. it seems consistent with the STR literature. and with the example set in the West. to interpret this as meaning the pervasive and effective use of computer systems throughout the CEMA economies. Success here has not been insubstantial, but it lags considerably the easier achievement of manufacturing greater quantities of respectable hardware. The disincentives and inhospitalities for the use of computing in the centrally planned economies are being overcome very slowly. These problems vary from country to country. and from sector to sector within a given economy, but they will limit progress toward this goal everywhere.

5. Satisfaction in the long run of the national economic requirements of countries for.., modern equipment... mainly through the production and rational utilization of the resources of the CEMA member countries. [This will be interpreted as the desire to eliminate dependence on non-CEMA countries for critical items.]

Indigenous hardware production has achieved levels of quality and quantity such that there is little need to import the kind of equipment that was widely used and produced in the West in the early 1970s. Some problem areas remain. e.g. high speed scientific computing. large disk stores. and telecommunications hardware. Enough software has been "borrowed" from the West. or built at home, to give CEMA a minimally viable inventory by reasonably modern standards. If all of Western computing should disappear overnight. CEMA computing would be able to chug along. although at a reduced rate. In some ways. the more Western computer technology they acquire. the less (not more) dependent they become.

6. The gradual drawing closer together and evening out of the economic development levels of the CEMA member countries.

The most notable cases in point are the development of the Bulgarian and Hungarian industries from essentially nothing to respectable industries with good export records. A certain "evening out" has also taken place because of the

relative demise of the Polish and Czech industries as a result of their policies with regard to cooperation. Romanian progress has been almost completely outside the domain of the joint programs. Cuban progress has been nontrivial, but it would appear that the rest of CEMA has not provided much help. Various technical and economic factors. notably successful complementary specialties and the lack of hard currency. have certainly contributed to a fairly rapid "drawing closer together".

7. The growth of the capacity and stability of the socialist world market.

The market for computer products and services in the primary CEMA countries is large. and growing at a respectable rate. All are still "undercomputerized" by Western per capita standards. The market in the USSR is the second or third largest in the world. and it provides considerable opportunity and stability for the joint undertakings. The socialist computer market is now economically and technically viable and self contained. In terms of effectiveness and efficiency. it continues to suffer from major structural and behavioral problems.

8. The strengthening of the defensive capability of the CEMA member countries.

A detailed discussion of this goal is beyond the scope of this analysis. However. the technical and economic strenghtening of the CEMA computer industries contributes greatly to Warsaw Pact capabilities. One needs only to look at the pervasive applicability of computing in Western military systems to appreciate the value of this technology, even granting arguments regarding differences in military doctrine and procedures.

A distinction should be made between technical state-of-the-art and functional capability. Most military computer systems around the world do not reflect the "leading technical edge". Certain technological levels are necessary or desirable to provide certain functional capabilities. The gap between Ryad and SM on the one hand. and the pre-1970 machines on the other. represents the opportunity for much greater functional capabilites in military systems - although the former are hardly world technical state-of-the-art.

9. To avoid the duplication of research and development work. To provide checks against work done elsewhere.

Certainly. the reproduction of Western designs may be considered the duplication of development and. to a lesser extent. research. However. this approach saved the greater duplication of effort that would have been necessary to produce comparable hardware and software of CEMA design.

Little of the CEMA work has "checked" or improved upon developed Western systems. The Western systems they copied-for all their faults in retrospect, were exercised in test and user environments to an extent that still has not been achieved in CEMA.

At another level, the CEMA division of labor and specialization has saved the potentially enormous duplication and waste of effort that would have been the case if each of the members had tried to build a fairly complete range of hardware and software products. The extent to which they "check" each other is harder to guage. There are important CEMA-level standards and certification committes, and there is enough product redundancy across the countries (e.g. with the Soviets making almost everything), that they can carry on if one country fails to come through (there are exceptions: only the Soviets produce large scale machines, and the failure of the USSR here has been conspicuous).

10. To develop specialization in the smaller countries. This will be made possible by the availability of the full CEMA market [especially that of the USSR] to provide for enough exports to permit efficient large scale production within the smaller economies.

The cooperative efforts have been notably successful in achieving this goal, much more so than would have been predicted in the West 15 years ago. Every country has some sort of niche. and some of the smallest have effectively claimed some of the best niches (Bulgaria, the GDR, and Hungary). It should be interesting to watch the evolving dynamics of these specialties.

11. The coordination of national economic plans and reciprocal deliveries.

The most direct and widespread "hard" evidence that this is being done with some success is that there are thousands of CEMA computer installations with equipment from most of the other members. This equipment works together, is reasonably well matched technically, and often arrives closely enough in time to avoid crippling delays. The MPKVT is organized into several permanent Councils which appear to have long term authority in working with the technical organizations and FTOs. In principle, the organizational coverage is comprehensive. but many complex CEMA organizations look better on paper than they function in practice. We have only spotty glimpses of the detailed operation of these coordinating organizations.

12. To build a qualitatively new form of scientific and technical cooperation based on the three principles of: (i) voluntary participation; (ii) full equality of participants; and (iii) mutual benefit and comradely mutual

assistance.

This is the sort of goal that is proclaimed in the CEMA literature and often dismissed as propaganda. We briefly consider the principles: (i) Some effort was made to at least formally line up all the obvious participants as signatories to the 1969 Agreement. but several members chose initially to go much their own ways. They were able to do so. although some may have had cause to rethink those policies in light of subsequent economic and technical developments. (ii) All participants are obviously not equal. The Soviets can wield considerable power through political means and. perhaps more importantly in the current context, through the size of their internal market. Within Eastern Europe. the East Germans are "more equal" than others. There may be some sort of one-country one-vote arrangement at MPKVT meetings. but it is hard to believe that this (if it ever gets to that) has much to do with the determination of policy and practice beyond a single country's apparent option to withhold its own participation. (iii) Almost all of the participants have benefitted from the joint efforts. They have built respectable industries and imported useful products from the other members. This has enabled them to obtain the benefits of computing for their economies in ways that far transcend what had been the case before 1970. and to an extent that they could not hope to have been provided by the West. Day-to-day dealings involve more basic business behavior than "comradely mutual

assistance".

13. The national achievements and experience of individual countries in the field of science and technology becomes the property of all the members of the socialist community.

A lot more computer related information is flowing between the CEMA members than was the case even ten years ago, but much of this is the kind of information that is found in Western commercial environments. and the CEMA quality and quantity is poorer. The participants are not overly eager to share the kinds of information that Western firms protect from their competitors Conversely, we have not seen East European firms try to covertly acquire what other CEMA firms have. If they are going to go to that kind of trouble and risk, they may as well dedicate the efforts to acquiring Western technology - the reward/risk ratios are better. A much improved flow of technology and information continues to be hindered by serious economic. legal and social barriers.

14. The formation of modern. highly effective, national economic structures.

With regard to computing, there are at least three general categories to consider under this goal: (1) The establishment of new structures that serve the general economy. e.g. large computer-telecommunications networks; (2) The reorganization of existing structures around

computing, e.g. a more decentralized (or more centralized) management structure through the use of distributed data bases and management information systems; and (3) The formation of structures within the CEMA computing industries.

The first two are beyond the scope of this study, although we are starting a detailed investigation. We mention them briefly because of their importance. All of the CEMA participants claim to be working hard in these areas, and there is much ideological noise associated with these efforts. In practice, enormous amounts of energy and resources are being expended. Much of this goes under the generic heading of ASU (automated systems of control and management), which refer to a wide spectrum of computerized systems, including process control and management information systems. Some of these are working in some fashion, but many are "Potemkin villages" or total disasters. These problems are deeply interwoven with those noted under Goal 4 above.

Within the CEMA computing industries, some notable progress has been made. The MPKVT has been established, and it seems to be working as well as could reasonably be expected. Each of the members has set up computer service organizations that are desperately needed improvements over what had existed before. Some of the participating countries, notably the GDR and Hungary, have built computer companies with substantial technical and managerial

capabilities.

15. Priority now will be given to forms and methods of the division of labor... linked to technical progress... [to] enable all the socialist countries to raise the technical levels of production and make their products competitive on world markets.

A successful divison of labor for hardware has been established among the East European industries. Other divisions. software for example. have been much less successful or well defined. The CEMA computing industries have been able to raise the technical levels of production fairly impressively. None of them have been able to make their products seriously competitive on the non-CEMA world market. although some have aspirations.

16. Improvement of the forms and methods of cooperation in foreign trade and standardization.

Intra-CEMA trade in computing has expanded at respectable rates during the last dozen years. although absolute volume is still low in comparison with West-West trade. There appears to be some improvement in the way this trade is handled. All of the CEMA countries have improved their abilities to acquire Western computer products and technologies by both overt and covert means.

A large number of hardware standards. at several levels. have been effectively established. Efforts to define and implement systems and applications software standards have been much less successful. but this is to be expected. Standardization has been made easier through the adoption of standards that have been formally or informally established in the West.

CEMA Integration and the Characteristics of an INMC

We conclude by briefly comparing the extent of integration of the CEMA computer industries with some of the features of international technological integration associated with IBM [55]. We reconsider the characteristics used to define IBM as an IMNC in Section 3.

i. The Internationalization of Markets. An IMNC considers many countries to be its current or potential market.

With eight countries officially part of the cooperative effort. and with some sales to over a dozen others. the internationalization of markets appears to be well established. However. much of this is very shallow. There has been considerable progress in five of the eight MPKVT countries. but the industry in Poland is not in good shape. Romania has chosen to remain on the far sidelines. and the Cuban effort is tiny and remote. Sales to non-CEMA countries over the last dozen years have been negligible by

world market volumes. although they serve useful political and publicity purposes. The potential for extensive expansion into the non-CEMA markets is not promising. and real progress would require special circumstances such as much improved services. friendly governments or local companies. or favorable sales arrangements. It should be emphasized. however. that the Soviet-East European market for computing is both large and stable. and that this alone is enough to sustain further development and integration of the CEMA industries.

ii. The Rationalization of Tasks Within a Contentious System. Although there may be considerable central control. there exists a competitive and contentious system among the international affiliates. Within this system, there is a political process under which the affiliates bid for and develop their roles and workloads.

An international division of labor has evolved among the CEMA computing industries as the result of a contentious and competitive process under the supervision of a dominant member with considerable centralizing power. This is evident in the form and dynamics of the various niches that have and have not materialized. Although there has certainly been some coercion by the dominant member. its overall behavior seems to reflect considerable tolerance, or at least reluctance to push the affiliates too hard. In practice the USSR exerts less control over its CEMA computing affiliates than US ("Domestic") IBM exerts over

its IBM World Trade affiliates. This statement would seem to apply to general policy determination. technological developments. and task assignments. Niche building appears to reflect past strengths. current ambitions. political animosities and caution. We do not fully understand how this is done within various organizational and political contexts (this statement applies to both CEMA and IBM).

iii. The Naturalization of Subsidiaries. Within each country the affiliate behaves as an organizational "citizen" of that country. Most of the people who work for the affiliate. at all levels including top management. are citizens of the host country.

The independent and nationalistic orientations of the CEMA affiliates have been noted throughout this study. Each of the East European and Cuban affiliates is part of the economic structure of its native country, and essentially all employees are citizens of that country.

In summary, all three characteristics defining an IMNC seem to apply to the cooperative CEMA computing undertakings. Not only are they satisfied- but they hold at least as strongly as they hold for IBM. which served as the canonical company for the definition. and as a model in some ways for the CEMA effort. We have chosen to explicitly emphasize these general similarities and CEMA's technical tracking of IBM. However. it is important to state that major differences exist between these two extreme ends of

the spectrum of possible comparison.

Very briefly, IBM and other Western computer IMNC continue to outperform the CEMA industries by substantial margins. This statement applies to the rate and importance of technological innovation, the efficiency of allocation and distribution, production volume (IBM only, total CEMA production is greater than that of any other single Western IMNC), standardization, user-vendor relations (the greatest "gap") and labor productivity (perhaps the second greatest "gap") [56]. There also exist major differences in form and effectiveness at all organizational levels.

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[16] Much of this subsection is based on N.C. Davis and S.E. Goodman. "The Soviet Bloc's Unified System of Computers." ACM Computing Surveys. Vol. 10, No. 2. June. 1978, 93-122; and Goodman. 1979(a) (fn. 5).

[17] Both the Czechs and East Germans claim leading roles during the embryonic years 1967-69. Automatizace (Cz.). Vol. 19, No. 7. July 1976. 169-173; Hans Kaemmerer. "Successful Integration in the Foreground of Production", Neues Deutschland (GDR). March 13. 1980. 6. Subsequent developments support the German claim, whereas the Czechs behaved like reluctant participants.

[18] A short partial list of informative references for this subsection include: Applications Software for the ES Computers. Coordinating Center of the MPKVT. Moscow, Vols. 1 through 3. 1977-1979; M.E. Rakovskiy, Vychislitel'naya tekhnika sotsialisticheskikh stran. (Computer Technology of the Socialist Countries). Statistika. Moscow, Volumes 1 through 9, 1977-1981; William K. McHenry. "The Role of the MPK in CEMA Integration." Unpublished background information. June 18, 1981; Catalog-Reference Guide, Exhibits of the Unified Series of Computers and the SM Minicomputers and Their Applications. June 14-July 15. 1979, Moscow; "10 Years". Soviet V/O ELECTRONORGTECHNIKA (Elorg) FTO English language brochure of reprinted computer articles and advertisements from Soviet Export. Moscow, no clear date. probably 1980; Ivan Peceny. "Making SMEP Minicomputers Available to Czechoslovak Users." Vyber Informaci z Organicni a Vypocetni Techniky (Cz.). No. 3, 1981. 275-282; Control Data Corporation. Report on the 1979 Moscow Computer Exhibition. 1980; "Developers Discuss Advantages of the New ES-1036 Computer." Sovetskaya Belorussiya. No. 259, Nov. 10, 1981. 1; Henryk Orlowski, "The Minicomputer Industry and Information Science in Poland." Informatyka (Pol.). Nov. - Dec. 1982. 6-9; P.S. Pleshakov. "Computer Hardware." Ekonomicheskaya Gazeta. No. 31. 1978. 15; Yu.D. Alekseyev and A.A. Myachev, Instruments. Automation Equipment and Control Systems. Tech. Series 2: Peripheral Units of SM Computers. TsNIITEI priborostroyeniya. Moscow. Jan.-Feb. 1980; K. Mikul'skiy, "The Coordination of Economic Policy is an Urgent Need in the Socialist Community." Mirovaya Ekonomika i Mezhdunarodnyye Otnosheniya. No. 12. Dec. 1981. 42-53; Lajos Ivanyos. "Experiences with the SM-4 Computers." Szamitastechnika (Hung.). No. 7-8. Jul.-Aug. 1981, 7.

[19] Helmut Peiper, "Main Features of Further Cooperation in ESER - Multilateral Specialization Agreement on Electronic Computer Technology Signed." Rechentechnik Datenverarbeitung (GDR). Vol. 17. No. 9. Sept. 1980, 5-6; V. Petrunya, "CEMA in Action." Sovetskaya Estoniya. July 29. 1981, 3. "Communist Nations Conclude Summit. Sign Technical Pact'" The Wall Street Journal, June 11, 1982, 29.

[20] Covert CEMA efforts to acquire Western computer and electronics technology have become so widespread in recent years that articles describing some of these activities have regularly appeared in the general media and trade publications. A small sample: "Belgian Charged with Bribery" and "Belgian Sentenced. Fined in Adabas Bribe Case", Computerworld, June 16. 1980 and Aug. 18, 1980; "Eastern Bloc Evades Technology Embargo." Science (Jan. 23. 1981). 364-368; "KGB and Industry", The Arizona Daily Star, Aug. 2. 1981. 1C; "Electronics Underworld: Feds Cap Smuggler's Pipeline Stretching from Silicon Valley to Soviet Union", Computerworld, Aug. 31. 1981; "Flourishing Illegal Technology Transfer in CEMA - East Interested in Computers

and Microelectronics", Neue Zuercher Zeitung (Zurich). Sept. 12. 1981. 16; "The Spies Among Us", NBC Report. Telecast Nov. 28, 1981; "Valley of Thefts", Time. Dec. 14. 1981. 66; "Guarding US Technology". The Chicago Tribune. Dec. 26. 1981. 11. For a more detailed article in a similar vein from a US Government source. see "Soviet Acquisition of Western Technology." Unattributed US Government Publication. April. 1982.

[21] Not all Western technology transfers to Eastern Europe work out well for the receiver. For two not so successful instances involving what should have been effective transfer mechanisms (a turnkey plant and a joint venture) see: Katalin Bossanyi. "The Unintegrated Circuit." Magyar Hirlap (Hung.). April 30. 1979. 7; "An Assessment of the K-202 Project." Informatyka (Pol.). Sept.-Oct., 1981, 8-17.

[22] Prayda. July 7. 1981. 1 and 4 (Communique on the 35th Session of CEMA). See also "CEMA Committee Session On the Joint Development of the Electronics Industry." Magyar Hirlap (Hung.). Sept. 26. 1981. 7; Gerhard Tautenhahn. "Microelectronics in our National Economy," Einheit (GDR). Vol. 36. No. 6. June 1981. 554-562. Eduard Schliksbier. "Microprocessors and Their Trends." Elektrotechniky Obzor (Cz.). No. 10. 1981. 578-581; Interview with Sandor Mihaly. Muszaki Elet (Hung.). No. 3. Feb. 4. 1982. 3. Although detailed discussions of some areas mentioned in the last 2 paragraphs are outside the scope of this study. it is important to note that most of the East European countries are increasingly aware of their deficiencies and are at least making serious noises about building up their indigenous industries. As yet. it appears that no clear and effective division of labor comparable to that for computers has been implemented.

[23] Constraints on the length of this study made it necessary to drop the section on this topic. A short. insufficient chapter is contained in Mundie and Goodman (fn. 4. pp. 23-31). Since then we have collected additional information that has been partially synthesized in McHenry (fn. 18). For a broad overview of CEMA scientific and technological organizations and their functions. see Louvan E. Nolting. "Integration of Science and Technology in CEMA", Foreign Demographic Analysis Division. US Bureau of the Census. draft report. Nov. 1981.

[24] Parts of this are taken from the national sections of Chapter III in Mundie and Goodman (fn. 4. pp. 31-156). Since that was written. other useful articles have been found. A few of these include: Serafim P. Popov, "The Development of Electronics and Electrical Engineering in Bulgaria - The Result of Integration with the CEMA Member Countries." Elektropromishlenost i priborostroene (Bulg.). No. 3. 1979. 82-85; B.N. Naumov. "MSZR - The Uniform Minicomputer System." Szamitastechnika (Hung.). July-Aug.

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[25] An extensive list of Bulgarian computer hardware claimed to be in production is given in "Data Processing Equipment in Bulgaria", Vyber Informaci (Cz.). No. 1. 1981, pp. 3-36

[26] Within CEMA. the Bulgarians claim to be second to the USSR in "the production of electronic equipment for computers", Tekhnichesko Delo (Bulg.). Feb. 12, 1977. 3.

[27] For example: "Words Do Not Deepen Integration" Editorial in Bratislava Prayda (Cz.). Dec. 28, 1981, 1; Announcement of electronics export goals in Zemedelske Noviny (Cz.). Feb. 11. 1982, 6; Martin Denemark. "Goods of Which One is Unaware." Svobodne Slovo (Cz.). May 15. 1982. 3; and Turcan (fn. 22).

[28] A description of the East German computer and electronics industry. and a comparison with the FRG, may be found in Schwartau (fn. 24). A more glowing account of Robotron. prepared by its management and addressed to E. Honecker. may be found in Wolfgang Sieber et al., "Results From Science and Technology Will Be Put to Even Better Use ...," Neues Deutchland (GDR). Dec. 8, 1981, 3.

[29] Zoltan Emodi. Gyorgy Harsenyi and Gabor Reich. "Store Expansion - Hungarian Style", Szanitastechnika (Hung.). Nov. 1980, 4; Interview with "Imre Csenterits" of the System Computer Technology PJT. Magyar Nemzet (Hung.). March 19, 1981. 5.

[30] Many of the workers and technical professionals in Poland's computing industry became involved with the independent labor movement. See Bohdan O. Szuprowicz. "Polish DPers Caught Up in Labor Fight", Computerworld. March 30. 1981. 1 and 8; and "DP Workers in Thick of Polish Labor Struggle". Computerworld. Jan. 11. 1981. 6. The Polish computer trade journal Informatyka. one of the few such publications in CEMA (the most notable being Hungary's Szamitastechnika). carried discussions of various labor related issues and frank assessments of Poland's information processing industry. See especially Kilinski et al. (fn. 24); Orlowski (fn. 18); "K-202" (fn. 21).

[31] Alexandru Drogut. "Romania's Technical-Scientific Collaboration and Cooperation with the Socialist Countries." Revista Economica (Rom.). No. 40. October 1980. 15-16; Cornel Lazar and Ion Stan. Revista Economica (Rom.). No. 33. Aug. 14. 1981. 18-19; Catalog-Reference Guide and CDC Report (fn. 18).

[32] Many catalogs and brochures were available. One of the most complete was: "Unified Computer System ESZR." (Hung.). Statisztikai Kiado Valalat. 1973. The ensuing division of labor evolved quite rapidly. e.g. Avtomatika. telemekhanika i svyaz'. No. 8, 1973. 40-42.

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[34] McHenry (fn. 18).

[35] Most of Section 7 will be concerned with intra-CEMA trade and technology transfer. For a review of imports from the West. see Kenneth Tasky. "Eastern Europe: Trends in Imports of Western Computer Equipment and Technology," in Hardt. 1981 (fn. 2. Vol. 2. 296-327). In this section. "Eastern Europe" will refer to Bulgaria. Czechoslovakia. the GDR. Hungary. and Poland. References to Romania will be explicit.

[36] Thirty-Fourth CEMA Summit. Prague. Cz.. Official Czech. Communique. June 19. 1981; Twenty-Firsst Session of the MPKVT. Sofia. Bulg., Sofia Broadcast. May 15. 1980. 1846 hrs; "Common Plans for a Five Year Period. Economic Cooperation - Complex Program - Computer Technology. Patents. Standardization", Esti Hirlap (Hung.). April 29. 1981. 33; "CEMA Committee Session On the Joint Development of the Electronics Industry". Magyar Hirlap (Hung.). Sept. 26. 1981. 7. These figures may include some non-computing microelectronics.

[37] Yu. D. Scherbina. "From Electronic Components to Computer Systems Capable of Carrying Out 12 Million Operations a Second". Soviet Export. 5(122) 1980. 2-7; also reprinted in "10 Years" (fn. 18).

[38] For example. a figure of 50% is given for Poland's MERA in Szamitastechnika (Hung.). Oct. 16. 1980. Similar figures have been obtained for the GDR and Hungary.

[39] Schwartau (fn. 24) discusses how the export of computer equipment to the USSR to pay for raw materials imports is hurting East Germany. See also Kilinski et al (fn. 24).

[40] Scherbina (fn. 37) and Tasky (fn. 35). All quantitative estimates presented in this section should be regarded as rough approximations.

[41] Vyber Informaci (Cz.). No. 1. 1981. 4; Mlada Fronta (Cz.). May 14. 1980. 4. There may be a greater imbalance in Soviet trade with the GDR and Hungary: Neues Deutschland (GDR). March 20. 1981, 1-2; Budapest Home Service Broadcast. 1630 GMT. May 28. 1981.

[42] Prague Home Service Broadcast. Oct. 19. 1979, 1130 hrs., BBC Summary of World Broadcasts. 1979. No. W1056. A1; Revue Obchodu Prumyslu Hospodarstvi. No. 7-8. 1979, 51; comments by I. Korec in Soviet Export. 4(127). 1980 (reprinted in "10 Years", 27. fn. 18); other related statements in the Czech references in fn. 41.

[43] See. for example: Szamitaztechnika (Hung.). Apr. and Sept. 1978. Aug. and Oct. 1980; Rechentechnik Datenverarbeitung (GDR). Vol. 16. No. 2. 1979. 2; Kaemmerer (fn. 17); "The Status of Computer Technology in Czechoslovakia", Szamitastechnika (Hung.). March 1980. 9; also references in fn. 42. West German discussions of GDR ambitions to export less to CEMA and more to the outside world may be found in "GDR Wants to Deliver More to World Market - Cautious Disentanglement of Economic Relations in East Bloc". Sueddeutsche Zeitung (Munich). Mar. 4, 1981, 21; "GDR Depresses Deficit in Foreign Trade." Sueddeutsche Zeitung (Munich). Feb. 9. 1982. 19.

[44] Nandor Balogh. "Hungary's Role in World Computer Trade", Kulgazdasag (Budapest). No. 8. 1980. 61-63; Szuprowicz (fn. 24); Z. Marian. "Polish-Hungarian Technical and Commercial Cooperation in Computer Technology", Szamitastechnika (Hung.). July-Aug. 1980. 1; Mrs. Ervin Ban. "The Manufacture of Computer Technology Devices as a Reflection of the Central Computer Technology Development Program." Iparzazdasag (Hung.). No. 11. Nov. 1979, 45-48.

[45] From Balogh (fn. 44. The "other European" category consists mainly of Sweden and Switzerland. The two major "outside of Europe" capitalist countries are the US and. to a much lesser extent. Japan. "Developing countries" are mainly India and Hong Kong. An interesting small item worth noting in Table 7.1 is the trade with non-CEMA socialist

countries. Some of this is with Yugoslavia (Automatizacija Poslovanja. Vol. 20. No. 3. 1979, 36-48). some may be with the People's Republic of China.

[46] Bulgaria certainly has an impressive claimed growth rate in computer exports. In 1970. computer equipment made up 0.6% of total industrial equipment exports; by 1980 this had risen to 24.7% (from 1.4 million foreign exchange leva to 441.3 million). "1980 Foreign Trade of the Bulgarian People's Republic in Figures." Vunshna Turgoviya (Bulg.). No. 9. 1981. 26-27.

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[48] Tass Broadcast. June 16. 1979, 2020 hrs. The Czech Tesla firm is helping the Vietnamese build an unsophisticated components industry: Mlada Fronta (Cz.). Nov. 24. 1981. 2.

[49] E.g. Rakovskiy. Vol. 7 (fn. 18); Tim Palmer. "Do-it-yourself Service is the Robotron Rule." Computer Weekly (UK). May 31. 1979, 12; comments by Igor A. Polyushkin. Mlada Fonta (Cz.). May 14, 1980, 2; "Knowledge Export; From Czechoslovakia to India; Foreign Exchange Source." Nepszava (Hung.). July 29. 1980. 3.

[50] Tim Palmer. "Paying for Soviet Computers in Software", Computer Weekly (UK). July 6. 1978, 18.

[51] These included some ties with Japanese and other Western companies.

[52] Peter B. Maggs. "The Legal Structure of Technology Transfer in Eastern Europe." in Smith et al. 1981 (fn. 15). 1981. 272-294; and Peter B. Maggs. "Legal Aspects of the Computerization of Management Systems in the USSR and Eastern Europe." to appear in Law and Soviet Economic Modernization (P. Maggs. G. Ginsburgs. and G. Smith eds.). Westview Press. Boulder. CO., forthcoming.

[53] E.g. Nepszava (fn. 51); "Computer Training for Foreigners Too". Hungarian Foreign Trade. No. 1. 1980. 26-27.

[54] E.g. "On the Problems of the Development of an Electronics Industry". Jemna Mechanika a Optika (Cz.). June 1980. 145-148.

[55] For a recent effort at a comprehensive study of IBM. see Sobel (fn. 7). Chapter 9 deals with IBM World Trade. An IBM listing of its history and product announcements may be found in: "IBM ... yesterday and today." IBM brochure

G520-3140-2. Armonk, N.Y., 1981.

[56] It hardly begins to balance the IBM performance superiorities. but it may be noted that the ES program has a more rational equipment numbering scheme.

APPENDIX A

A LIST OF SELECTED ABBREVIATIONS AND ACRONYMS

ASU - Automated System of Management/Control

CDC - Control Data Corp.(US)

CEMA/CMEA/COMECON - Council for Economic Mutual Assistance

CIETC - The major Romanian manufacturer of computing equipment.

CII - Compagnie Internationale pour l'Informatique (Fr.)

CPU - Central Processing Unit

DEC - Digital Equipment Corp.(US)

ES (EVM) - Unified System (of Electronic Computers) (Ryad)
Main group of CEMA IBM-like mainframes.

FTO - Foreign Trade Organization

GDR - German Democratic Republic (East Germany)

HP - Hewlett-Packard (US)

HOL - Higher Order (programming) Language

IBM - International Business Machines

ICL - International Computers Ltd.(UK)

IMNC - Integrated Multinational Corp

IZOT - The major Bulgarian manufacturer of computing equipment.

MERA - The major Polish manufacturer of computing equipment.

MNC - Multinational Corp.

MPKVT - Intergovernmental Commission for Cooperation of the Socialist Countries in the Field of Computer Technology (sometimes just MPK)

NCR - National Cash Register (US)

ODRA - A group of MERA-made computers

PDP - A group of DEC-made minicomputers

Robotron - The major East German manufacturer of computing equipment.

Ryad - See ES above.

SM - Small System. Main group of CEMA minicomputers

STR - Scientific-Technological Revolution (also NTR)

Videoton - The major Hungarian manufacturer of computing equipment.

ZPA - The major Czechoslovakian manufacturer of computing equipment.

APPENDIX B

A SELECTED BIBLIOGRAPHY OF FIFTY REFERENCES

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