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Enterprise-Level Computing in the Soviet Economy

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Enterprise-Level Computing in the Soviet Economy

Summary

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Since 1966 the Soviets have undertaken a massive program to introduce computer-based information and control systems (ASUs) into all management levels of the economy. ASU is a generic term used by the Soviets to designate a wide variety of computerized data-processing systems, from simple automated bookkeeping to complex systems for the collection, processing, and distribution of economic data throughout the economy. ASUs applied to enterprise management (ASUPs) are intended to foster more rapid and extensive information exchange within and outside the enterprise and, ultimately, the routine use of optimization techniques in enterprise management decisions. Dynamic management outside the enterprise requires interactive access to data, or at least the ability to request and receive data in machine-readable form. Ministries and central planning authorities need accurate, timely information to deal with bottlenecks in the economy and to create achievable plans that reflect policymakers' preferences.

After two decades ASUPs have been introduced in less than 10 percent of all enterprises, and these ASUPs generally are limited to information collection and processing for accounting applications. Soviet industry has provided slow, unreliable, and sometimes obsolete computer equipment to enterprises, usually in insufficient quantities. Technical service, software, and employee training also have been inadequate. These factors exacerbate the disruption to enterprise operations associated with computerization, which jeopardizes enterprise fulfillment of production goals. Even if successfully installed, computerized systems threaten the managerial ability to control and manipulate information. Overall, the enterprise manager has had little incentive to install an ASUP system.

Progress in linking ASUPs with other organizations by using ministry and regional networks has been hampered by deficient telecommunications technology and investment. Networking relies on the general purpose phone network, the general and special-purpose telegraph networks, a "subscriber" telephone network for data transmission, and new-technology media. The Soviets have built some impressive isolated networks, such as the KONET local area network developed by the Estonian Academy of Sciences. Overall, however, relatively few enterprise computers have been directly connected to ministry and regional networks, and many that are use expensive dedicated lines that provide somewhat better services than

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the regular phone system. Most of the linkages are hierarchical and use aspects of the teleprocessing designs embodied in IBM's Systems Network Architecture. These systems provide for data transmission but do not include such capabilities as interactive sessions on remote computers or load balancing.

The Soviets have only begun to create distributed processing systems for optimal planning, an extension of the ASUPs. These "integrated automated management systems" (IASUs) are supposed to: (1) integrate subsystems of autonomous ASUPs; and (2) link traditional ASUP functions and automated manufacturing functions, either for continuous processesing (process control) or discrete manufacturing (robotics, flexible manufacturing). Three IASU models are being explored:

- One being developed and implemented by the Minsk Central Scientific Research Institute of the Technology of Management (TsNIITU) is restricted to linking production automation with the ASUP.
- A more comprehensive Leningrad system resembles Western Manufacturing Resources Planning (MRP-II) systems. It develops a production plan on the basis of demand forecasts and makes it possible to adjust more quickly to changing delivery requirements.
- The most ambitious system under development at the Academy of Science's Computer Center in Novosibirsk embraces true decentralization of management relying on interactive processing and distributed data bases, and restricting upward data flows.

IASUs make greater demands than ASUPs on suppliers and the infrastructure and so are seriously hampered by current Soviet deficiencies. For example, few industrial local area networks, a critical ingredient, have been built. IASUs are also likely to face even greater resistance from managers, since tight integration leaves little room for error or obfuscation. If upper management fears that distributed processing will reduce its controls too much, lower-level management may worry that it will actually lead to greater centralization.

The majority of enterprises without ASUPs obtain limited computing services from tabulators and sorters operated by regional Central Statistical Administration (TsSU) offices; a variety of small, special-purpose accounting machines used internally; branch computer centers; and large collective-use computer centers. Only the last two options give enterprises the ability to undertake complex ASUP tasks, such as those connected with material technical supply, production management, accounting, and planning. Even then data processing usually is not integrated, meaning that data must be entered for individual operations, even if sequential. These limitations have meant that computerization has mainly led to the automation of some existing practices, without leading to substantive changes in management practice.

Gorbachev has taken initiatives to step up and change the character of enterprise computerization:

- Interbranch scientific technical complexes (MNTKs) have been established to further development of personal computers and industrial automation. MNTKs group research and production facilities into a single organization and are designed to accelerate the introduction of new technology. They will undoubtedly make progress, if only because of their priority, but they are encountering problems such as insufficient funding and organizational confusion.

- Production of computers, and especially microcomputers, is being increased and new mechanisms are being introduced to shore up the performance of the computer industry. The new State Committee for Computing and Informatics (GKVTI) has been directed to improve computer hardware, stimulate better computer usage, create a new system of computer servicing, coordinate the implementation of the party directive on computing, and oversee new training programs. The GKVTI's effectiveness will depend on how well it fares against the large bureaucracies of the dozens of ministries that participate in computer hardware and software production.

- Enterprise managers are also being given some increased autonomy, and encouraged to take greater initiative. Microcomputers in distributed processing systems in particular represent a major departure from the top-down imposition of control, giving lower-level managers a powerful tool for their own data processing. They bring significant computing resources right to the workplace of bookkeepers, economists, and statisticians. Nevertheless, changes in the Soviet planning and management system have not yet been sufficient to sustain widespread managerial enthusiasm for rapid computerization—that is, assuring adequate supplies of reliable equipment and support, and incentives to use optimization techniques and to maintain realistic data in enterprise computers.

Some managers will probably find innovative ways to improve production, while others will find new ways to beat the system. The challenge for the Politburo is to reap the efficiencies of the microcomputer without losing too much control.

In any case, it is clear that the mid-1980s mark the real beginning of the computerization of Soviet society. Until now, the centralized form of service provision, even in ASUP, has led to few changes in the way that management functions. The task is immense, involving the mass production of huge numbers of personal computers, education of millions of users, and reorganization of the whole centralized accounting system.

One of the key issues for success is the extent to which the Gorbachev administration will be able to free up the enterprises from the heavy hands of their ministries. The less data collected, the harder to exert specific control. Yet ministries and regional agencies are in the process of building networks which will give them even greater access to all sorts of data. For the first time, the use of personal computers is giving smaller organizations a means to avoid this centralized processing. If enterprise directors are convinced that there will be less direct oversight, they may be more willing to use optimization routines and do more analysis with computers. The extent to which less data is being collected is one way to measure the success of Gorbachev's decentralization drive.

On balance, computerization of management is likely to proceed slowly. The key factors that helped spur the use of computers in the United States—the pressures of the marketplace, corporate autonomy, and marketing pressure from the major vendors—are generally absent in the Soviet centrally planned economic system. Because ASUP, IASU, and other computing applications involve so many aspects of the external operation of the enterprise and the surrounding social-political system, management-oriented computing will remain one of the hardest technologies for the Soviet enterprise to absorb.

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Enterprise-Level Computing in the Soviet Economy

Introduction: The ASU Program

In 1966, the Soviet Union launched what would become an ambitious program to reform economic management by installing computers at all levels of the economy. Automated management systems (ASUs) were designed, implemented, and introduced at the state committee level, at the ministry level, at the regional and city levels, and at the enterprise level, including systems for management dubbed "organizational-economic" ASUs and systems for process control, called ASUTPs.[1]

Financial appropriations for ASUs have been huge and have risen steadily. They totaled one billion rubles in 1966-70, 3-5 billion in 1971-75, 6 billion in 1976-80, and a projected 11 billion in 1981-85 (Sots72; Veli78b; Yers75). Between 1966 and 1985, total expenditures on computing in the Soviet economy were expected to be 24.5 billion rubles (Simc84).

The Roots of Enterprise Computing

The ASU program is the result of a number of trends in Soviet society dating back to the mid-1950s (Thom83). Numerous Soviet researchers became enamored with cybernetics, which rose from the ashes of Stalinist denunciation and became a highly acclaimed theory that received wide application in a number of fields (see (Grah72). Cybernetics is defined as the science of control *(upravleniye)*, reception, transmission, and transformation of information in any system, including systems of a technical, biological, economic, social, or administrative nature (Glus79). It held out the promise of restoring central control of the increasingly unwieldy economy (Thom83). In the late 1950s, A. Berg and a group of proponents of cybernetics first began arguing that the entire national economic planning process could be computerized (Cave82). Conyngham believes that this has been the principle organizing concept of Soviet management science for the past two decades. However, even among Soviet cyberneticians such as Berg and V. Glushkov, there was considerable disagreement over the extent to which it could play this role (Cony82).

Somewhat later a movement was started to make management science an independent scientific discipline that would link cybernetics, operations research, and economic reform. At the same time, purposeful study of Western management science began. Through the efforts of D. Gvishiani, who was Kosygin's son-in-law, Western management concepts were widely discussed among scholars and researchers in various disciplines. In 1966, it was finally recognized as an independent discipline. Throughout the rest of the decade, sometimes bitter disputes continued between the various disciplines over the nature of management science and its place in the academic community (Beis82; Thom83).

Meanwhile, the ASU program was officially started by an important resolution of the Central Committee of the CPSU and the USSR Council of Ministers in 1963 (Losk66; Makh74). This resolution laid out plans for the first experimental applications of computers to enterprise management. In addition, plans were made for a state network of computer centers (GSVTs). The initial analysis of the GSVTs was carried out from 1964 to 1966, but the necessary hardware was simply not available (Maks82). The program was plagued with bureaucratic conflict. Both the Central Statistical Administration (TsSU) and Gosplan vied for predominance, but their interests were perceived as being too narrow to meet the needs of all users, including enterprises, ministries, Gosplan, Gossnab, the TsSU, and other bodies (Bart72).

The introduction in 1966-70 of about 400 ASUs at all levels in the Soviet economy laid the groundwork for the great expansion of the ASU program which took place in the early 1970s. At the XXIVth Party

[1] The various acronyms in use for a large number of types of ASUs are given in Appendix A.

Congress in 1971, the GSVTs idea was subsumed by an even grander plan to create OGAS, the All-Union System for the Collection and Processing of Information For Accounting, Planning and Management of the National Economy. OGAS was supposed to bring about the complete linkage of all major units in the Soviet economy through a huge network of computers (Cave83; Cony80). The approval of the OGAS conception gave the ASUP program an even greater top-down emphasis.

Although the development of ASUs continued apace in the 1970s, the trio of operations research, cybernetics, and management science did not provide the hoped-for unified conceptual foundation of ASU. There was widespread agreement, however, that ASUs could become the foundation of a qualitatively new form of management in which the computer would somehow suggest or even make optimal decisions. This quotation from Nikolay Fedorenko, Director of the Central Economics Mathematics Institute (TsEMI), and one of the leading proponents of the ASU program, is typical:

> An ASU is not created in parallel with, or next to, an "ordinary" management system ... The process of designing an ASU is the sequential and step-by-step introduction of improved methods and hardware into the existing management system. The new methods and means must naturally grow into the structure of management, becoming its foundation, and the means by which it will function on a higher level. In such a way, standardization and automation of the design and creation of ASU is a most important direction of improving management systems at enterprises ... ministries and departments, on a nationwide basis. This path will guarantee the fastest transfer of the best practical experience from one organization to others, the use of well-designed and well-tested modules in management systems, and the choice of optimal decisions of the basis of using a greater quantity of information ... (Emm74, pp. 1202-1203).

ASUs were seen as an integral part of the scientific technical revolution, a Soviet concept that included the belief that only under socialism can the fruits of technological innovation be fully realized. These views of ASU were widespread (Dani86). In order to foster sharing of experience and to mandate the widespread usage of the best techniques, various ASU design guidelines were introduced (Ormm72; Ormm77; Ormm80; Ormm86).

ASUs represent the most sophisticated forms of computer usage in the economy. Most enterprises, however, go elsewhere for computing services they use. These services are rooted in the drive for the centralization and mechanization of accounting, which began in the late 1950s. In 1960, after several years of initial experimentation with what the Soviets call punch card computers, or simple tabulators and sorters, the TsSU was given a mandate to set up a network of machine calculating stations in all the major regions and cities of the country (Isak80). A drive began to create centralized bookkeeping operations on the basis of various forms of calculating organizations. By 1965 the number of these had grown to 6,100 (Isak65). By the early 1970s almost all bookkeeping operations were centralized within enterprises (Isak80). Organizations in the service sphere, kolkhozes and sovkhozes, and small local enterprises of the same type lost their bookkeeping departments and began to use central bookkeeping shops in city and regional (rayon) centers.

The proposals to create the State Network of Computer Centers (GSVTs) and OGAS should be seen as a natural outgrowth of the centralization of accounting drive which began a decade earlier. In addition to the GSVTs, OGAS would be supported by the creation of a Unified Automated System of Communications, an All-Union Data Transmission System, and numerous computerized management information systems. Subsequent analyses showed that the GSVTs would have to consist of 200 territorial collective use computer centers (VTsKPs), 2,500 collective use computer centers subordinated to branches (KIVTs), and 22,000 other computer centers (Maks82). The collective use computer centers were to become the counterparts of the machine calculating stations set up in the 1960s for mechanization of accounting. Roughly 40 percent of all production takes place at small- or medium-sized enterprises; the vision for the GSVTs included building ASUPs for these enterprises based on its computers (Gune77). With the same intention of standardizing and thereby improving management throughout the economy, guidelines and standard software packages have been issued for centralized accounting tasks (Pusp86).

Overview of Results to Date

ASUs have been introduced into the Soviet economy at a rather measured pace which has yet to exhibit the typical S-curve tendencies of the diffusion of many technologies (table 1). After an initial quick start in the early 1970s, the rate of introduction of ASUPs (automated enterprise management systems) has remained about the same. The average yearly introduction of ministry ASUs has fallen off, reflecting the saturation of parts of this market segment. The biggest growth area in the ASU program at present is in the area of process control. The average yearly rate of introduction of ASUPs during the 11th Five-Year Plan was just 180, while the average rate for ASUTPs was 520 (Nark85b). At the end of 1985, according to official statistics, 4,651 ASUTPs had been built versus 3,672 ASUPs. Almost three-quarters of the systems introduced in the 11th Five-Year Plan period fell into this category. This trend apparently will continue: over 5,000 ASUTPs are scheduled to be installed during the 12th Five-Year Plan (Prav860304), while the rate of introduction of ASUPs is likely to decline (Emm85b).

By both qualitative and quantitative measures, the ASUP program has fallen short of its ambitious goals. Of the approximately 44,000 industrial enterprises now in the USSR, only 8.4 percent have ASUPs. At current rates of introduction of about 200-300 ASUPs per year, less than one quarter of all Soviet industrial enterprises will have them by the year 2000. However, since about one third of Soviet enterprises with more than 500 employees have ASUPs, they cover a disproportionately large percentage of overall production. Nonetheless the number of ASUPs appears minuscule when compared with the approximately 580,000 enterprises, organizations, and institutions that the Soviets say have a need for computing in management applications (Simc84).

For the most part, ASUPs have failed to significantly alter the way that Soviet enterprises are managed and thus have failed to bring about the desired improvements in effectiveness. A head of a laboratory at the Academy of the National Economy, V. I. Danilov-Danil'yan, points out that "The recent period has demonstrated, probably to all, that the main reserve of raising the quality of management is not automation" (Dani86, p. 905). As the following section will explain in much greater detail, the main achievements have been in increasing the efficiency of the data processing part of the management information system, although in some cases overall efficiency has actually been reduced (Birb86). Basic data processing systems have been built in areas such as scheduling and tracking of production status, calculation of the annual plan, production engineering, and management of sales and inventory. Other ASUP functions have included: quality control, management of auxiliary production, personnel, finance, long-range planning, wages and labor, order execution, dispatching, and norms (Mchc85).

Because the ASUP program was nurtured in the cradle of cybernetics, operations research, and economic reform, the goals were elevated to an impossibly high level given existing hardware and software capabilities and the ability of the economy to absorb change. The vast majority of enterprises were struggling with mechanization of accounting at a time when ASUPs were being portrayed as a panacea for all management difficulties. It was inevitable that disillusionment would set in. According to Danilov-Danil'yan, the concept of "ASU . . . (as) a system of economic management" has been abandoned in practice over the last decade (Dani86, p. 906). Instead, designers stuck to automating existing management functions (Emm85c). Many managers are now more reluctant to assimilate ASUPs than they were 20 years ago (Emm85).

Providing Computing Services to Enterprises: The ASUP Program

The successful integration of computing technology into an enterprise requires both sufficient technical support in the form of an infrastructure which can provide reliable hardware, software, and service and an environment which is amenable to computerization. One of the theses of this paper is that, while the

Table 1
Growth in the Number of ASUs in the 1966-85 Period

	ASUP	ASOI	ASUt	OASU	ASUTP	Total
Total	1,674	513	1,485	339	4,651	8,662
1966-70	151	13	61	19	170	414
1971	96	7	48	11	36	198
1972	96	8	48	12	36	200
1973	161	17	110	22	115	425
1974	229	30	162	21	195	637
1975	256	46	263	102	182	849
1976	60	28	69	8	130	295
1977	93	13	78	24	200	408
1978	65	26	83	20	265	459
1979	79	25	86	9	316	515
1980	92	41	138	31	395	697
1981	59	32	46	6	320	463
1982	49	45	59	2	376	531
1983	57	29	62	6	527	681
1984	45	77	53	15	605	795
1985	86	76	119	31	783	1,095
Average Percentage	19	6	17	4	54	100
Averages for:						
1965-70	36	3	15	5	41	100
1971-75	36	5	28	7	24	100
1976-80	16	6	19	4	55	100
1981-85	8	7	10	2	73	100

Sources: (Mche85; Nark85b)

Notes: ASUTP for 1971-75 slightly revised to reflect TsSU revisions. 1971 and 1972 are averages based on number of systems created in 1971-72. ASUt is ASU of a territorial organization. ASOI is an Automatic Data Processing System. ASUt, ASOI, and ASUP comprise the ASUP category discussed in this paper.

deficiences of the infrastructure played a significant role in hindering the effective diffusion of management information technologies, the role of the surrounding social-economic milieu was more decisive. The following sections give an overview of the role of the infrastructure and examine four major areas of application of ASUP. These sections show that despite continued improvement in available computers, the incentives to incorporate ASUP have remained ambiguous.

The Role of the Computing Infrastructure

In the early stages of the ASUP program, Soviet industry provided second-generation transistor computers without direct access storage devices. Over the past 15 years the Soviets have chosen functional duplication of foreign computer models in order to follow a low risk technology development plan and use Western software (Davi78; Hamm84). A network of institutes under the USSR All-Union Ministry of Instrument Building, Means of Automation, and Control Systems (Minpribor) is tasked with writing ASUP software in conjunction with institutes from other branches. When available, hardware maintenance services have been provided by national organizations run by the computer producers, by local organizations, or by in-house groups. Software maintenance is largely done in-house. The effects of problems with the infrastructure include:

- *A reduced scope of applications* that could be implemented *and longer development times* because of slow, unreliable hardware, small main memory sizes, small disk sizes, and absence of peripherals. Some of these constraints have been relaxed as Soviet industry has continued to produce new models and upgrade old ones. At present, large disk drives, terminals, data communications peripherals, and the largest mainframe models are still in short supply (Bukh86; Chum84b; Emm85; Skac86). N. Moiseyev, who is Deputy Director of the Academy of Sciences Computer Center and a full member of the Academy's Department of Information, Computer Technology, and Automation, recently discussed this problem. He noted that:

  > There is another problem about which I cannot fail to speak. Neither the variety nor the number of computers produced satisfy today's requirements. During this five year plan their output is supposed to increase 2-2.3 fold. But we should note for comparison that in certain countries that kind of growth in the production of personal computers was achieved during the 80s in just one year (In the US, for example, a million computers in this class were produced back in 1980). No one can fail to be uneasy about the acute shortage of terminals, especially color displays and plotters. This reduces the capabilities of the computers to a fraction. Because of the insufficient assortment of computer hardware produced there are typical situations today in which an institution could solve economic problems if it had a computer worth 10,000-15,000 rubles, but it must use a computer in the ES series and pay tens of thousands of rubles per year for computer time. In such cases can there be any question of computers showing a return? This gives rise to a paradoxical situation—although there is an acute shortage of computers, the present stock of computers is being used at a level of less than 50 percent (Nemo86, p. 2).

  Only this year have the Soviets started to cross the threshold into larger capacity sealed disk drives.

- The *inability to totally rely on the computer* because of hardware failures and difficulty of obtaining service. The mainframe models that are in widest use still break down about once a week (Seme84). It has been estimated that to bring about the massive introduction of microcomputers throughout the economy, models that are at least two orders of magnitude or 10-20 times more reliable[2] than these mainframes will have to be created (Grom85; Mikh86d). There are no signs that the newest ES models are any more reliable. N. Moiseyev again explains:

  > Why is the problem of quality such an acute one? Well because serious complaints have been presented to computer manufacturers, they have immediately passed them on to their plants which are the manufacturers of the various components, and they in turn pass the buck to suppliers from another ministry, and so on. There seem to be many at fault and no one to call to account. The experience of the largest foreign firms which manufacture computers shows that the quality of the individual components must be checked out not by the plants producing them, but by enterprises which stand at the end of the chain of computer manufacturing. They bear full responsibility for the finished product (Nemo86, p. 2). One of the major goals of the newly created State Committee on Computers and Informatics (GKVTI) is to improve the provision of hardware and software maintenance services (Deni86b). In 1985, it was said that the Ministry of the Radio Industry provided service on

[2] The Soviets have published very little data about the reliability of any computers. In 1984, data were reported for five mainframe models (M-4030, ES-1022, ES-1033, ES-1040, ES-1055) used between 1977 and 1983 by Minenergo. The mean time between failures for these computers ranged from 53.3 hours (ES-1022, 1977) to 1,030.2 hours (ES-1040, 1983), with a mean of about 200 hours. More information about the reliability of machines used in ASUP can be found in [Mche85, pp. 239-245].

less than 40 percent of the computers it produced. Minpribor provided it on less than 12 percent, and the Ministry of the Electronics Industry offered no such service whatever (Eg85d).

- *Increased costs* due to the necessity to maintain hardware and software locally, and to fill in the gaps left by the infrastructure.

- The *difficulty of obtaining new machines* and help in migrating from old ones, leading to a tendency to hang onto the old system longer than necessary.

- The *inability to procure packaged software*, leading to increased local development of relatively poorly tested and documented programs.

- *Poor relations with software providers*, leading to incorrect specifications and the delivery of unusable products.

- *Poor user training and difficult-to-use systems* which alienate users. It is hoped that the new State Committee on Computer Technology and Informatics (GKVTI) will be able to signficantly improve the infrastructure performance. The GKVTI is supposed to establish a new nationwide chain of service organizations which may considerably shore up this part of the infrastracture (Deni86b).

The shortcomings of the infrastructure continue to constrain ASUP to a certain extent. There are undoubtedly some managers who are unwilling to risk having an ASUP primarily because of worries about the computer industry's ability to deliver workable systems. But over the past few years, users have ceased citing hardware and software problems as their primary concerns. As a recent participant in an important roundtable discussion of ASU remarked, sufficient hardware is available; now the problem is to overcome the residual attitudes or so-called psychological barriers (Emm85). These attitudes are the result of the way that the economic system structures enterprise incentives.

Integrating ASUP's into the Soviet Management Milieu

Four of the most widely implemented functions in ASUP, using the Soviet names and acronyms, are material technical supply (MTS), operational management of basic production (OUOP), accounting, and planning. Together they account for almost all of the basic operations in the production cycle: constructing initial and corrected five-year and yearly plan estimates, estimating needs for supplies and keeping track of inventories, scheduling and tracking production, and accounting for all the activities of the enterprise. Each of these ASUP functions has met with a particular set of environmental problems which has limited its usefulness.

Material Technical Supply. The chief characteristic of the supply system in the USSR for producer goods is the pervasiveness of shortages brought about by taut plans and weak enterprise budget constraints. Shortages lead to a climate of uncertainty, changes in output mixes, poorer quality goods, the use of expediters to obtain goods, and a host of other practices that generally fall outside the bounds of legitimate managerial activities.

Applications of computing to supply problems can be divided into those concerned with formulating the yearly supply plan and those dealing with maintenance of inventories. Traditionally, the enterprise has had direct control only over the requirements statement drawn up by its purchasing department (Ber176). Negotiations with the ministry for sufficient supplies to ensure that plan targets can be met are therefore of great importance (Linz86).

On the one hand, calculating supply needs would seem to be an ideal ASUP application. In enterprises without significant data processing capabilities, the MTS department can be overburdened with information leading to errors, delays, and the inability to carry out calculations for optimization, more than one scenario, and daily or short-horizon use. Requirements must be defined well in advance because of the tremendous calculations involved (Soko80b). Recent evidence indicates that technical oversight of enterprises at the ministry level is becoming more sophisticated, so that only through well-supported calculations can an enterprise succeed in negotiating higher allocations (Linz86). Because of the symbolic legitimacy attached to computer output and the convenience of doing multiple calculations during the planning process, the incentives to use this part of the ASUP would seem to be large.

On the other hand, the standard methodology of formulating supply requests in ASUP, which uses lists of goods which comprise every product to produce total estimates of supply needs, presents definite problems for the enterprise. First, most enterprises do not receive their portfolios of orders until about a month before the next year. However, they must submit requests for metals 125 days in advance and requests for all other materials 45 days before the beginning of the year (Stos86). Enterprises must therefore use estimates of what they think the final plan will be, which undoubtedly throws off the computer calculations of needed parts, subassemblies, and raw materials.

Second, enterprise directors would like to pad the requests in order to include a safety factor. In a computerized environment, this could entail systematically falsifying data, e.g. for how much material is required to produce a certain good, or altering selected computer outputs (Buni85). The former solution would result in inconsistent data in various parts of the data base or in the propagation of errors to other calculations. The latter solution might be easy to detect. Currently, enterprises that are caught falsifying data can sometimes use "calculating errors" as an excuse; presumably this would be more difficult to pull off in a computerized environment (Linz86).

Planning from the achieved level, which is still the principle planning technique, may render computer calculations irrelevant or unnecessary. Here the ministry faces a dilemma because if it does ascribe greater legitimacy to computerized requests, enterprises would be given an effective license to pad. In the case of Barnaul Radio Factory, which has one of the most widely publicized ASUPs, the ministry continued to cut allocation requests even when accurate computer reports were supplied (Podk79). In other cases, the ministry insisted on plans that were proven by computer to be unfulfillable. Soviet enterprises reportedly have a good deal of success in hiding their true production capacities (Rume86).

Once the yearly plan has been defined, the computer can be used for inventory maintenance tasks. In the West, a major goal of manufacturing resources planning (MRP-II) systems is to combine information about demand, goods on hand, and production capacity to minimize inventory carrying costs while ensuring smooth production processes. Such applications require accurate databases. Many of the reports which are produced by the MTS subsystem in ASUP concern current stock levels, but even here there are often substantial discrepancies between the database and actual stock (Emm85b).

More importantly, MRP-II assumes an environment in which orders can be placed at will in order to respond to changing conditions. Soviet inventory levels are "basically defined by the lot size of the delivery, which depends on the producer and the transportation system" (Soko80b, 230). At the L'vov TV Plant, which has one of the premier ASUPs in the Soviet Union, a computerized production monitoring system was set up which was designed for supply precision calculated in minutes. However, supplies would be planned with a precision of three to four months. Consequently, work time losses, which were supposed to be significantly reduced by the ASUP, barely changed (Glus81). In any case, norms for enterprise stocks of production goods are established by directive from above rather than being determined on the basis of many dynamic factors (Golo80c, Soko80b). Managers have a greater desire to fulfill basic plan targets than to meet targets for reducing inventories. The lack of enterprise autonomy excludes the most sophisticated inventory planning and maintenance techniques.

Some Soviets hoped that the computer could be used to overcome some of the difficulties with the supply system. S. Golobokov, for example, hoped that including transportation costs in calculations for optimal delivery sizes, formulating a computer-generated graph that could nail down an hourly delivery schedule, and keeping track of suppliers' shipments would provide a means of forcing suppliers to be more responsive to producers' needs (Golo80c). In 1983, Golobokov wrote a scathing assessment of the supply situation in metallurgy, reaching the conclusion that "under (current supply) conditions, electronic computers will not help at all" (Golo83). Both the suppliers and the railroad, who could fulfill their plans without regard to the final result, were at fault for wide variations in regularity of supplies. Golobokov concludes:

> The slow renovation of organizational fundamentals of administration of the enterprise provides rich soil for the development of false methods of solving problems. Certain managers still place great hopes in the utilization of electronic computers for strengthening of economic ties. This is partially explained by the considerable number of technical specialists who are engaged in economic and administrative problems. These ideas are quite common among specialists of information and computer centers in nonferrous metallurgy. But the solution to organizational and economic problems cannot be reached by technical and economic-mathematical methods alone (Golo83).

Despite various changes in economic incentives, fundamental disruptions in supplies are likely to continue as long as the plan is taut and supplies are planned centrally (Berl76; Dyke85b; Schr82). The 12th Five-Year Plan is one of the most taut in recent history. Starting with the "Kosygin" reforms in 1965, attempts have periodically been made to introduce direct supplier-consumer contract relationships in order to short-circuit the supply bottlenecks. However, these contracts have always been planned in some fashion from above (Berl76; Ryav75; Sohr71). The provisions of the contracts are supposed to be enforced by state arbitration, but enterprises are unwilling to risk their relationships with their suppliers by taking them to court (Prav84h).

In the early 1980s the trend in supply was toward more centralized control of goods by Gosplan, Gossnab, and specially designated organizations (fundholders) in goal-directed programs (Sohr82). Phil Hanson has reported that the wholesale trade system is to be expanded, not through free trade, but through greater control of Gossnab (Hans86g). It is possible, of course, that some direct ties will be permitted free of interference, and there is some evidence that steps in this direction are being taken (Moze86; Moze86b). But even the proponents of these steps admit that central control cannot be dismantled entirely and that an "optimal" center-periphery relationship must be found (Moze86b). A more intriguing possibility, which requires further research, is that the computers used in Gossnab will permit more efficient supply allocations and redistributions (for example, Stos86).

Production Management. Many Soviet authors consider production management in general, and the operational (or short-term) management of basic-production (OUOP) subsystem in particular, to be of greatest importance in ASUP (Siny83b; Soko80b). A survey of a number of Soviet enterprises showed that about 40 percent of production losses were due to lack of synchronization of production and poor coordination and incomplete organization of supply. The OUOP subsystem is said to be able to reduce production losses by 50-60 percent (Mami81b). Experts surveyed in 1983 used results from a survey of 103 enterprises as a starting point. They concluded that savings such as a 7.35-percent reduction in waste and reductions of 3, 7 and 4 percent for equipment, shop, and enterprise outlays, respectively, are possible (Krue83). The evidence that such gains have been realized, however, is inconclusive. Most of it is based on formal calculations of "economic effectiveness" which are at best problematical, and at worst, deliberate distortions (Mche85).

Unlike Western production management systems—which integrate functions spanning order entry, inventory management, accounting, purchasing, and shipping—Soviet operational management systems have been concerned for the most part with only two of these functions, planning and accounting. ASUPs in the 1970s were often delivered with a number of discrete subsystems, each of which contained a relatively small number of applications. A great deal of the old work scheduling system remained intact, precluding the use of capacity planning and optimization techniques (Mche85).

The planning tasks which were considered typical for operational management in the early 1980s included taking production targets and translating them into specific targets for subassemblies and parts, and creating calendar plans for production, assembly, release, and acceptance of parts and assemblies (Kruc83). Optimization was still excluded because capacity planning and inventory modules were not integrated. Only within the last two years have descriptions of multi-level, multi-machine, on-line management information systems appeared in the Soviet press (see page 33). It is only when sufficient terminals are located on the shop floor that sufficient data can be collected to make detailed planning models possible. Thus, it appears that Soviet operational management systems have not reached the level of sophistication of the Western MRP systems that have been adopted in many corporations since the late 1970s (Hoar81).

Generally, one of the major advantages of MRP-II is considered to be the ability to quickly recalculate plans based on changing conditions. Soviet enterprises have some ability to negotiate changed monthly targets, but yearly targets are rather firm (Linz86). If supplies are late, a recalculated plan may be of no value because it does not match up with the (unchanged) official plan. Optimal operational plans calculated in the oil industry, for instance, bore no relationship to the official targets set from above, so that in practice workers followed the plans handed down from above in order to obtain bonuses (Bere82).

Planning calculations are based on a huge number of norms which are in the database. In addition to the fact that the norms may be set externally, and thus reflect branch-wide standards or levels of performance which are unobtainable in practice (Podv84; Rut184), it is doubtful that norms are changed to reflect temporary environmental changes. For example, a foreman may choose to use less metal in a good than the norm calls for in order to produce more and fulfill the output plan. Unless the norms are changed, the computer can only schedule the production of the lower number of goods. In almost all ASUPs, the vast majority of processing is not interactive, so that foremen would have no ability to make such a change without clearing it through the bureaucracy. There is no evidence to suggest that ASUPs have any ability to take into account other frequent "shocks" to the production process such as brown-outs; absenteeism, alcoholism, and shirking; and equipment breakdowns and the poor quality of maintenance services (Schr85; Trem82).

The second major function of the operational management subsystem is to collect accounting information. The accounting data that are collected are geared to show the movement of goods throughout the production process, the amount of unfinished production, and the degree of plan fulfillment (Kruc83). The more data available on-line for cross-correlation, the harder it becomes for a manager to hide quasi-legal or illegal practices. For example, managers must pay workers even if there is no work to do because of supply shortages (Feof85). However, an integrated MRP system could easily leave an audit trail showing that undeserved wages were paid. This may explain why most of the reports which are generated are straightforward listings of basic quantities rather than analytical comparisons. These reports duplicate the output of the previous manual systems and therefore do not pose a great threat.

The relative absence of direct collection sensing devices, which could be viewed as a function of the failure of the instrument building industry, should also be viewed as the result of lack of demand. Both upper and lower level management have an incentive to "cook the books" if necessary in order to show plan fulfillment. The magnitude of this "simulation" is not often large, but it can be critical, for instance, when it is necessary to borrow output from next month to cover shortfalls this month (Linz86). Data collected directly from the shop floor will reveal the true state of affairs in the enterprise to any and all auditors.

Accounting. Accounting is one of the most widely implemented functions of the ASUP. In the 1970s, 40-50 percent of the calculations in ASUP were devoted to it (Mche85). The latest evidence is based on a 1984 survey of enterprises with ASUPs in Lithuania. More than 70 percent of the tasks were considered to be of the "regulation" type, which may be construed as accounting (Birb86).

Enterprises can realize two important benefits from computerizing accounting operations. The first is eliminating hordes of clerks operating abacuses and primitive data tabulation machinery. The second is a streamlining of the entire accounting operation, including the ability to put together timely new reports which improve managerial decision making. In the 1970s, neither of these goals were fully realized. Although some enterprises reported labor savings due to ASUP, others reported that procedures became more complicated and labor-consuming because of partial automation (for example, see Balt79).

The traditional accounting system in enterprises consists of three parts. Statistical accounting is geared towards reporting plan fulfillment data in accordance with requirements of the Central Statistical Administration (TsSU), the State Planning Committee (Gosplan), and the ministries. Bookkeeping accounting, or simply, bookkeeping, is oriented towards the needs of financial organs such as the USSR Ministry of Finance (Minfin). Both of these types of accounting fall under the control of the planning and economic departments and the main bookkeeping office. Operational accounting, such as the operations included in the production management and inventory subsystems, arose because neither statistical accounting nor bookkeeping could meet the expanding need for operational data that has been generated over the past two decades by growing enterprise autonomy, the increasing complexity of production, and the centralization of bookkeeping functions.

Although there was a debate about redesigning the entire accounting system to accommodate computing, and some enterprises did reorganize document flows (Gune77), the traditional accounting system remained intact. Despite the presence of the computer, statistical and bookkeeping accounting continued to produce the reports required by superiors while operational accounting was built into other functional subsystems. Analytical tasks, which might have integrated and reconciled these data, fell through the cracks.

Since the late 1970s, there have been several initiatives to improve the bookkeeping subsystem in ASUP and, more generally, the accounting services available to enterprises. The All Union State Design Engineering Institute (VGPTI) of the Central Statistical Administration has been assigned the development of designs and software packages for enterprise accounting. The automation of accounting received a major push from a resolution of the USSR Council of Ministers "On measures for improving the organization of bookkeeping accounting and raising its role in the rational and economic use of material, labor and financial resources (Jan. 24, 1980)." The resolution turned over the task of organizing programs to create a standard bookkeeping subsystem for enterprises to the State Committee on Science and Technology (GKNT), working with TsSU, Minfin, and other organizations. This expanded program included the creation of a special guidelines document specifically for accounting (ORMM-*uchet*), due in the first quarter of 1983, and the completion of a number of software packages by the second quarter of 1985 (Polk83).

The ORMM-*uchet* guidelines, which were not approved until 1984, represent an attempt to impose orthodox accounting methods on enterprises from above. The fact that branch ministries and the TsSU are reportedly working on improving primary accounting forms in conjunction with the development of these designs and software will make them more palatable for enterprises (Polk84). In the past, the continued use of old forms negated many of the advantages of using the computer (Shen86). The new packages are supposed to include analytical tasks that encompass all of the economic activity of the enterprise. Interactive data entry and analysis are included for the first time (Mche85).

The impact of the new designs and software is likely to be limited for a number of reasons. First, enterprises may be unwilling to adopt it if it entails major reorganizations and modifications of existing software. Second, the ORMM-*uchet* guidelines appear to be directed at the centralized parts of the bookkeeping system only. Discrepancies between operational and other forms of data may persist if old methods of data collection are continued. The use of keypunching and data entry from paper tape is still widespread, leading to numerous errors (cf. Blan84).

Third, enterprises have a stake in maintaining some discrepancies in any case. A manual or partially automated system is more attractive because:

- Discrepancies are not discovered immediately, or are never discovered.
- Calculations can only be done once.
- It is virtually impossible to respond to queries for non-standard types of information due to the labor intensity of calculations.
- Inaccurate results can be blamed on the use of manual calculations.
- Bookkeepers have direct access to records. Accounting can be done by functional departments and thereby remain under their control.

Enterprises need to be able to conceal true production capacity, hoard stocks, pay overtime to workers during storming periods, etc. In earlier ASUPs, the fact that separate files were maintained for each subsystem allowed the enterprise to continue its practices relatively easily, while realizing gains based strictly on replacing labor. The ORMM-*uchet* programs would give enterprises far less control over their own accounting practices. The new analytical tasks in these software packages might easily reveal falsification. An ASUP which used direct collection devices to continuously monitor all important parameters and included easily-used analytical tasks to process all this data would leave an enterprise director naked before his critics. Previous attempts to impose reform on enterprise management through computerization have more or less failed (Mche86i).

Planning. Besides accounting, the most frequent application encountered in ASUP is planning. About 40 percent of ASUP calculations were devoted to it according to data of the 1970s. [In Lithuania in 1984, a survey of 15 enterprises showed an average of only 8.5 planning tasks per ASUP (Birb86).] Most of these fall under the category of technical economic planning, or the creation of yearly plan targets in accordance with the figures handed down by the ministry. Savings from computerizing planning can come directly from replacing current procedures with automated ones and from using optimization.

In large Soviet enterprises, a tremendous amount of effort goes into creating yearly plans. For example, at the Moscow Electro-Mechanical Factory imeni Vladimir Il'ich, more than 8,000 documents in the yearly plan include about 400,000 lines and 4,000,000 data items (Gord78). It can take six months of effort by the enterprise planning-economic department to develop the plan. Added to inevitable inaccuracies due to the long lead times involved, the not infrequent changes in plans by the ministry rapidly cause the plan to become unbalanced (Dyke85b). Its recalculation takes 3-4 months, which means that complete recalculations are more or less out of the question using manual methods.

Thus, the savings from computerizing planning come from: replacing manual labor, repeated use of constant data, ability to check consistency and calculate several options, and the ability to recalculate the plan in response to changing conditions. It is undoubtedly becoming harder and harder for Soviet enterprises to continue calculating the plan manually, if only because of the shortage of labor which will grow more acute during the next two decades. An important criticism leveled against the new normative net production indicator (which is replacing profits as a prime indicator of enterprise performance) is that it is much more difficult to calculate than previous indicators were. If the enterprise plan remains in its present form, some means of automating its calculation will become indispensable to most large Soviet enterprises.

Optimal planning has been one of the key concepts behind the widespread introduction of computers. Isolated reports in the press suggest that some enterprises have been able to reap large benefits from its use. The Barnaul Radio Factory was able to increase production by 7 percent based on optimal planning (Bobk78; Emm85b). According to the head of the Central Economics and Mathematics Institute, N. Fedorenko, optimization models reduce unit costs 5-7 percent, capital expenditures 8-10 percent, and operating expenses 6 percent (Fedo85).

Nevertheless, the percentage of optimization applications being solved in ASUP has remained quite low. Part of the problem is that optimization models have been developed in isolation from the other tasks, which meant that data had to be re-entered for their use (Fedo85; Mikh83b; Solo79). But the main problems are environmental. If an enterprise runs an optimization model which is unconstrained by directive targets from above, it is likely to come up with a plan for which supplies will be unavailable. Enterprises have little incentive to produce close to maximum capacity (Fedo85). The central planning process cannot be accomplished without "planning from the achieved level" (Birm78), which is likely to render unconstrained optimization irrelevant in any case.

Once the plan targets have been handed down from above, enterprises have a greater incentive to use optimization. However, targets are numerous. Very few models use more than one optimality criterion, and a feasible solution may not exist (Emm85c). In the oil industry, for example, the ministry had to divide its targets among its enterprises even though none of the enterprises could actually fulfill them (Bere82). Models do not reflect the realities of the Soviet system:

> The effectiveness of optimization calculations turned out to be significantly less than expected because designers have frequently underestimated the complexity of the economic mechanism in general, and the process of working out the plan, in particular. Putting together the plan is a creative act, in which an important role is played by difficult-to-formalize information; the mechanism of combining the requirements of optimality and reliablity (safety) is not very clear; the practice of planning sharply differs from the official instructions, and one may therefore talk about two planning mechanisms — the real and the normative. In ASU everything is built according to the latter, and the results turn out to be inapplicable in practice (Emm85, 551).

Out of 22 models created for the construction industry only two had found practical use a decade later (Golu81.) Many construction organizations wound up rejecting the use of models after finding them inadequate (Mche85).

What happened to attempts to reduce metal content in pipes illustrates how economic realities interfere with optimization. The economic indicators of the enterprises worsened, Gosplan did not consider the plan to be acceptable, and even the consumers were not interested because the optimal plan did not reflect the necessary assortment mix. "In summary, it (turned) out that reducing the metal content (was) profitable only for the branch institute which proposed the methodology and (dragged) the planners and producers into a worthless affair which they (didn't) need" (Emm85b, 752-753).

As optimization models become more flexible and permit suboptimal solutions which are consistent with Soviet conditions, enterprise managers will be more willing to use them. At the Ministry of the Fish Industry, higher officials permit trawler captains to choose plans which are a 3-4 percent improvement over traditional means, but another 7-8 percent worse than the optimal. "When the economic mechanism is improved, and the enterprise and the higher-up organization turn out to be interested in making decisions which are closer to the absolutely optimal, we will be ready for those changes, inasmuch as the technology of forming trip assignments already contains the corresponding optimization task" (Emm85b, 749). The models that have had the most success have given enterprise directors the ability to mimimize deviations from the plan. The involvement of high level managers is paramount for success (Emm85b).

Providing Computer Services to Enterprises: Other Options

The statistics on the number of ASUPs make it clear that most enterprises are getting whatever calculating services they use elsewhere. The number of organizations which have independent bank balances and are in need of computing services for accounting and planning is almost 600,000 (Myas82f). Perhaps many actually have computers, but are not being counted in the official statistics on ASUP? Perhaps the magnitude of computer usage by Soviet enterprises is being grossly underestimated?

It seems clear that the answer to the first question is no. First, multiple uses of ASUPs are rarely reported, and when they are, authors are careful to explicitly indicate them. The creation of libraries of software has been given much attention, yet it is very difficult to put together a complete ASUP on the basis of the available software (Deni86b; Emm85c; Mche85). Second, ministries and design institutes would certainly have an incentive to put their accomplishments in the best light by counting each ASUP separately. Third, because of the very high cost of most Unified System machines, it is almost certain that enterprises who acquired them would be compelled to develop an ASUP or at least say they had. Less expensive SM minicomputers have been directed mainly towards the engineering community until the last few years and have not shown up as the main computers for enterprise ASUP. Fourth, the official statistics are probably counting some ASUPs that are barely functioning in any case.

Thus, these two questions can be boiled down to one, which is: how are most Soviet enterprises getting their calculations done? The present state of the computing services industry is a result of the somewhat chaotic thirty-year history of the introduction of computing equipment in the USSR. Over the past 30 years the bureacracy has been striving to achieve the goal of mechanization of bookkeeping and other enterprise calculating operations.

The success of this drive has not been complete, however. As of 1986, for example, labor and wage calculations were mechanized at only 73 percent of enterprises. Only 22 percent have "integrated mechanization," meaning that all operations from data collection to final printing involved some form of mechanization with results from one stage directly usable at the next (Budy86; Isak80). In the largest republic, the RSFSR, one quarter of the data processed by the TsSU is done on the "bookkeeping" class of machines, which consists mainly of adding machines or adding machines with text printing capabilities (Guzh86). In Georgia, only 10 percent of accounting and reporting information is produced using mechanization (Basa86), and the degree of mechanization in the Turkmen and Armenian republics is also low (Budy86).

The following sections examine in greater detail the services which are being offered for users that do not have ASUPs. They discuss the overall automation of the TsSU system, which is a major supplier of computing services; the evolution of the small bookkeeping machines into microcomputers; the regional level of the TsSU system, where punch card tabulators are still in use; the growth of the State Network of Computer Centers; other options for obtaining computing services; and finally, the challenge of integrating microcomputers into the overall data processing strategy.

The sections show that the computing infrastructure, when faced with the task of providing equipment to a much larger number of organizations than were implementing ASUPs, did not perform as well as it did in producing large mainframes. The problems caused by the surrounding milieu are not as visible because in many cases Soviet managers have yet to confront them.

Overall Automation of the TsSU System

Although one might expect that by the middle of the 1980s, the chief data processing organization in the most centrally controlled economy in the world would have totally replaced the use of punch cards, table top adding machines, and other obsolete devices with computers, this is not the case. By 1980, only 60 percent of the total work carried out by the TsSU was performed on computers (table 2).[3] Almost all of this work was concentrated in a few large centers: in Moscow, in regional capitals, and in oblast' capitals. Regional and city computation organizations carried out almost 40 percent of the TsSU work without using computers at all.

Table 2 shows the rate distribution of TsSUs in total work and work using computers in the late 1970s. The data imply that about 2.6 percent of the work was transferred to computers per year. Data for the RSFSR, which must represent a substantial fraction of the total work, show that the same rate of computerization took place in the 1981-86 period (Guzh86). The percentage of calculations carried out on computers in 1980 in the RSFSR TsSU system was 41

[3] In this paper the term computer refers to electronic, digital, stored program computers. The Soviets call other forms of calculating devices computers, for example, as in a "punch card computer" which is a tabulator, sorter, and so forth.

Table 2
Hierarchical Work Distribution and Work Using a Computer, TsSU

Level	Total Work (%)		Work With Computer (%)	
	1977	1980	1977	1980
All Computer Centers	52.0	60.2	100.0	100.0
Union Level, TsSU	3.1	3.6	6.8	6.9
Republic Level, TsSU	7.2	8.3	19.4	17.2
Autononous Republic, Kray, Oblast' Level	24.5	28.4	51.5	53.0
Regional and City Information Computer Centers	17.2	19.9	22.0	22.9
Machine Calculating Stations of Autonomous Republic, Kray, Oblast'	0.2	0.2	0.0	0.0
Regional and City Information Computing Stations and Machine Calculating Stations	47.8	39.6	0.0	0.0

Source: (Gorb81c)

percent, rising to 57 percent in 1986. The rate of introduction of Complexes of Economic Data Processing (KEOI), which are part of the Automated System of State Statistics (ASGS) and which automate the processing of a particular important indicator, also shows a slow, gradual increase over the last decade (Bush83b; Gorb81c; Koro86b; Maty86). If this gradual rate of introduction continues, it will take roughly until the year 2000 to totally re-equip the TsSU system with computers. This goal of total elimination of the obsolete equipment has been articulated, but without a completion date. A more modest goal has been selected for the 1986-90 period: eliminating punch card and paper tape entry data technology (Arzh86).

The way that any particular enterprise gets computing services depends on its size and its departmental affiliation. A 1984 textbook on mechanization of accounting describes three basic types of computing organizations. The Machine-Calculating Bureau (MCB) usually has the so-called "keyboard" machines [4] and carries out simple work for calculations, arranging primary accounting data and putting together single-and multiple-column tables and monetary-related documents. MSBs handle less than 200,000 document-lines per month. The next class consists of Machine-Calculating Stations (MSS) and Information Computing Stations (IVS). These organizations have at least two tabulator sets and a full complement of keyboard machines. (Machine-Calculating Stations probably become Information Computing Stations as their equipment is upgraded.) They carry out full accounting operations and process 200,000 to 2 million document-lines per month. Information Computer Center (IVTs) are equipped with one or more universal computers and other equipment, including punchcard and keyboard machines. They handle more than 2 million document-lines per month (Oshe84).

Each of these organizations may be created for one enterprise, may belong to a branch and service only enterprises in that branch, or may belong to the TsSU. Enterprises and affiliated organizations which do not have separate financial status from their parent organizations must use centralized bookkeeping services (Marg79). For medical, educational, and agricultural organizations, these services are provided by the Central Statistical Administration itself. Table 3 presents partial information on the distribution of computing centers in the TsSU system. There were almost 10,000 computation centers as a whole in 1978 in the USSR, so the TsSU system comprises about 30 percent of the total (Dubr83). By 1984 there were about 4,000 computation centers throughout the USSR equipped with computers (Mikh84). Even with consolidation and upgrading, there still must be a rather sizeable number of calculation centers that still use punch card and "bookkeeping" technologies.

[4] A "keyboard" machine ranges from a desktop calculator to a small microprocessor-based computer. These devices are examined in detail below. The Soviet word for computing also carries over into the term "computer center", although there may be no computer present. In this work the term computer center means that computers are present. Computational center is the used as the more generic term. The Soviets also sometimes use the word network to mean a system, where no network is actually implied. Here the word system will be used as appropriate.

Table 3
Number of Computing Establishments in the TsSU System

Type of Center	Year 1977	1979	1981	1982
Total Computing Establishments	2,966	2,911	2,867	2,868
Total Computer Centers	410	502	510	
Computer Centers (union, republic, oblast')	167			176
Computer Centers (regions, cities)	243			
Total Computing Stations	2,556	2,409	2,352	
Machine Calculating Stations (regions, cities)	596			–
Information Computing Stations (regions, cities)	1,960			

Sources: (Gorb79; Gorb81c; Maty79; Tg82)

The TsSU provides computer services for about 91,000 organizations. In 1982, only 13 percent of the information coming from these organizations was actually processed using a computer (Bush83b). By 1982, the TsSU had introduced integrated mechanization of accounting at 3,184 agricultural enterprises, 676 central bookkeeping establishments, and 829 enterprises of "user cooperation" (Bush83b). Integrated mechanization of accounting has been introduced at about 400 agricultural organizations per year over the last decade (Bush83b; Gorb81c). Central bookkeeping establishments usually handle the bookkeeping chores for as many as seven or eight organizations in the same field, such as child care centers.

The extent to which the central bookkeeping organizations (TsB) rely directly on the TsSU is illustrated by data from the Poltava region. There are about 600 TsBs serving 5,739 budget organizations and 54 TsBs for 483 self-financed enterprises and organizations in the region. Only 143 TsBs are considered large enough to be amenable to mechanization. Of these, 131 use the services of the regional TsSU (Bukh86). These data provide one measure of the extent to which organizations in the economy have access to computing services.

Despite the drive to bring computers into the TsSU system, a rather substantial number of the organizations it serves still receive services that are based on older technologies. The next section examines one of these, the small "bookkeeping" computers, and the following section examines the replacement of punch card devices.

The Evolution of Bookkeeping Computers

Over the past two decades, the Soviets have produced or imported over 50 types of electromechanical and electronic devices which have been specifically geared towards bookkeeping and statistical operations. These machines are usually divided into three classes. "Keyboard" machines include desk-top adding machines and "factographic" machines, which do some mathematical operations and also allow printing of text. "Punch card" machines are tabulators, sorters, and so forth that do data processing with large sets of punched cards. Electronic digital computers range from large mainframes to microcomputers. A review of the most widely used machines shows the very limited capabilities for data processing which have been present in the Soviet Union over the last decade.

According to a 1984 textbook on data processing, various types of adding machines are finding greater and greater application for processing accounting and planning information by workers right at their workplaces. They are also used for checking the results of other forms of processing involving punch cards and computers. The machines include a number of the Askota series, imported from the GDR, and the Iskra-108 which is an adding machine with a paper tape (Aver79; Oshe84). In addition to these adding machines the Soviets have a number of calculators, both of the table top size and microcalculators. One gets the impression that unlike in the United States, where hand-held calculators have replaced just about all other forms, the Soviets are still using a much greater variety of equipment.

The next class of machine is the keyboard computer, which can be broken down into two subclasses. These are machines which have been specifically designed for a limited range of bookkeeping operations. (We do not think that they have counterparts in the West.) Bookkeeping machines can perform addition and subtraction and have full typewriter keyboards for inserting text. The East German Askota-170 series is considered to be one of the best examples of this machine class. It has up to 55 registers for holding intermediate calculations and can be connected to devices to perform multiplication and to punch paper tapes. Bookkeeping machines are used in small enterprises for putting together multi-column reports and for general data processing operations. They may also be used, when there is an ASU, as devices for local data collection and punching of paper tapes which are sent to the computer center (Oshe84).

Electromechanical "factographic" machines print text and carry out calculations, so they can be used to formulate specific reports. The report format is programmed, the data are typed in, and then the report is automatically produced. Each electromechanical model produces only one type of report. These machines are being widely replaced by electronic factographic machines (Oshe84). The Zoemtron 380 series has been one of the most widely used in the USSR, with thousands of machines imported yearly; it has been one of the main machines used at MSBs (Bobr71; Mikh81b; Yaro81b). The Zoemtron 385 prints at a speed of 14 characters per second and takes from four to 500 milliseconds for the basic mathematical operations. It has 100 slots for program commands; each slot corresponds to a space on the typewriter carriage (Tikh77). Even though the Zoemtron can be programmed, the types of programs that can be written revolve around doing mathematical operations in columns. Thousands of these machines have been exported by the GDR to the USSR, and replacements for them were just beginning to be produced in the early 1980s (Mikh81b). In addition to the Zoemtron machines, the Iskra 23 series is also widely used. Production of this machine, which included 512 ferrite core bytes of memory and had no ability for error checking ceased only in 1982 (Term83). Production of yet another electronic factographic machine (the EFM-1-6446) began in 1982 (Term83).

The most powerful of the keyboard machines are now reaching the capabilities of general purpose microcomputers. However, they are still highly oriented towards bookkeeping operations and represent an evolutionary process of design. The first models of the Iskra series appeared in the early 1970s (Yaro81b). The Iskra 525, for example, was intended for stand-alone data processing in small organizations. Unlike the Zoemtron series, it could accept input from magnetic tape, had an 8 KByte read-only memory, and could accomodate up to 99 columns in the output document (Alek76; Oshe84). The Iskra 534 entered series production in 1978 (Btsw83j). This machine had a ferrite core main memory of at most 8,912 bits (in practice this may have been only 1 Kbit) (Yaro81b). It had 253 registers, could handle 31-column tables, and had a magnetic card memory on which programs could be stored (Kach78; Koro83; Oshe84). The Iskra 534 was the first to use a "language for bookkeeping machines" (YaMB), which is a combination of assembly language-like operators for manipulating registers and higher level commands for control such as loops (Yaro81b; Zavo84). While it may be completely general for producing bookkeeping documents, it would be extremely difficult to use as a general programming language.

On the heels of the Iskra 534 came the Iskra 554, the Iskra 555, the Iskra 2106, and the Neva 501. The first production runs of the Iskra 554 appeared in 1979 (Yaro81b). The Iskra 554 was the first machine of that class to use semiconductor memory. One configuration was intended primarily for replacing the Iskra

534, but others included a casette tape storage device. It performed about 1,000 operations per second (Yaro81b). Production of the Neva 501 and its stand-alone version, the Iskra 2106, began in 1981, although it was not until modernized versions started coming out in 1983 that the full main memory amounts became available. They are now in series production (Gold85). The Neva 501 and Iskra 2106 are both implemented using the K580 chip, which is a copy of the Intel 8080 chip (Stap85d). The Neva 501 can be connected to a floppy disk drive, while the Iskra 2106 is more like an intelligent terminal. Obtaining service for both these machines has apparently been quite difficult, as it can be done only at the plant in Ryazan' (Vest86h). The Neva-501 will not be sold without the user sending someone to be trained for maintenance at the factory (Term83).

The larger Iskra 555 uses the K589 series chip set (see Stap85d). It entered production in 1983 (Bbsw83j), and according to another author is now in mass production (Gold85). This machine can use both floppy and hard disk drives, and can run up to eight of the smaller machines in a local terminal configuration (Koga85b; Zavo84). Some Iskra 554 and 555 models can communicate with SM minicomputers, making it entirely possible to use them in hierarchical data processing systems (Koga85b). In 1986, it is intended to produce the Iskra 556 and Neva 502 "third-generation" electronic bookkeeping machines and terminals. Both the Iskra 555 and Neva 501 currently have small operating systems which are stored in read only memory; the new models will include more complete OS software (Koga85b). In 1986-1990, all regional centers of the TsSU are supposed to get at least two "modern microcomputers" (Vest86i).

In competition with these four machines is a new generation of bookkeeping and office machines from East Germany. The Robotron 1355 and 1711 were introduced in the early 1980s as replacements for the Askota and Zoemtron series (Krak82; Mikh81b). The Robotron 1720 and 1840 are more powerful, general purpose machines which still fall into the bookkeeping class. By 1981, at least 120 Robotron 1840s had already been imported (Mikh81b). The TsSU in particular chose the Robotron 1720 (along with the Iskra 2106) to replace the electromechnical machine stock (Bush83b). By 1985, 10,000 Robotron 1720 devices had already been exported to the USSR (Pole85). Three office computers, the A5110, A5120, and A5130, are also being exported. They apparently have some compatibility with the YaMB language.

Over the last few years, most of the attention of Western analysts who are following enterprise level computing has been focused on the assimilation of large, general purpose computers in ASUP (Cave83; Mehe85). ASUPs were built in many large, important enterprises, but the vast majority of enterprises did not have access to large mainframe computers. For the most part they were using bookkeeping machines. It is safe to say that, at least until 1980, almost all of these users had to make do with glorified calculators that could print multi-column reports, or carry out the operations by hand with adding machines or abacuses. In 1982, it could still be said that the Central Statistical Administration had "a large stock of small electromechanical and keyboard machines" (Bush83b, 42). Sometimes the data could be punched onto paper tape for later use, but in many instances accounting was being done in a fashion that made further use of the data extremely difficult. When it was necessary to compare data from a previous period, it all had to be re-entered (Pars86). The range of information available to enterprise managers was limited to those standard reports which could be produced on these kinds of machines by the data processing staff. When one considers the staggering number of indicators which go into the *tekhpromfinplan* alone, one appreciates the magnitude of the tasks faced by these departments.

The new generation of electronic bookkeeping machines have the potential, according to the staff of a Ministry of Construction computer center, to "radically alter the way accounting is done" (Yavs83, 3). Although the Iskra-534 came out near the beginning of the 1980s, it is only within the past three years that applications using all of these machines have started to appear (e.g. Baby86; Lady86; Levi86c; Koga85b; Mukh86; Seme86; Vlas85c; Vest86h; Vest86j; Yako86d). The TsSU has been working on standard designs for bookkeeping which will make use of the Iskra 555 and the Robotron A5110 (Baby86; Nefe86; Polk84).

One of the most important advantages of using microcomputers is the fact that the bookkeepers will finally have a machine with which they can interact directly (Daga84). A tremendous amount of time is spent on "primary accounting," or collecting and preparing data for other stages of processing. Even at enterprises with ASUPs, primary accounting is often performed manually or with the use of the low-capability factographic machines. The sad state of primary accounting has continued to be a great concern, being blamed in part for the numerous errors and exaggerations that often occur in enterprise data (Baby86; Doma86; Koro86b; Vest86d). Delays in collecting data on-site also lower the effectiveness of centralized bookkeeping, the next level of accounting using computers (Yego86).

Replacing Punch Card Computers

It is not an exaggeration to say that the foundation of calculations in the Soviet Union from the late-1950s to at least the mid-1970s consisted of punch card devices: tabulators, sorters, etc. The following account from the textile industry is probably typical:

> The application of these machines did not give a significant effect, since their operational capabilities did not make it possible to check for arithmetic mistakes and the balance between indicators; it only slightly speeded up the control calculation and reduced the labor-intensiveness of the process of entry. Errors in the associated reporting indicators were revealed in the old way—by hand, and it was not always possible to check all economic relationships. At the time of receiving reports many highly qualified specialists almost fully switched over to checking reporting indicators, in as much as the quality of the checking depended on qualified checkers. Much time was spent analyzing the results of the activity of the enterprise (Blok82).

In the late 1960s and early 1970s the TsSU moved in two directions to replace punch card machines. For the very largest computer centers—at the union, republic, and oblast levels—Minsk-22 and Minsk-32 computers were used along with Unified System (ES) computers. In the 11th FYP the process of replacing Minsk-32 computers with ES machines continued (Bush83b). The main computer center of the TsSU was slated to get an ES-1060 and an ES-1055, the republic level centers were to be equipped with ES-1045 and ES-1035 machines, while the oblast level centers were to get ES-1035, ES-1033, and ES-1022 machines. In the 12th FYP, every oblast level computer center is supposed to receive at least two more ES mainframes (Vest86i).

The hardware and software limitations of the ES machines have been discussed elsewhere (Davi78; Hamm84; Mche85). Some of these problems include too little main memory in the initial configurations, insufficient disk space, lack of terminals and other peripherals, low reliability, missed shipping dates for the newer and larger models, inability or unwillingness to use the computers in multiprogramming mode, and software which was not tailored to meet users' needs. These problems probably affected the Central Statistical Administration less than other users because in its KEOIs it had a standard way of processing certain indicators and because interactive processing was not all that important for crunching large volumes of statistics. However, the KEOIs are said to be inflexible and do not necessarily automate all parts of the data processing cycle (Doma86). It has proven economical to use M 5000 computers in separate phases (Ivan83k; Yaku81c).

The second direction was the development of the M 5000 as a replacement for punch card machines at the regional (rayon) level, a process which began in the mid-1970s (Lerm81). The M 5000 is a general purpose 16-bit minicomputer that has an operating system and translators for languages such as COBOL, RPG, and PL/I (Mits81). It has been said to be based on the DEC PDP-8. The M 5010 differs only in the addition of more peripherals, while the M 5100 has a faster processor (Litv81). Production of the M 5100 began in 1980 (Sov180), and installations of them continued at least until 1985 (Karu85).

The M 5000 was also intended for use in ASUPs of small and medium sized enterprises, but this does not seem to have taken place to any great extent (Grin73; Mche85; Novi80). In the 1976-80 period, the M 5000 series computers began to replace the punch card machines in the TsSU system (Bush82). In Lithuania, where the M 5000 is produced, it comprised 2.5 percent of the computer stock in 1976, and 26.3 percent in 1980, more than all other types of computers (Novi83). At least by 1980, essentially all of the regional and city computer centers of the TsSU were equipped with M 5000 computers (Belo80d; Table 3).

As already noted, the All-Union State Design and Engineering Institute (VGPTI) was assigned the development of standard designs and software packages for accounting subsystems in ASUP and for accounting at other organizations making use of the TsSU system. The TsSU launched a program in the late 1970s to develop packages for 10 sectors of the economy: industry, construction, agriculture, automobile transportation, centralized bookkeeping at budget organizations, trade and food supply, supply and sales, housing, daily services, and scientific-research and design-engineering organizations (Bart80; Dolg80; Grin73; Neme82b; Polk81; Voro83b; Yaku81c). The initial designs that were developed were based on the M 5000. By 1981, 150 agricultural organizations had installed an accounting system worked out by VGPTI [5] based on this computer (Polk81b).

Examples of successful regional use of the M 5000 show that the M 5000 accomplished the objectives set for it (Neme82b; see also, Pili86; Rabo86). It automated the processing of accounting and reporting data for numerous enterprises that could not have or were too small to have their own computers (Avde86; Neme82b). However, it is also true that in using the M 5000 series, a decision was made to continue the batch-oriented remote processing of data. Accounting data processing was automated, but not in a fashion that gave managers access to anything but predetermined reports (Mali86). It was still necessary to physically transport the primary data to the computer centers, costly manual or partially automated bookkeeping practices remained at user enterprises, and the reports went no further than a standard list of values for the basic accounts of the enterprise (for example, see Sido86b). Other reporting forms and analytical tables had to be prepared manually (Polk81; Polk81b). The need to use account codes which were suitable for the computer led to many mistakes (Polk84b).

In addition, it is hard to believe that any kind of extensive databases could be built up with such small disk sizes (1.3, 2.56, and 5.1 MBytes (Vasi86b)). Moreover, serious complaints have been registered about the quality of the M 5000 disks (Zhuy86). For example, the SGR package, which has been widely used on the M 5000 series, does not pre-sort the data but accesses each piece randomly, presumably because of limited space (Avde86). In 1979 the M 5010 was being delivered with only 16 removable disk packs, whereas the information for one medium-sized agricultural enterprise required five or six (Belo80d). Apparently because computer centers have tried to stockpile as many of this and other expensive resources as possible, norms have been derived for the TsSU which link the number of disk packs allocated to the number of tasks and the number of hours the machine is used (Vasi86b).[6]

In 1980 it was decided that the M 5000 series should move into the SM line. One reason for this was that production of the SM-4 was three to four times as large as that of the M 5000 machines (Gold85). In addition, the disk sizes available for the M 5000 line were small. The solution was to develop a computer with two processors: one to execute the M 5000 line commands, and the other an SM 1420, which is an upgraded version of the SM-4 (Popk84). The SM 1600 passed state testing in 1981 and entered series production in 1983 (Bbew831; Neme82b). Experimental use of the SM-1600 in TsSU applications was begun in 1983 and 1984 (Bush83b; Bush84; Ivan83k), but full scale production of the SM 1600 did not occur until 1984 (Greb86). Modernizations were planned for 1985 (Bbew85r). The Soyuzschettekhnika Association, which is TsSU's Main Administration for

[5] The VGPTI was renamed VNIPIuchet (The All Union Scientific Research and Engineering Institue of Accounting) in 1985.

[6] Vasi86b gives a table showing what is apparently the number of disk drives allocated by machine types. ES machines get four 29 MByte drives and one 7.25 MByte drive. M 5000 class machines get four 5.1 MByte drives, two 2.56 MByte drives, and one 1.3 MByte drive. Another table shows the actual norms for ES machines, which depend on volume of work and number of tasks. The norms range from 65 to 193 disk packs.

Accounting Equipment, was scheduled to put 70 SM-1600 configurations in operation in 1985 (Gold85). In Lithuania the replacement of the M 5000 line has begun (Ivan86).

Is the SM 1600 an improvement? On the one hand, its technical characteristics are much better than the M 5000 series. It can have up to three 14 MByte disks attached, for instance (Brus85). Main memory is 256 KBytes (four times greater than the M 5000), and is expandable to 1 MByte (Neme82b). It can run DEC operating systems, including TSX-Plus (Tsem85), and can easily be tied into other SM machines. On the other hand, according to one writer, use of the SM-1600 will lead to few changes in the way that accounting data are processed, since it does not have sufficient terminal capabilities to allow a lot of interactive processing (Mali86).

Throughout the 11th FYP, VGPTI continued to work on standardized systems of accounting using Unified System machines. The main results have been for state budget organizations in the health, education, and "social-cultural" spheres (Yego84c). The design developed by the Belorussian affiliate of VGPTI has now undergone an extensive testing period. After being test run at one institution in each field, many changes were made; additional tests were performed in other cities, and finally, the packages were turned over to an interbranch software library (Tuz86). It is estimated that this package could be used at 1,000 to 1,500 centralized bookkeeping organizations throughout the country (Yego86). These standard designs notwithstanding, only 11 percent of those organizations in the health field considered suitable have even switched over to centralized bookkeeping. Another 4,000 are too small or for some other reason cannot use centralized services (Zapo85).

Despite all of the progress made with the M 5000, SM 1600, and Unified System machines, there still appears to be a rather large complement of punch card machines in use in the Soviet Union. In the Lithuanian TsSU system in 1979, for example, there were just 16 computers, but 254 punch card configurations, and around 4,000 keyboard calculators (Belo80d). It was not expected to finish moving all the agricultural enterprises in Lithuania to accounting using punch card machines until 1980 (Belo80d; Bart81). In the early 1980s the Belorussian affiliate of VGPTI developed a new standard design for accounting which was based on 45- and 80-column punch card machines. This standard has been successfully assimilated by a number of organizations; accounts of punch card computer uses were considered newsworthy in 1985 (Buld85; Zhuk85d). In 1986, it was said that the expenditures on both punch card and keyboard machines were going down slowly (Gorb86).

The Growing GSVTs System

Since the beginning of the 10th FYP, the TsSU, the State Committee on Science and Technology, and other organizations have been building up a series of collective-use computer centers (VTsKPs) which would become the backbone of the State Network of Computer Centers (GSVTs) (Tg82). The VTsKPs differ from the regional TsSU centers in that they offer more services to their users. For instance, a small enterprise can sign a long-term contract for a complete ASUP using the VTsKP resources. The VTsKPs are the means by which users can get more services than standardized, batch-oriented accounting on an M 5000 or SM 1600 machine.

The VTsKP are an outgrowth of the development of the design for the State Network of Computer Centers (GSVTs) which was worked out in 1973 (Zhim76c). In the early 1970s, the All-Union Scientific Research Institute for Problems of Management (VNIIPOU) advanced a plan for VTsKP which envisioned 200 territorial centers serving 600,000 enterprises and organizations by 1990 (Kurg84; Zhim78b). VTsKP may belong to the TsSU or to another ministry or organization (Trud82d). Some offer services within their own branches only. The TsSU would probably like to have the entire GSVTs under its direction, but that does not appear to be happening (Tg82).

The VTsKP program was established as a key national problem in the plan for 1976-80 (Teri80). Under VNIIPOU's oversight, at least seven VTsKPs were created in this period, four belonging to the TsSU (Dubr81; Makh80; Teri80; Teri81). The intent seemed to be to take computer centers of any affiliation which were already operating effectively, add resources, and turn them into time-sharing centers that could support regional processing requirements (Kima84; Lerm81). In the 1981-85 period, the liquidation of ineffective computer centers was planned, along with the transfer of small users to VTsKP (Myas82e). Because of the emphasis on the ability to handle remote job entry, the presence of multimachine configurations, multiprogramming, and DBMS, the aggressive pursuit of full loads, and the services offered to users, the VTsKP are among the best run and most effective computer centers in the USSR (Gorb86). One service planned, for example, was the development of software engineering tools which could then be used to more easily build software for users (Tg82).

In 1979, the State Committee for Science and Technology was working on selecting 45-50 computer centers that could be upgraded to VTsKPs (Zabo79). Originally it was intended to create 45 (Naus79; Sed181), or 22 (Myas82e; Tg82) VTsKPs in the 1981-85 period. Ten of these were within the TsSU system (Taga83). It appears that somewhat less than 22 centers were built (probably about 17) (Baub84; Bayz85; Bbc85c; Bele86; Bozi86; Ivan83k; Kalm84; Khod85; Levi86c; Lvov85; Maks82; Myas82f; Nesh86; Samo84; Shur86; Sult85; Telk84). The new VTsKPs created in the 10th FYP were to use ES-1035, ES-1045 and ES-1060 computers. Each center was to be connected to 16-32 subscribers and have an overall capacity of 0.9 to 1.5 millions of operations per second (MOPS). (Subscribers sign long term contracts with the VTsKP as opposed to users, who make use of the VTsKP irregularly (Kvas84).) The data presented in Table 4 show that the goals for number of subscribers have been met, but the overall computing power has been less than intended.

In 1981-85, the second phase of the development plan for the VTsKP in Minsk, Tallinn, Tomsk, and Tula was to be implemented as well. This phase included using mini- and microcomputers as remote processing stations, doubling the processing capacity of the centers, and expanding to 40-60 remote job entry stations per VTsKP (Dubr83). The Vil'nyus VTsKP has now gone into operation with a dual ES-1045 configuration and 26 initial user organizations. It has worked on using the SM-4 and SM-1600 as remote processing stations (Baub84).

Table 4
USSR: Performance of First Collective Use Computer Centers

City	Total KOPS [a] in Center	Number of Subscribers	Number of Tasks	Number of Remote Users
Tula	800	33	460	22
Leningrad	310	30	239	9
Belorussian SSR TsSU	420	26	122	18
Tomsk	420	23	189	30
Tallinn	580	36	339	42

Source: (Kvas85)

[a] Thousands of operations per second (KOPS). The VTsKP in the TsSU system are now located in Alma-Ata, Brest, Frunze, Kiev, L'vov, Minsk, Samarkand, Saratov, Tallinn, Tomsk, Tula, Vil'nyus, Vinnitsa, and Voronezh.

Goals for creating more VTsKPs in the 12th FYP have not been clearly articulated. As part of the Intensification-90 program in Leningrad, it has been planned to create a total of 45 VTsKPs by 1990; however, the author's claim of 10 VTsKPs already there in 1985 does not fit with the other statistics and one wonders what definition of VTsKP is being used (Lipk85). One author claims that by the year 2000, the TsSU system will include 177 VTsKPs, and that many other ministries and departments are developing specialized VTsKPs (Cher86e).

Have the goals of the VTsKP program been met? The number one goal was to put an end to inefficient usage of computers at small computer centers. A source of great concern to Soviet officials has been the mean daily load of computers, which fluctuated from 9-10 hours a day to 12-14 hours per day in the 1973-80 period (Mche85). In 1981-85 many ministries and agencies continued to open new computer centers, despite these low loads (Khod85; Pere84c). A 1985 *Pravda* editorial stated: "Apparently the time has come to restrain the unbridled growth in the number of low-output computer centers and to decide the fate of those that are not performing up to acceptable productivity levels" (Prav85k). This is not the first time that such statements have appeared, yet very little progress has been made to shut down ineffective computer centers. In 1986, the chairman of the new state Committee on Information and Computer Technology stated that ES machines were being used, as a whole, 11 hours every work day, and of those only 3-4 hours could be said to be useful calculations (that is, running production jobs) (Deni86b).

The overall ES usage in the TsSU was only 13.6 hours per day, or little better than the overall rate, but in 1985 it shot up to 20.3 hours, perhaps because this was the last year of the FYP (Gorb86; Kost86). Similarly, the average daily load in 1984 at VTsKP was a little over 15 hours (Kvas84), but in 1985 it climbed to 21 hours (Kvas85). This form of organization was praised by the *Pravda* editorial (Kvas85; Prav85k). The answer, therefore, is a qualified yes: the VTsKPs do seem to make more efficient use of computer time. But the number of them is still so small that they cannot have made much of a dent in the problem. The qualification is that the mean daily load says little about whether or not useful calculations are being performed.

And what of providing services to users? Table 4 shows that the number of subscribers in the first phases of VTsKPs has been quite low. With an average of 30 subscribers per center, it will take a huge number of centers to meet the demands of 600,000 organizations (Kvas85). There are three main reasons why the number of subscribers is low.

First is the hardware base. With the exception of the Novosibirsk center, which included three BESM-6s, an ES-1052, an ES-1060, and various mini- and microcomputers, these VTsKPs were built on the basis of the ES-I upgrades, the ES-1022 and ES-1033 computers. At first, they were all equipped with 512 MBytes of memory (Teri80). The Tallinn center, which was the largest of those controlled by the TsSU, included a total of 739.5 MBytes of on-line disk storage shared between three ES-1033 mainframes, all of which were upgraded to include one megabyte main memory (Myas82f; Kima84). This hardware base reflects what was available in the second half of the 1970s when design work on the centers began. Throughout most of the 11th FYP, the VTsKPs ran mainly on ES-1033s (Kvas84). In addition, the VTsKPs did not receive sufficient peripheral devices and had to contend with integrating much hardware and software (Mche85).

How much processing power do the VTsKPs need? According to two researchers from VNIIPOU, each center needs to have a total throughput of 100 MOPS (Maks84). Another account related the goal of increasing the processing power at VTsKP to 20 MOPS in the 11th FYP (Myas82e). This was not met according to the statistics in (Kvas85). At a similar center in East Germany, 236 users, or about 10 times the number of users at the Soviet VTsKPs, have their work done on five ES-1055s, an ES-1040, and an ES-1022 (Nort85). The plans for 1986-90 envision giving each TsSU oblast center an additional two ES mainframes (Vest86i). It is reasonable to assume that the VTsKP will get at least this, but even this may not be enough to serve the 1,000-1,500 users that were originally projected for these centers (Zhim77). One of the explicit goals of the joint CEMA "electronization" program is to build a computer that can execute 10 billion operations per second. Such a computer would be used for huge collective use centers (Popo86b). In the meantime, the VTsKP will be outfitted with whatever large Soviet ES mainframes are available, including ES-III machines (Dani84b).

The second reason for the low number of subscribers is the way the incentive system for the VTsKPs works. Computer centers, including VTsKPs, are evaluated on the basis of their mean daily load (MDL), or how many hours the computer is running either production or development jobs during the day (Bush83b). Naturally, this gives computer centers little reason to care whether or not those jobs have any value (Kany83). The MDL has retarded the introduction of multiprogramming, although VTsKPs have done better in this regard (Gorb86). The VTsKPs are self-financing organizations, which gives them a strong incentive to operate in the black. However, it turns out that they can charge outrageous prices for their services because state standards mandate that charges are by hour of computer use, regardless of how the machine is actually being used during that time or whether or not time sharing is being used. The pricing of services at computer centers has long been problematical (Golo86; Kute85; Kute86; Maka86). An article about some students who were using the VTsKP in Tallinn but then had to quit because of a price increase provides the following interesting perspective:

> Outside users at the TsSU pay the hourly rate for machine time even during that time when a person at a terminal is only engaged in data preparation and input. While the person is really only using minutes or even seconds of machine time, payment is for an entire hour, from 90 to 135 rubles. True, last year they started dividing these hours by the number of people simultaneously using the machine, reducing the costs. All the same, this is nothing but eyewash, thanks to which VTsKP's taut financial plan is easily fulfilled and overfulfilled. All VTsKP users know this, and criticize it in the hallways, but do not want to spoil their relationship with the management. Anyway, the money is not out of their pockets, so it's no bother. Referring to USSR TsSU instructions, the VTsKP management claims some sort of "legal" right to take this 12 fold price from users. However, other computer centers (for example Gosstroy ESSR) based upon the same country wide price list, have been able to introduce programs which take into account the actual use of machine time with a high degree of accuracy. Above all, they exclude handwritten entries into logs, that is, make impossible exaggeration and wide ranging arbitrary action authorized by "instructions" (Shur86, 2).

A third problem faced by the VTsKPs is actually attracting users. The first results showed that few industrial users signed on for complete ASUPs. One of the reasons for this was the incentives the enterprises faced. At least until 1981, enterprises that wanted to buy outside computer services had to do so out of their budget allocations for the management apparatus. Since decreasing the size of this apparatus is one of the plan targets, increased expenditures for it run counter to enterprise incentives (Myag81). Moreover, prestige is still an important reason for acquiring one's own computer center.

More importantly, it is doubtful that enterprises want to put their primary data onto a computer that is controlled by another organization. It is no secret that one of the motivations for developing regional VTsKP is to provide local and superior bodies with much better information. At the present stage those organizations have to settle, for the most part, for receiving processed data from enterprises in the form of reports. In 1986 the head of the RSFSR, P. Guzhvin, contended that "We will no longer tolerate such violations of the principles of centralized accounting" (Guzh86). The VTsKP will allow the TsSU to make direct use of the enterprise data, which is already in machine-readable form, for other purposes (Chum84b; Emm85c; Many86; Vana86).

Other Sources of Computer Services

Enterprises have two other options for obtaining computing services. In addition to using the computers of the TsSU, they may turn to computers in their own branch, or to outside computers for time rental.

Branch computer centers (KVTs) share much in common with VTsKP, including organizational problems. The overall conception is the same: to provide centralized computing services to a localized group of users. The main difference is one of scale and subordination. The KVTs are intended to serve no more than 10-20 users, all in the same branch (Maks78b). They command fewer resources than the VTsKPs, but are not expected to do as much.

In 1978, more than 120 KVTs already existed in the Soviet economy (Maks80). The 1976-80 plan called for the creation of 100 of them (Maks78b). No information is available about whether these centers were created from scratch or whether they were already performing tasks for other users and were given the name KVTs when it came into vogue. What was once considered a KVTs at Glavtyumen'neftegazstroy is now called a VTsKP (Maks78b; Myas82f). Other examples of KVTs can be found in the literature (Agan81; Aref82; Keri82; Miro79; Stro82d).

Particular success is claimed for KVTs in light industry in the Belorussian republic. Seven centers operate 20 computers for 27 ASUs, so that 80 percent of the information processed in ASUs is done at KVTs. "From the moment they were put into operation," writes Ye. Volyanskiy, the director of the republic-wide computer center for light industry, "the load was greater than that planned, and in some cases is achieving more than 16 hours daily with three-shift operation." The average cost of a machine hour in 1982 was about 50 rubles for ES machines and 29 rubles for Minsk-32s, which is said to be eight to 12 percent lower than at corresponding individual computer centers. The republic branch computer center has been able to run its ES-1035 under MVT for a significant portion of the time (Voly83).

Unlike the VTsKP, which in some cases are installing dedicated communications lines for their subscribers (Bush83b), the KVTs are supposed to be limited to a single city. Volyanskiy explains that telecommunications costs are too high for transmission of large amounts of data, and that using a courier to transmit the data outside of a city is "ineffective" (Voly83). The departmental orientation of KVTs appears to be an important advantage over the VTsKP. Specialization can allow the KVTs to better meet the needs of its clients.

Over the last few years, the amount of computer time rented has increased greatly thanks to the proliferation of computer centers and the need to fulfill the mean daily load targets. According to one author, something akin to competition for clients between ministries and departments is taking place. In 1977 the majority of centers rented time, although the amount rarely exceeded 25 percent (Ruvi75; Kvas77). Eighty-five percent of computer centers in Moscow served only one organization, probably reflecting the fact that Moscow has been supplied with more computers (Mosp82c). Statistics for ths Lithuanian SSR show a considerable fluctuation in the percentage of rented time and a steady increase in the number of renters over the period 1971-79 (Novi83). The greater number of computer centers that have time to offer has aroused considerable concern (Sido82b). Because of the competition for clients, the tasks may actually have no value (Kvas77; Sido82b).

Renting time has been facilitated in a few cities by the establishment of a centralized dispatcher service for unused time. The first was created in Kiev in 1977, followed by services in Alma-Ata and Tbilisi in 1978. Ten centers, including ones in Dnepropetrovsk, Donetsk, Khar'kov, Kishinev, L'vov, Minsk, Moscow, Odessa, Voroshilovgrad, and Zaporozh'ye were planned for 1981-82 (Koro79b; Vedi81). According to VNIIPOU, they have won great popularity among users and have done a big business. The dispatcher agency at the computer center of the statistical administration in Kiev sold 2 million rubles worth of machine time annually during the years of the 11th FYP (Pans86). Another benefit of the dispatcher services was that they offered additional services to the users. These include providing consultation to users on formulating problems, finding standard software packages as well as free machine time, storing the user's data and programs in computer center libraries, leasing hardware, transmitting data, and checking data for correctness.

The dispatcher services were not without initial problems. One was gaining the participation of the city's computer centers (Koro79b). Many ministries and departments were not forcing their computer centers to make time available, even though a resolution of the interdepartmental council on problems of the improvement of management of the national economy required them to do so. A related problem is that the computer centers only sent data on time availability once every six months in accordance with a TsSU form, which, of course, inhibited effective matching of demand and supply (Vedi81). The dispatcher services ran into further roadblocks from the way payments were handled, from Ministry of Finance regulations, and the lack of exclusive control over time distribution (Koro79b; Sido82b; Vedi81). Now that the GKVTI has begun emphasizing the use of computer time as a high priority task, the role of dispatcher services may increase (Pans86).

Of all the types of computer services available to an enterprise, renting time provides the least support to users (Kvas77). The main drawback of renting time is that the renter is not responsible for the tasks solved. Dispatcher services exist in no more than a handful of cities, and the organizational questions attending their creation have yet to be fully solved. Despite the enthusiastic announcements related above, there is no further evidence that the additional centers have been created or that the others are still working. If no agreement could be reached on paying for the basic service, then it is doubtful that the other services have gotten off the ground. An additional drawback is that most computer centers do not have the capability of offering remote processing services, causing users to have to hand-carry their data across town (Ruvi75).

The Challenge of Integrating Microcomputers

Unlike in the United States, where computers in large corporations rapidly replaced older punch card technologies in the late 1950s and early 1960s, the introduction of computers in Soviet society has occurred at a much slower, steadier pace. Two of the reasons for this are the production rates of large computers and the costs associated with running them. Installing computers in regional and city statistical operations has not been possible because there was not enough work to justify the large machines.

Conservatism is bred by a system that rewards yearly quota fulfillment. Once a punch card or bookkeeping machine is in place with all the associated maintenance and supply channels established, it is hard for a manager to replace it with a technology that may be riskier. This is one of the reasons why even the republic and oblast centers continue to use the older technologies side by side with computers.

The most important consequence of the equipment used is the style of management it engenders. Accounting collects statistics about what has already happened, often with significant time lags. Managers submit data to computer centers which are often located off-site and get back reports, having very little influence over the quality of data entry or the presentation of the results. Some types of equipment just produce the reports without storing the data for further analysis. The result can be nothing more than speeding up the conventional way that Soviet enterprises are managed, rather than introducing new, quantitative management techniques.

For the first time, terminals connected to minicomputers or microcomputers offer the possibility of bringing significant computing resources right to the workplace of bookkeepers, economists, and statisticians. In the 1986-90 period, for example, every administration in the central management of the TsSU is to receive a minicomputer-based multi-terminal configuration for local use (Vest86i). For the first time in three decades, the trend towards centralized processing of accounting data may be reversed. In the 1960s it was thought that the amount of data being sent over telephone and telegraph lines would grow very rapidly. The main source of all of this traffic was to be VTsKPs (Shva86). However, by the 1980s it became clear that the microprocessor would make an entirely new strategy possible. According to members of VNIIPOU, the GSVTs are now expected to carry out only 20 percent of all calculations in the region. The rest will be done on small computers or at local user computer centers (Maks84). VTsKPs will be used in conjunction with microcomputers, perhaps with some of the micros being supplied by or rented through the VTsKP (Levi86c; Maka86). This may partially explain why it seems as if the rate of introduction of VTsKPs has not lived up to expectations and why they have recently received less coverage in the press.

The challenge for the Politburo is to reap the efficiencies of the microcomputer without losing too much control. One way to do this is to supply machines which are highly oriented to specific tasks, such as the Iskra-555 with its highly specific bookkeeping language. The danger of *samizdat* being spread through these Iskra machines or other automated workplaces of bookkeepers is slight. These are machines which are located in public places; their use can easily be monitored. More threatening is probably the prospect that the machines will be used for economic functions which effectively hide problems in enterprise performance much better than cooking the manual books could. The advent of microcomputers marks the first time that users, who actually know how to do such things, will also be in control of their machines. The TsSU is trying to impose standards for micro-based accounting, but it is hard to tell to what extent they have been successful so far (Baby86). The central organizations must find more effective, sophisticated ways to audit how microcomputers are being used (Doma86).

In any case, it is clear that the mid-1980s mark the real beginning of the computerization of Soviet society. Until now, the centralized form of service provision, even in ASUP, has led to few changes in the way that management functions. The task is immense, involving the mass production of huge numbers of personal computers, education of millions of users, and reorganization of the whole centralized accounting system. Regardless of how fast this is pushed from above, it will take a substantial amount of time.

Future Directions of Enterprise Computing

Over the past few years, it has often seemed as if the ASUP program has withdrawn from view, and the question has arisen, where will the Soviets go from here? The program is apparently being extended in three directions. The first is simply dropping the ASUP title and using computers for data processing tasks which will support management in various concrete ways. These services are provided by the TsSU or by microcomputers, and have already been discussed.

The second direction is enhancing ties with external organizations. This is being done under the auspices of the OGAS program, which has continued to receive approval from the highest authorities. Links are being built hierarchically (to ministries) and horizontally (to regional bodies).

The third direction is the continued expansion and development of existing ASUPs, including attempts to make them more applicable to the existing social-economic conditions. If Western experience can serve as a guide, and it often can, the next large item on the Soviet agenda should be distributed processing, where data processing is spread over a variety of computers of differing sizes at various levels in the enterprise hierarchy, all joined together by a local area network. Distributed processing addresses the problem of the so-called "accounting approach" and the incorporation of microcomputers in enterprise management.

All of these developments come against the backdrop of significant real and potential changes in both the infrastructure of computing and in the surrounding social-political environment which are being initiated by the Gorbachev administration.

Networking to External Entities

So far in this study we have evaluated the internal impact of data processing on enterprises. In the US economy, where corporations are largely independent units which have to do a relatively small amount of reporting to governmental agencies in comparison with their Soviet counterarts, this would be enough. However, if the full potential of ASUPs and non-ASUP-based computing is to be realized, the Soviets must find ways of linking various machines and various levels together. Soviet leaders have always recognized this fact and have, since 1971, continually promoted the development of the All-Union System for the Collection and Processing of Information for Accounting, Planning, and Management of the National Economy (OGAS).

It became clear in the previous sections that most data processing at the enterprise level is subject to what may be called "the accounting approach." Data processing is a separate function, carried out by the ASUP department or an external computing service bureau and not integrated into the daily work of managers. The reports that are provided to managers and exchanged among levels, either inside the enterprise or with higher-level organizations, are static windows which permit only a glimpse of the state of these organizational entities at any given time. Even when massive amounts of data are provided to other organizations, their presentation in the form of static reports makes their usage problematical.

Dynamic management outside the enterprise requires interactive access to data, or at least the ability to request and receive data in machine-readable form. The overall performance of the Soviet economy depends on the soundness of the centrally created plans. Ministries and central planning authorities need accurate, timely information to deal with bottlenecks in the economy and to create achievable plans which reflect policymakers' preferences. The data which are collected and processed are the working material for the whole management system of the economy. Regardless of how well Soviet enterprises are using computers internally, if the data cannot easily be transmitted to other levels, a considerable part of the benefit of computerization is lost. In addition, high-speed telecommunications can improve efficiency by speeding transmissions, and by eliminating the reentry of data by various organizations inside and outside the ministry hierarchy, leading to labor savings, greater accuracy, and greater speed.

At the same time, networking presents some difficult challenges for the organization of the Soviet economy. Enterprises are naturally protective of their data because it gives them a certain amount of leverage in negotiating for the most favorable production conditions every year. Networking may open the information floodgates for information collection by all sorts of organizations. Before telecommunications, the ministries, the TsSU, Minfin, Gosplan, Gosstandart, and regional Party committees were more or less limited in the amount of information that they could request by the available set of prearranged reports, but teleprocessing could conceivably permit direct access to data by any of these organizations.

So far, it appears that enterprises have little to worry about in this regard. Most of the remainder of this section will demonstrate that the extent of direct connections to enterprise data sources is limited.

The Networking Infrastructure. Data are transmitted in the USSR by a variety of media, including the general purpose phone network, the general and special purpose telegraph networks, a "subscriber" telephone network for data transmission, and new technology media such as fiber optics, microwave, coaxial cable, and satellite.

The usefulness of the general purpose switched telephone network (TF-OP) for data transmission is limited by statute, quality, physical design, and size. Only nine minutes out of every hour may be used for data communications (Levi85; Mikh86h). The quality of the lines also leaves a great deal to be desired. The error rate on switched lines may be no better than one error per 1,000 characters with substantial variations in individual line quality (Gavr85b; Kry185; Myas82f). Errors tend to be grouped in bunches, increasing the likelihood of the termination of a connection. As speeds go up, the error rate gets worse (Dmit85c). Establishing a connection can take a minute, and the lines are down two to five percent of the time with slow repairs (Myas82f). Three hundred bits/second is the practical limit without using sophisticated error compensation equipment (Mikh86h).

Although steady progress has been made over the past few years towards increased direct dialing of long distance calls, intercity links are weak; in 1985 only 65 percent of the public network had direct dial (Camp87). Many calls must be made from the central post office. In 1984 over 214,000 orders that were taken for long-distance telephone calls were not filled. "The quantity of statements and complaints connected with . . . the long delays in repairing telephones and radio outlets was 40 percent higher in 1984 than in 1980," the First Secretary of the Pskov Province Party Committee reported in 1985 (Petr84b). By 1990 it is planned to have automatic exchanges which allow direct inter-city dialing in 85 percent of the country's 3,600 rayon centers (Bbcw85d).

The size of the existing phone network is indicated by the statistics. In 1985, there were approximately 25 million to 30 million phones in the USSR connected to the public network. The majority of these were in urban areas: 23 percent of urban families and 7 percent of rural families had phones. The 12th Five-Year Plan (1986-90) calls for the addition of 12.1 million numbers by 1990, 75 percent of which will be for private citizens. With demand estimated to be 100 million phones and a current waiting list of 10 million, it is clear that the Soviets have a long way to go to reach the level of saturation of the developed Western nations, but the telecommunications sector is receiving higher priority and significant progress is likely to be made over the next five years (Bbcw85d; Camp87).[7]

In addition to the general phone system, there is an extensive switched telegraph network, known as the AT-50, which can transmit data at 50, 100, or 200 baud. "Practically all" organizations have the East German T-63 teletype machines which works with this network at 50 baud (Levi85). In recent years the USSR has produced devices for 100-200 baud use, and new computerized switching centers are being installed with greatly improved results (Golu85; Tver86; Zhev84). The AT-50 can only be used 12 minutes per hour for data communications (Mikh86h).

In the early 1970s it was recognized that the general purpose phone system and telegraph lines were insufficient means for transmitting data. Under the umbrella of programs for an All Union State network of Computer Centers (GSVTs) and a Unified Automatic Communications System (YeASS), the first design of the All-Union System of Data Transmission (OGSPD) was completed by 1977 (Myas82f). Five years later, 129 main automatic switching nodes and substations had been installed throughout the country (Makh82). These nodes are part of the PD-200 network, which is the first stage of the OGSPD and which is only now being completed (Tver86). One

[7] The excellent analysis of Robert Campbell examines the Soviet telephone network in much greater detail. See (Camp87).

major advantage of the PD-200 is that it provides automatic circumvention of lines that are down. However, the only intelligent terminal available for this network is Hungarian; this and the absence of multiplexers or adapters for use with SM machines (DEC- and PDP-like minicomputers) limit its applicability (Kuzm84c; Levi85; Makh82). Each PD-200 connection is limited to 18 minutes per hour (Mikh86h). Work is going on to upgrade the system to 1200 baud and raise the quality of transmission, but the first 2400 baud link on the system is not expected until sometime during the 12th FYP (Camp87; Tver86). The OGSPD is eventually supposed to become the backbone network for most data communications in the USSR, but its predominance is being threatened by the creation of independent ministry networks (Mikh84; Myas82f; Yaku86).

A fourth option, which can be quite expensive, is leasing lines from the Ministry of Communications (Minsvyazi). Within a city, the cost is about 1,000 rubles per year (Levi85). A Moscow-Leningrad line can cost 50,000 rubles per year, and a Moscow-Novosibirsk line, about 80,000 rubles (Nest84b). Lines cannot be rented in units of less than 24 hours (Gusy86). The installation of connections between a large time sharing center in Yerevan and approximately 40 other cities was recently studied using a simulation. The remote nodes would be connected with 1200 baud leased lines, at an installation cost of 2,800 rubles per kilometer per channel. The cost of the entire network would be 73,654,000 rubles (Ogan85). Delays of at least two months can be expected before leased lines are available (Butr83). The quality of leased lines is generally said to be one to two orders of magnitude better than the switched lines (Butr83; Chug85; Myas82f).

Minsvyazi has begun work on the Unified Automatic Communications System (YeASS), which represents a massive upgrading of the entire Soviet communications infrastructure. It will adhere to international standards and follow a well-trodden path from crossbar mechanical switching equipment to all-electronic and then computer-controlled switching (Seli85c). This architecture will span the other CEMA countries, who are participating heavily in the development of the "Unified System of Switching Technology" and in other parts of the program (Fran83; Masl84; Popo86b). The ultimate goal is an all-digital long distance network (Seli85c). According to placards on display at the Svyaz'-86 exhibition in June, 1986 in Moscow, the YeASS will eventually offer a wide variety of user-oriented services including teleconferencing, videotext, and facsimile.

Ivan Selin feels that the YeASS program is moving apace, that extensive use is being made of satellite and coaxial cable (for secure communications) in the new network, and that the Soviets will be able to obtain any technologies they need in the West, particularly through non-COCOM countries (Seli85c). However, it appears that the Soviets have a very long way to go before the YeASS becomes a reality.

Technologies under development or already deployed include quasi-electronic exchanges and integrated analog digital dial exchanges (Moni85). Several million numbers will be covered by quasi-electronic and electronic exchanges in 1986-90 (Ales85; Bbcw85d). The USSR Ministry of the Communications Equipment Industry (Minpromsvyazi) was recently excoriated for continued series production of obsolete labor-intensive and bulky crossbar and step-by-step switching equipment that foreign countries had ceased producing by the 1970s (Petr85b). Minsvyazi has not succeeded in mastering the necessary technologies for high-speed, high-capacity switching. The Kvarts system, which went into series production in 1985, is 1960s-style analog technology (Camp87). The cable products supplied by the Ministry of the Electrical Equipment Industry (Minelektrotekhprom) were said to be substantially inferior to their foreign counterparts and in addition were still in extremely short supply (Petr85b).

After years in which only a small fraction of the satellite capacity was used for telephony, the installation of the needed equipment is to be expanded (Camp85b; Kuzn85b). But "the managers of the system have been extraordinarily dilatory in moving to capture the potential benefit to the operation of the economy of satellite links for two-way communications" (Camp85b, p. 324). Large scale fiber optic cable use is to begin in the 1986-90 period. In 1986, a new inter-branch scientific technical complex was formed to do research and development on fiber optics. Two reports indicate that the work of this MNTK is proceeding very slowly; practical results should not be expected soon (Prok86; Tara86b).

The poor quality and use limitations of the regular lines, the high cost of leased lines, the assignment of the PD-200 network for specialized industrial users, and the inaccessibility of other media has left most institutions electronically isolated. The main forms of data transmission have been the telegraph network and magnetic tape. New capabilities are becoming available in the general purpose telephone system, including better switching centers, higher transmission speeds, and radio-relay, cable, or satellite links, but the restriction on usage of this system for data transmission apparently remains. Leased lines seem to be available, but are quite expensive. Thus, the state of the telecommunications infrastructure does not make networking impossible, but makes it quite difficult, especially if a large-scale network is desired. In apparent recognition of this fact, several large ministries have turned to the Hungarians for substantial help in upgrading their networks (Odor85).

The ability of ministries and other organizations to build computer networks has also been hindered by the available hardware and software. The fact that the Soviets decided to copy the IBM S/360 and S/370 series computers (in the Unified System machines) has had a marked effect on the solutions chosen for networking. The IBM S/360 machines were not initially oriented towards interactive processing and telecommunications. IBM's strategy resulted in a confusing multiplicity of terminals and protocols, so that by the early 1970s it was necessary to introduce the Systems Network Architecture (SNA) to provide interconnectibility.

A fairly large percentage of the activity of the Soviet networking community has been directed towards mastery of SNA in the industrial and governmental sphere. In 1981, the basic outline of the ES telecommunications strategy was published as the Open System of Network Teleprocessing (OSST). The program for creating OSST generally followed the stages of development through which the various stages of SNA have passed, while including the goals of operation with X.25-access packet switching networks and eventual compatibility with the CCITT Open Systems Interconnection (OSI) model (Bogd81; Sand81). Software which fulfills the functions of comparable SNA components has appeared in various releases of ES operating systems, one of the most recent being the TCAM/NF access method (Baum84d). A recent article of the branch-wide MIS for the Ministry of Instrument Building, the Means of Automation, and Control Systems (Minpribor) all but states directly that SNA is being used to build the network, and says that "SNA may become the goal-oriented program of the development of hardware and user software in the coming decades" (Kaza86).

A key component of SNA is the IBM 3705 telecommunications processor. Bulgarian and Polish versions of this machine apparently had been debugged by 1982 (Myas82f). Supplying a machine of this class is part of a new networking agreement that the Soviets have signed with the Hungarians, and the East Germans are apparently working on a microprocessor version (Odor85; Samo85). Minpribor is using a dual ES-8371 configuration in its network (Kaza86). However, in the USSR, the wide availability of SM minicomputers and the very limited availability of the 3705-class machines has led to the development of a variety of other networking solutions involving SM machines in the front end processing role (for example, Zama86).

One of the major problems in bringing networking into the general economy is the current hardware and software stock. A. S. Kazak, the assistant director for science of the All-Union Scientific Research and Design Institute for Branch Management Information Systems (VNIPI OASU) explains:

> In the majority of computer centers there still exists "task by task" data processing, which corresponds to the single-user computer use that was characteristic of first and second generation computers.... Improving data processing for the user has been braked by the absence of hardware and systems software standardization. At the beginning of the 1980's in the majority of large computer centers there were at least two to three types of large computers, a minimum of at least two operating systems, two to three teleprocessing monitors and several database management systems (Kaza86, p. 12).

Smaller computer centers are equipped with lower-end ES machines with limited main memories and disk storage, the turnover of equipment there is much slower, and allocations of new machines to organizations that already have machines are few and far between (Mche85). Multiprocessing is difficult

Table 5
General Economy Computer Networks in the USSR

Organization(s)	Year	Type of Network
Minpribor	1984	Hierarchical connection
	1986	Use of ES-8371 front-end
UkSSR VUZes	1984	Three or more computers, hierarchical design
Ministry of Maritime Fleet	1981	Plans for networking
	1986	Plans for regional network of ports, shipping lines, satellite links, DECNET
Baltic Shipping Fleet	1986	Plans for satellite links to shipboard computers
Ministry of Railroads	1985	Hierarchical data collection
Ukranian Ministry of Automobile Transport	1986	ES/SM star network with communication
Civil Aviation	1972	Hierarchical time-sharing reservation system (Moscow)
	1985	Packet switched, ES/SM, being expanded from test zone, now 8 hosts, 1,000 terminals
Moscow Savings Bank	1983	Hierarchical, ES/SM 3000 terminals
Leningrad Stroybank	1986	Plans for regional network in 12th FYP
UkSSR Gosstroy	1986	Small part of planned "distributed database" for design information implemented
TsSU Statistical Data Processing	1983	Hierarchical Processing System
Tyumen' Gas Industry PO	1985	Partially hierarchical, partially ring, ES/ASVT
Ministry of Petroleum and Gas Industry Construction	1985	Network to be built by Hungarians
Ministry of Gas Industry	1985	Work on distributed databases, hierarchical design
	1985	Network to be built by Hungarians
	1986	Planned packet switched link on some gas pipelines
Moscow Energy Administration	1984	Hierarchical data exchange
Ministry of Energy	1985	Introduction of Hungarian equipment into network
Petroleum Industry	1985	Hungarians to build ring net
Ministry of Agriculture	1985	Hungarians to build ES-8534 terminal to include image transmission
Ministry of Agricultural Machine Building	1985	Hungarians to build intelligent terminal systems
Lithuanian State Committee	1985	Hierarchical master-slave of Television and Radio
TASS	1985	Further development of worldwide network by Hungarians
Elektronika PTO, Voronezh CPSU oblast' committee, urban economic management	1982	Local area network based on Elektronika-60s

Sources: (Bach85b; Bond81b; Buly85; Butr83; Bych85; Fion85; Gazo84; Ginz85; Ivan83k; Ivan86; Izve84e; Kaza86; Khat82; Kry185; Kuzm84c; Odor85; Roma85; Simo86; Step85; Zamu86) enough on these machines, let alone networking using IBM's BSC protocol, which uses a lot of the resources of the central processing unit. Apparently, users do not want to make the conversions that would be necessary to use new hardware (Yaku85). A large number of modems, multiplexers, and terminals have gone into production, but as noted above, these peripherals are often cited as being in short supply, of poor quality, or not completely compatible with each other (Hamm84; Iskr83; Kere85b; Mche85; Sosi83; Yaku86; Yevs83).

Thus, it is more accurate to say that while the Soviets have embraced SNA as a standard for wide area networks, they have only begun to reach the necessary hardware and software levels to use it. In teleprocessing applications, for example, pre-SNA equivalents of CRJE (DUVZ), CICS (KAMA), and TSO (SRV) have been used widely. As explained in the next section, most of the networks that have been built in the USSR have been in specific industrial applications using these facilities.

Ministry Networks. A number of important ministries have now begun to construct what might be called computer networks. A listing of some of these ministries, along with characterizations of the nature of their networks, is presented in Table 5. (It should be noted that Table 5 is not intended to be an exhaustive listing of all networks in the economy.)

As Table 5 suggests, most ministries are putting together hierarchical applications. The network being constructed by Minpribor can serve as an example of what hierarchical means. The designers used only series-produced equipment which has passed official testing. The production system configuration includes one East German ES-1055 and one ES-1055M, which are each connected to two ES-8371 front end processors. The two large mainframes are connected to 29, 100, and 200 MByte disk drives. The front end processors are linked to intelligent terminals, dumb terminals, and telegraph terminals at enterprises. The Minpribor configuration also includes a mirror configuration for software development and testing, a stand-alone ES-1055 for a batch processor, and a data preparation center including some key-to-disk devices (Kaza86). The PD-200 system is used for data transmission (Kuzm84c).

The software in the network distinctly follows IBM. A. S. Lazak relates the names of well-known packages which are in use in the network and are given along with their IBM counterparts in parentheses (Kaza86). These include: OS ES 6.1 SVS (VS/1); NCP (network control program), BTAM, TCAM, and VTAM communications protocols; the OKA/VP (IMS/VS) database management system, and the KAMA/VP (CICS/VS) conversational monitor. The network is given the label "industrial teleprocessing," which seems to indicate that little more than remote dial-up access has been achieved. This remote access gives enterprises the ability to communicate with the ministry. Software has been developed so that they can send and receive "messages" by using files. But it does not allow the ministry to directly access the computers of its enterprises, and the enterprises apparently must move data from their machines to the remote entry stations which connect to Minpribor, perhaps on a storage media, perhaps by hand. "Network teleprocessing," which more closely resembles SNA and would at least allow for direct interaction between the computers, is a possibility for the future.

While many of the listings in the table show only hierarchical connections like Minpribor's, some ministries are building networks in the full sense of the term, i.e. including at least two co-equal hosts. The network of the Ukrainian Ministry of Automobile Transportation uses ES and SM machines as equal hosts in a packet-switched network. Because no such software was available, it was custom built by the Institute of Cybernetics of the Ukranian Academy of Sciences. A "fragment" of the network went into service in 1985 (Zama86). The network of the Sirena ticketing system in 1985 comprised eight SM-2M hosts servicing about 1,000 terminals through a packet-switched, Electronika-60-based subnetwork (Pest85; Zhoz85).

If nothing else, these latter two examples show that the Soviets have the capability of building reasonably sophisticated networks (see also Mche86h). To date, however, it is very difficult to find any examples of ministries which have real network connections to the computer centers of their enterprises. The one piece of evidence which suggests that ministries are collecting a lot of data from the enterprises are the complaints about too much information collection through branch automated management systems (OASUs) (Guzh86; Koro86b; Vest86d; Vest86g; Vest86k). The Minsk Tractor Plant, whose ASUP has received massive publicity over the years, is an example: it is supplying five times as much data as is approved by the TsSU (Vest86d). It appears that most of the data exchange is either by paper, by magnetic tape, or by teletype. Departmental networks are apparently highly underutilized. The load [a] is said to be only one to four percent of capacity (Meli86).

Why are there so few direct connections to enterprises? Although there may well be resistance from enterprise officials, it appears that the main bottlenecks have been in the infrastructure. As noted earlier, it can be quite difficult to ensure that telecommunications lines are available given the state of the telecommunications network. The available hardware and software also create obstacles to successful network applications. In addition, the enterprise ASUPs have been built as stand-alone systems. Enterprise computers do not have a lot of spare capacity for participation in networks. Finally, because so many enterprises do not have data processing systems of their own, the old system of the ministry must continue functioning as before. This is why a large portion of the data that comes into OASUs is undoubtedly sent in on the standard report forms and keypunched by the ministry or is transmitted by telegraph.

In conclusion, it should be noted that the OASUs are a uniquely Soviet creation in that they have the potential of linking together all the enterprises in any given ministry. In comparing them with US corporations, however, it becomes apparent that they fall well short of the sophistication of US corporate networks.

Regional Data Links. Regional data collection is another means by which the value of enterprise computing can be enhanced. For example, if the regional Gossnab organization is able to collect information on all of the goods going in and out of the republic, it can become a broker for shifting around supplies to where they are needed most and can monitor enterprises to ensure that above-norm reserves are not accumulated (Stos86).[b]

Most regional collection seems to be based on two directions which are coming together in some republics. First, data collection can occur as a by-product of the processing performed by the TsSU for budget organizations and for some enterprises. Second, Gosplan, Gossnab, and the TsSU have divisions in each republic that are building their own data processing systems. It is envisioned that these systems will be unified into regional automated management systems (RASUs), and work is proceeding on RASUs in all 15 republics (Meli86).

The developers of RASUs must contend with problems that stem from the poor infrastructure of networking already described. In addition, a very significant barrier is that the data of enterprises that are subordinated to outside ministries have all of their data coded in various formats (Meli86). The solution to this problem is to collect the data which appeared on standard reporting forms, i.e. the data that has always been collected. This kind of data is being supplied to the TsSU on tape and via some data tranmission channels from the ASUPs of large enterprises (Vest86i). If only the usual data are collected, then some of the benefits of computerization will be lost, although improvements will come from collecting the data in machine-readable form.

In the original plans for OGAS, more emphasis was given on building OASUs than on RASUs; RASUs were seen as data processing systems which would involve only the strictly republic enterprises and organizations (Pyar85). Enterprises subordinated to union organizations were developing their own, incompatible systems. However, in some republics the goal has now been formulated of trying to link together all the ASUs in the region. In the 11th FYP, seven republics were given the mandate to investigate the subject of

[a] The author who provided this statistic is the director of the Armenian branch of the All-Union Scientific Research Institute for Problems of the Organization of Management. He appears to be heavily involved in developing a regional automated management system and the corresponding network, which may explain why he is so negative about department networks.

[b] The purpose of this section is not to give a comprehensive review of the potential for regional or branch level management systems. That would be the topic of an entire study. This section views the branch and regional systems only to the extent that they connect with enterprises.

republic-wide data networks (Meli86). At the present time, the Armenian republic has developed a standard design which has been approved in principle by nine republics, including Armenia. But the transfer of this technology is being delayed by bureauratic problems (Meli86).

Other networking approaches have been developed elsewhere. In Lithuania, the TsSU is unifying computer centers and machine calculating stations into a collective use computer network (Ivan86). In the Ukraine, a "three-terminal" network has been created linking the regional Gosplan, Gossnab, and TsSU (Glus80c).

In the Belorussian republic, a hierarchical network has been implemented with the republic Gosplan at the top, branch and oblast executive committee computer centers next, and TsSU centers and individual remote job entry stations at the bottom. The description of this network given by (Mart85c) leaves little doubt that it is based on the concepts of SNA. Because it includes both branch computer centers and the computer centers of the TsSU, the network is poised to capture data from almost all of the enterprises in the region. However, there are no direct connections to the enterprise computer centers.
In Latvia, a design has been developed for the automated data processing system (ASOD) of a region. This ASOD, which is centered in the Valmeira district in Latvia, is supposed to supply information to higher-level regional computerized subsystems for Gosplan, the TsSU, and other organizations (Vana86). Here there appears to be the possibility of direct links to enterprise computer centers, including enterprises of union subordination. "In administrative districts of the republic, as a rule, computer centers of other ministries and agencies are not being created, which means that there are favorable conditions for combining automated systems of all (TsSU) regional information computing centers into a unified territorial system" (Vana86, p. 31). The Latvian network also includes participation by the CPSU regional executive committees.

The ability to improve the management of the economy through the usage of RASUs depends on two factors. First, the telecommunications network is capable of providing lines for specific applications but is not capable of handling the kind of traffic that would occur in a region if all of the enterprises were transmitting substantial amounts of data. Second, as the second section of this study made clear, a substantial portion of data processing will continue to follow the "accounting approach" for quite some time; much work must be done before the regional organizations can easily collect machine-readable data from all the enterprises of the territories. In most of the regions surveyed, it is mainly the rigid accounting data that is being collected. Thus, while the first steps are being made towards linking up enterprise computer centers, the realization of integrated regional management systems will not occur for several years. The Soviets will gradually reap the benefits of linking these organizations.

A third kind of link, which is gaining more and more currency in the United States, is the direct linkage of heterogeneous corporations. We have seen no instances of such links in the USSR.

IASUs and Distributed Data Processing

In the late-1970s, the term "integrated automated management system" (IASU) began to appear in the ASU literature. An integrated enterprise management system is defined by V. Glushkov as "a system of management which solves interrelated tasks of management of the production processes of an enterprise and tasks of its organizational-administrative management in order to get the maximum economic effect from the work of the enterprise. (It) is an organic union of . . . ASUP and . . . ASUTP" (Glus79, p. 207).[10] Hence, the formal conception of IASU embraces the optimization framework developed for previous types of ASUs, but extends the production management capabilities of the ASUP all the way down to the level of using process control computers. IASUs represent the first attempts by the Soviets to adopt distributed processing.[11]

[10] IASUs have also been given the name ASUOT, or "organizational-technical automated management systems." It is under this name that specific guidelines for constructing ASUOT have been issued (Ormm80). These guidelines do not provide particular details about the nature of the subsystems of IASU, but talk mainly about the way that organizations should interact when building ASUPs and ASUTPs together.

[11] A distributed data processing system is characterized by having both the processor and storage facilities physically dispersed and interconnected by a network. This allows users to perform most of their data processing work locally but allows them to access the central computer when needed.

Functional Extensions of ASUPs. One of the chief characteristics of ASUPs that were built in the 1965-80 period was that their many subsystems were poorly linked together (More83). In many cases, specific tasks and specific subsystems accessed their own, separate files, which led to a great deal of information redundancy and inconsistency. The absence of integration was due partially to small capacity disk drives, small main memories, and the absence of data base management software. But it was also a result of the desire of enterprise managers to avoid changing the organizational structure of management and implementing integrated analytical tasks which might disclose certain management practices. Implementing primarily accounting functions did not require large organizational changes. Despite the fact that economic-social factors were hindering the assimilation of ASUPs, designers seized on the absence of integration as an explanation for why the ASUPs results did not meet expectations, predicting that as soon as ASUP subsystems and ASUTPs could be integrated, their impact would be much greater.

In October 1985, an all-union conference was held in Novosibirsk on the subject of IASUs (Glus86). Although not all details are known about how IASUs work, a record of this conference and several recent articles provide a broad overview of what IASUs are. At least three major organizations have been heavily involved in building IASUs, and the designs which have been created by them will serve as the examples for this discussion.

The first of these is the Computer Center of the Siberian Department of the Academy of Sciences. This organization has been involved in the ASUP program from the mid-1960s on, and is the creator of the well-knowm Barnaul and Sigma ASUPs. The Barnaul ASUP, which was implemented on a second generation computer and installed at the Barnaul Radio Factory, was the first ASUP to explicitly address problems of the surrounding social-economic system as part of the design. In the transition to third generation computers, the Barnaul ASUP became the Sigma ASUP. It has been installed in as many as 60 enterprises. The Sigma designers are now emphasizing four key ideas for its further development (Bobk86).

The first principle is decentralization of management. It embraces the idea that this is needed in order to bring about the "intensification of production." In theory, autonomous units can be treated as black boxes with management through goals and incentives. Unlike almost all other ASUPs, Sigma has always set up its system so that each shop could have its own computer or at least so that the data processing would be divided along production divisions rather than trying to build the system for the whole enterprise as a single entity. This principle recognizes that each ASUP user subgroup has different needs and interests, and that these are best served by hierarchically coordinated, autonomous units. Once this kind of hierarchical information system is in place, the next step is to ensure the autonomy of lower levels by only allowing aggregrated data to flow upwards. This will also increase efficiency by drastically reducing data flows. A multi-level system of models is being developed for Sigma which consists of long range forecasting, annual planning, and calendar planning for production management (Glus86).

The second principle is the introduction of interactive computing. This is the best way to support decision making, especially through the use of interactive, multi-criteria optimization models. The third principle is the use of sound software engineering methods. It is recognized that the software needs to be adaptable to the conditions at other enterprises, and that it will also be in a continuous state of modification and improvement. The last principle is the use of a distributed database scheme which flows nuturally from the way that the ASUP is divided.

It is not clear to what extent all of these principles have already been realized in the Sigma ASUP and whether or not there are any factories at which they are all in use. Previous innovations in the ASUP, such as providing incentives for workers to enter accurate data into the database, led to some marked successes at the Barnaul Radio Factory and elsewhere. As noted above, it ultimately ran up against difficulties because of the connections with the external environment (Podk79). In any case, the ASU Sigma probably represents the most radical extension of the ASUP program because of the amount of autonomy for sub-enterprise units that it presupposes.

The IASU which has been implemented at the Leningrad Turbine Blades Factory Production Association imeni 50th Anniversary of the USSR (LTB) is a hierarchical distributed data processing system. It probably is an example of the work which is being done at the Leningrad Electrical Machines Plant (Lenelektronmash), which is one of the biggest developers of ASUPs in the USSR (Mche85). It uses an ES-1035 at the highest level, an SM-1420 at the next level, and an SM-1800 at the lowest level, and uses a fair amount of off-the-shelf software, which is a cornerstone of the Lenelektronmash approach.

The LTB system conceives of management as consisting of a number of layers, each carrying out certain production management functions. The top layer is production planning and accounting, followed by layers for calculating parts and assemblies requirements, capacity planning for work centers, and tasks designed for actual management of production. Data is collected from the fifth level, which is a series of robotized flexible production complexes (Melt83). Rather than dividing up management tasks along functional lines, as in previous ASUPs, the LTB system takes an approach which is similar to the MRP-II concept in the West. The MRP-II philosophy says that production needs should drive everything else that happens in the corporation, which is quite consistent with the Soviet system. Interactive processing is built into some of the packages that form the basis of this system (Melt86).

A different approach has been taken by the Minsk Central Design Engineering Scientific Research Institute of the Organization and Technology of Management (TsNIITU) (Mikh86f; see also Iasu85). TsNIITU is also one of the largest developers of ASUPs. In the Sigma and LTB cases, considerable management reorganization was necessary in order to incorporate the IASUs. In the TsNIITU scheme, the existence of an ASUP is taken as a given, and the emphasis is placed on developing the lower levels of production management. As in the LTB system, the lowest level controls the operation of particular pieces of production equipment. The next level performs regulation, accounting, and reporting functions. The third level carries out daily shift planning and accounting, maintains data bases of production norms and production processes, and interfaces with the traditional ASUP.

The IASU program is primarily directed at linking up previously isolated subsystems and extending the use of computers all the way down to the shop floor. Other IASU developers have spoken about a horizontal broadening of functions as well, integrating the processing of information from computer-aided design and manufacturing to sales (Akho77; Glus86). It is germane to note that the number of IASUs reported in the literature remains quite small. Moreover, certain large enterprises where ASUPs were already in effective use probably were chosen for test implementations of IASUs. Nevertheless, the fact that an all-union conference on the subject was held indicates growing interest. It is likely that the ASUP program will move forward under the banner of IASU or its equivalent, ASUOT (Glus86).

Infrastructure Support for Distributed Processing. As in the case of ASUPs, the success or failure of IASUs will hinge both on the ability of the infrastructure to deliver the necessary hardware, software, and services and on the ability of enterprises to make effective use of IASUs under the current social-economic constraints. The key IASU areas that need development, according to the recommendations of the 1985 all-union conference, are: "using modern database management systems that are oriented toward the end user; inclusion of optimization and simulation models; expansion of the use of off-the-shelf software; (and) computer networking with flexible architecture and software compatibility" (Glus86, p. 376).

The Soviets have made some progress in at least three of these areas. A number of database management systems are currently available in the USSR, and an integrated set of tasks has been built for IASU using the SETOR-SM DBMS (Melt86; Stoy86). Most DBMSs use either the hierarchical or network models, which make them considerably more problematical for end users, and using a DBMS is sometimes constrained by limited amounts of main memory and disk storage. Other DBMS weaknesses can be pinpointed, but from a technical standpoint, this is not nearly as much as a barrier as it was a few years ago.

The incorporation of optimization and simulation is much more difficult, because it involves the surrounding economic situation, as will be discussed below.

Expansion of the use of off-the-shelf software is an area where the new GKVTI is expected to play a significant role. Until now, the main broker of software in the USSR has been the Tsentrprogrammsistem Production Association (TSP) in Kalinin. As originally conceived, TSP would house a national fund of algorithms and programs, maintaining the programs there and providing vendor services for them to users. In practice, TSP has had a hard time maintaining high quality standards for the software in the library. Ironically, TSP has now been given responsibility for national quality testing of software, including operating systems; the application programs for economic, engineering, scientific and technical and information retrieval functions and general-purpose application programs; as well as service programs for technology, control and processing programs, and software expanding the capabilities of operating systems (Kise86c). It is often hard to build composite systems using TSP packages. N. Gorshkov (head, GKVTI) remarks:

> In the past 10 years we have developed more than 700,000 different variations of programs but not more than 8,000 are registered in the all-union fund and only a few hundred titles are disseminated throughout the country in the norm of products. This is in part because our computer owners, be it an enterprise or an association, do not share their programs with others. These others, in effect, repeat the effort at colossal costs. Furthermore, it is still quite difficult to obtain a program ready to go because there are no legal rules or economic norms (Deni86b, 2).

Gorshkov has also stated that most of the programs have not been registered in the libraries because of their low quality (Mikh86d). The GKVTI is now poised to establish its own nationwide organization of computer associations which will be responsible for everything having to do with computing in a region (this is discussed at greater length in the next section). It is too early to say whether or not GKVTI will do a better job than TSP in disseminating and servicing software.

In the meantime, certain packages are available that can be used for building an IASU. When the LTP IASU was being constructed, about 70-75 percent of the functions were implemented using off-the-shelf software. The remainder of the software was coded by the production association itself (Melt86). Some of the IASU software is the result of a joint CEMA program that was started in 1980 to develop these packages. The USSR was assigned the most important subsystems at the production association and enterprise levels, amounting to putting the traditional ASUP subsystems in a hierarchical context. At the lowest level, assignments were made for control of mechanical processing lines, integrated-automatic sections, and mechanized warehouses (Sede80). The SM-Satellite program, developed by the Bulgarian-Soviet Interprogramm organization, is one of the products of this agreement (Melt86; Stoy86).

Some progress has been made in the field of local area networks, but this is most likely to be a bottleneck. Unlike wide area networks, which must generally use telephone lines and are characterized by relatively low transfer speeds, local area networks have the advantage of small distances, which translates into high speeds and transfer rates. A number of the largest scientific research centers have built local area networks of various sorts, but most would be considered rudimentary by Western standards. Many of the connections would not even be considered local area networks, because they consist only of hierarchically subordinated computers. Some do use more sophisticated protocols, but have slower transmission speeds. This is a function both of the lines they are using and of the speeds of the computers used in the networks (Mche86h). The Hungarians have actually done considerably more work in this area than the Soviets (Kova86e).

To date, the number of industrial enterprises which have even simple, hierarchical, low-bandwidth connections between mainframes at a computer center and mini- or microcomputers on the shop floor remains small. One network that has been created is called Estafeta ("relay"), and is a product of the State Design Engineering Institute of ASU in Ivanova. Estafeta has a ring architecture, uses regular twisted pair wires at distances of more than one kilometer, and can link up to 125 devices. It is in use at the International Center of Scientific Technical Information. "On its basis it is planned to create an office automation system, use it for flexible manufacturing, and of course, for collective use information" (Kash85, p. 4).

The KONET LAN was developed at the Institute of Cynernetics of the Estonian Academy of Sciences in collaboration with the Hungarians. At one megabyte per second, this is one of the highest speed LANs in the country. In 1984 it passed international testing at the Institute of Electronic Control Machines (INEUM) (Mart85b; Tava84). Because it uses a 34-bit frame, it may be suitable for industrial control applications. Another LAN intended for industrial use is based on fiber optic cables and is a development of the Institute of General Physics (Mosp85e; Mula85). The new Interbranch Scientific Technical Complex for personal computers may be involved in this (Mosc86).

These examples show that the Soviets have been able to begin putting together most of the right pieces for industrial LANs. It is hardly true that one can buy an off-the-shelf network in the USSR, and the most noticeable missing piece is firmware which implements network protocols. In collision detection networks, for example, the overall speed can be reduced tremendously if the chips which sense the state of the line are too slow. There are still shortages of terminals, and certainly the production rates of personal computers are not high enough to support a large number of LANs for the time being. Nevertheless, hardware and software are not the significant hindrances they once were. Whether or not building distributed processing systems is considered desirable is another question.

Challenges for IASU in the Soviet Environment. Most people, including managers, think of the first stage of computerization, when bookkeepers are forced to turn in their abacuses, as the hardest stage. In fact, this is the stage where applications that will directly save money are most obvious, where the algorithms are simplest, where the design is least complicated. The more sophisticated an information system, the harder it is to integrate into an organization unless that organization has both designed the information system it will use and gone through the organizational development and learning necessary to assimilate it.

The use of IASU has several consequences for the organizational structure of enterprises. First is decentralization. As noted in the review of IASU designs above, upper level management is conceived of as exercising only a long-range planning function; no longer are top-level managers to interfere in operational management. One of the obstacles to ASUPs, however, has been the fact that upper level managers insist on making so many decisions themselves. The result is that highest priority decisions are delayed while secondary ones are made by subordinates (Mche85). Changes in information flows naturally lead to changes in the organization of work and distribution of responsibilities. Many managers have formed a "psychological barrier" against ASUP because they do not want their situations to be changed (Mche85; More83). When tasks were only partially automated and the existing management system was mirrored in the ASUP design, there was not such a great threat.

If upper management fears that distributed processing will reduce its control too much, lower-level management may worry that it will actually lead to greater centralization. As in the relationship between enterprise and ministry, subunits of the enterprise also have incentives to hide their true production capacities, hoard supplies, etc. The designers of the Sigma ASUP recognize this danger and have apparently explicitly designed the system so that the subunits have control over their information. In the LTB system, however, the distribution of processing serves only to link all of the levels even more. If information flows are changed in such a way that subordinates can no longer feel safe about engaging in illegal or quasi-legal practices, the burden of carrying out such activities will be shifted upward, potentially putting enterprise directors at greater risk.

Finally, the integrated ASU may put the enterprise as a whole at greater risk of not fulfilling its plans. Consider the case of a computer-aided design and manufacturing system. The CAD system designs a part so that the amount of metal that is used is minimized. The planning subsystem of the integrated

ASU pulls out the derived metal norms, multiplies by the number of parts that are to be produced according to plan targets given from above, and submits a request to Gossnab for just the right amount of metal. This leaves no reserve whatsoever for the enterprise, because once the metal allocation is made, it becomes quite difficult to arrange for more metal. The integrated ASU leaves the enterprise at greater risk.

The rhetoric of the IASU drive sounds like the rhetoric of the ASUP campaign. The goal is still optimizing the performance of the enterprise, and the model in use is still the desired formal system of management which does not recognize the realities of the Soviet social-economic situation. The whole design methodology of the ASUP program has been carried over, and IASUs are still being built in a top-down manner. This is not like the idea of bookkeepers being allocated microcomputers and discovering on their own how best to use the machine under their circumstances, as foreseen in an earlier section. Only if the enterprises with IASUs are given high enough priority that they can be isolated from the shocks of the surrounding economy are IASUs likely to bring about large benefits for those enterprises. Most enterprises will have little incentive to pursue them. One of the tasks given the GKVTI is to figure out how to get a lot more organizations interested in using computers.

Gorbachev's Reforms and Enterprise Computing

The Gorbachev administration no doubt sees computerization as one of the keys to the so-called "intensification" of the economy: increased labor productivity without substantial new capital investment (e.g., Mikh86d). Gorbachev has so far attacked the computerization problem largely from the supply side. A set of reforms have been introduced in order to improve the performance of the computer industry. The broader reforms may have a limited effect on how enterprises perceive computing.

Changes in the Computing Infrastructure

The four parts of the Gorbachev strategy with respect to computing are increasing production, reorganizing the management of industry, creating new interbranch organizations for computing R&D, and increasing the quality of production.

Investment in the computer industry is to rise substantially in the 12th FYP. During this period, the computer industry as a whole is to grow anywhere from 100 to 140 percent, including the production of 1.1 million personal computers (Akhm85; Lepi86; Naum86; Prav860304; Tryb86m; Tryb86n). Disk storage capacity is scheduled to increase by a factor of three, along with substantial increases in printer throughput and new peripherals to go along with the personal computers (Kolo86). The number of ASUTPs is to almost double, as is the stock of industrial robots (Prav860304). Eight thousand automated work stations are to be introduced for technical and white collar workers (Akhm85). In 1987, the output of the computer industry is to increase by 19.5 percent (as opposed to 16 percent previously announced), and mass production of personal computers is to begin (Sots86d).

This growth represents an unprecedented expansion of the Soviet computing industry. In the past, it has seemed that Soviet industry was not up to such changes. Given the rates at which countries in the Pacific Rim have managed to master the production of clones, however, it is not inconceivable that the Soviets will satisfy a large part of this target by the end of the FYP. If they do not, and if Gorbachev is still in power, he will have no choice but to introduce even more sweeping reforms in the organization and incentive system of the computer producing ministries.

The second part of the strategy is the creation of the new State Committee for Computing and Informatics (GKVTI). The committee is a result of a resolution from the Central Committee and Council of Ministers called "On Improving the Coordination of Work in the Field of Computer Technology and on Heightening the Effectiveness of Its Utilization" (Izv860422). According to this resolution, the main tasks of GKVTI include:

- Radically raising the technical level of computer hardware and improving its use in the economy.
- Defining the main directions of development of computer technology and computerized information processing and overseeing the fulfillment of

decisions of the Party and government on questions of development, production and utilization of computer hardware.

- Ensuring the integrated development of the production of computer technology and solving inter-industry problems.

- Coordinating and overseeing targeted computer technology programs.

- Conducting and coordinating the training and retraining of specialists in this field.

Perceptions of what the GKVTI will do vary. N. Moiseyev, of the Academy of Sciences Division of Information, Computing, and Automation, describes the GKVTI's responsibilities in the following manner:

> According to the decree of the Communist Party Central Committee and the USSR Council of Ministers, the GKVTI has been given the responsibility for coordinating the entire effort of creating, manufacturing, using, and maintaining computers in the country's economy. Performing these tasks, of course, requires a structural reorientation and this will affect more than one ministry and department. Fundamental changes have long been necessary, since the low quality of domestic computers and the inability (or reluctance) to include them in the appropriate organizational structures is holding back scientific-technical progress and has become a barrier preventing management of the economy from moving to a new level. The resolution also gives GKVTI the ability to make binding policy in its areas of authority (Izv860422).

N. Gorshkov, the committee's head, does not go as far as Moiseyev in implying that a structural reorganization will take place, however. He merely says that the "main purpose of the committee is to unify the efforts of ministries and agencies for the creation and effective use of modern, high-throughput and reliable computers, and also to carry out a unified scientific-technical policy in this area" (Mikh86d, p. 2). He does affirm that some organizations under ministries, departments, the GKNT, Gosplan, and Gossnab will be transferred to the GKVTI.

What is the policy to which Gorshkov refers? "We have been called to take upon ourselves the leadership *(rukovodstvo)*, coordination, and monitoring of the realization of the program of "electronization" of the national economy in all spheres" (Mikh86d, p. 2). The work of the GKVTI is therefore linked with the decree on the "nationwide program of creation, development of production and effective use of computer technology and automated systems to the year 2000" which was approved by the Politburo in early 1985 (Eg85d; Prav85; Yasm86). It has yet to be published in full and may not even exist as a single document. But it apparently calls for better service; more hardware standardization and specialized computers; new training measures; the integration of process control, computer-aided manufacturing, and ASUP; and the introduction of computer workstations at the sub-enterprise levels. The program also endorses OGAS and the GSVTs, confirming both of the trends outlined earlier. Goals for the GKVTI as outlined by Gorshkov include (Mikh86d, p 2):

- An information industry which relies on automated technology and means for the creation, production, and effective use of software.
- The creation and wide introduction of data bases and knowledge bases for various categories of users with the possibility of broad access for all categories of users.
- The development of local, territorial, and a state network of computer centers, including supercomputers to microcomputers and data transmission devices.
- A system of computerized education of all levels of society.

The GKVTI is setting up computer service centers (TsVU) on the basis of service subdivisions of Minradioprom, Minpribor, and the TsSU. Two hundred of them are already in existence (Deni86b). Along with the "local organs," which probably means the local Party committees, these centers are to be the "law givers" *(zakondatel')* in the region. The exact meaning of this phrase is unclear, but it seems to imply that they are slated to play a similar role to Gossnab territorial organizations as brokers of the supply of computer services. The TsVUs will perform maintenance, repair, education of specialists, and distribution of software (Mikh86d). They will serve as a means to collect comprehensive information about how computers are used and what is needed where (Deni86b). Another possibility is that the TsVUs will

Further Tasks Outlined for the GKVTI
By N. Gorshkov, August 1986

Regulation

- *Create new normative documents for development and use of computers.*
- *Require ministries and departments to do a total software inventory.*
- *Require ministries to create branch-wide databases accessible to those who need to have access within the branch.*
- *Create new legal documents to increase personal responsibility for the information delivered by information service personnel.*
- *Set up an inspection office to check on the quality of scientific research and experimental design decisions at computer plants.*

Provide Hardware Services

- *Revamp the entire system of servicing computers.*

Provide Software Services

- *Create state system of software.*
- *Offer software engineering tools at TsVUs which include all "hardware and software instrumentation, mathematical models and systems of modeling, workbenches for debugging and testing finished products, and the consultation of highly qualified specialists."*
- *Register all programs in the national library, advertise them, and distribute them through software factories.*

Provide Computing Services

- *Possibly eventually take over the TsSU computing system.*
- *Possibly take over rental dispatching services which function in a few cities now.*

Promote Computer Usage

- *Create a new educational system for computer specialists and train others to have a real desire to use the computer in their work.*
- *investigate new user-vendor relations-e.g. users would rent machines and only pay for time the machine was actually working.*

cooperate with or absorb dispatcher services for the rental of computer time (Pans86). The TsVUs will be part of large production associations which will also include factories for computer repairs, software production, scientific-educational centers, and territorial libraries of algorithms and programs.

Scientific-production associations, which will cooperate with the Academy of Sciences, will also be a part of the committee's system (Mikh86d). The GKVTI will head a new center for Informatics and Electronics, which may be the lead organization of an Interbranch Scientific-Technical Complex (MNTK) (Deni86b; R1rb86d). No further information about this has yet surfaced.

Gorshkov has made several other statements about the kinds of changes that GKVTI will introduce (inset). But it is difficult to distinguish between what has been implemented, what is definitely the responsibility of GKVTI, and what is posturing by Gorshkov to try to gain turf. Nonetheless, Gorshkov's statements offer an intriguing vision of how the Soviet "informatics industry" might work.

It is significant that Gorshkov himself is a former deputy Minister of Minradioprom. His portfolio there was computer service, where he oversaw the expansion of the SoyuzEVMkompleks service organization, which was founded in 1976 to service ES computers. SoyuzEVMkompleks can hardly be called an unmitigated success, but it was a marked improvement over what existed before. The original charter for SoyuzEVMkompleks provided for the establishment of regional centers and repair services in all cities with more than five ES computers (Myas77b). By 1978, centers and repair stations existed in 43 cities (Ples78). In some areas, however, its penetration has been minimal, as in Western Siberia (Nest84b).

The services offered by SoyuzEVMkompleks are by no means universal. By 1983, Minradioprom had extended centralized servicing to 60 percent of the computers in the country, including about 50 percent of ES machines (Gors83; Novi83). A new program called for fulfilling all requests by users to subscribe in the 1983-85 period and raising the overall level of acceptance to 80 percent by 1985 (Gors83). However, a 1985 article charged that Minradioprom provided service to only 40 percent of the computers it produced (Eg85d). Services vary by distance from service centers (Novi83). Organizations which cannot subscribe to SoyuzEVMkompleks, including organizations waiting for initial debugging of their computer after it has been installed, typically wait two months for service calls to be answered (Vino83). Because SoyuzEVMkompleks holds exclusive control over spare parts for ES computers, enterprises which have their own engineers must turn to them anyway (Nest84b). Thus, Gorshkov's record is not fully convincing, although it appears that he has at least some of the experience and contacts necessary to perform well in his new job.

In sum, the GKVTI is supposed to play a role similar to what Western computer companies do to actively promote effective usage of computers. The GKVTI does not, however, have direct control of the production of computers, which may lead to further difficulties. Where it does not have control, it will try to exert pressure by inspections and regulations, which are much weaker forms of control in the Soviet system.

Although not all details about what the GKVTI will do are known, the statements cited here present a rather concrete agenda for the committee.

The third measure to improve the computing infrastructure has been the establishment of at least one MNTK for computers. The MNTK PC, for personal computers, has been set up under the leadership of the Institute for the Problems of Informatics, headed by Boris Naumov.

Interbranch Scientific-Technical Complexes address both the problem of continuity in the research and development cycle and the problem of ministerial "departmentalism." As mandated by a joint resolution of the TSKKPSS and SMSSSR (Prav851213), MNTKs are to consist of scientific institutes, design engineering organizations and experimental enterprises, each of which may fall under the jurisdiction of different ministries. In many cases the lead organization in the MNTK will be an Academy of Sciences Institute, which is a radical departure from past practice. They are to produce experimental models of new machines, equipment, or material in designated fields of advanced technology (Izv85o). The initial plans called for creating 16 MNTKs (Izv85o; Pank85). Since the initial announcements, several others have been mentioned, including ones which also have a republican basis (Deni86b; Lave86; Sovm86b).

Some of the tasking of the MNTK PC is known. It is working with Minelektronprom on designing school computers. With Minelektronprom, Minradioprom, Minpromsvyazi, and Minpribor, the MNTK PC is to develop software for all domestically produced computers, "based on a standardized system." The MNTK PC is cooperating with other CEMA partners in developing a program for a new generation of PCs under the "electronization" banner. It is participating in the drive to create production of tens of thousands of PCs initially, then hundreds of thousands, and then millions (Naum86).

Since the initial announcement, there has been considerable publicity about the problems that have been encountered in setting up MNTKs. Because each one is different, it is dangerous to generalize based on a few cases. The statement of Boris Paton in October, 1986 has held true for the MNTK PC, at least initially. He reported that "although the status of MNTKs has been defined and confirmed, in fact they exist only as scattered, hard-to-manage conglomerates of scientific research organizations and enterprises" (Prav861018, p.3). In July, 1986 the MNTK PC was housed in 17 buildings scattered throughout Moscow. It was receiving almost no support from the computer-producing ministries, who considered it to be a passing fad. Gosplan and the GKNT were also ignoring its requests for support. No experimental or test production facilities had been provided. Four different ministries were already producing their own personal computers (Naum86).

The funding of MNTKs has been something of a problem. Organizations that are nominally subordinated to the MNTK but are funded by their ministries are not likely to follow the commands of the MNTK. In June, 1986, each participating organization in an MNTK was still funded by its own ministry, leading to problems of coordinating their overall work (Kono86e). In September, before he moved to the Academy of Sciences, G. Marchuk related that GKNT has a reserve from which it can furnish additional financing and manpower for MNTKs. The MNTKs are supposed to be able to draw funds from the bonus funds of the enterprises themselves. Marchuk also mentioned a centralized fund of hard-currency revenues based on sales of licenses and products abroad (Lepi86). It should be noted that none of the sources can be expected to make up sizeable portions of the MNTK budget. There is also evidence that MNTKs will be funded from the state budget, although they are eventually supposed to be self-financing (Moze86). Two representatives of GKNT claimed in June, 1986 that MNTKs were receiving sufficient financing and priority supply (Vash86). Marchuk also notes their priority status, but also intimates difficulties because MNTKs were formed after everything was already allocated for the 12th FYP (Lepi86). The bottom line is that funding will probably come from a variety of sources and will exert a negative influence on the successful integration of the MNTKs. How this will specifically effect the MNTK PC, however, is not clear.

In addition to the MNTK PC, the Latvian Republic MNTK "Mashinostroyeniye" (Machinebuilding) has been created as of December 1986. It has several responsibilities related to computing, including robotics, information systems, and computer-aided design. It is said to be planning a republic designing-system network with central facilities located at the center, and automated work-places located at industrial enterprises (Lave86). The scope of the activities outlined for this MNTK indicate that it may be seen as a general high-technology development center for the republic, which could be interpreted as a creative way to use the flexibility given by the resolution on MNTKs.

Thus, it is still much too early to judge the impact of the MNTKs on the Soviet computing industry. General problems, such as funding, abound; yet each MNTK is different. In the case of the MNTK PC, the high importance of the tasks and support from the GKVTI may ensure that the necessary resources are allocated, and some progress will probably be made beyond what could have been expected without them. But will this progress be enough?

A fourth change which might affect the computer industry is a new resolution from the Central Committee and the Council of Ministers "On Measures for Radically Raising the Quality of Products." Developers of products and processes will now have personal responsibility for ensuring that their work meets the standards of the highest world levels. Gosstandart has been setting up offices directly at plants to monitor quality (Eg86d). The effectiveness of the resolution is called into question by the following factors. First, it is hard to believe that designers will be held personally responsible when it is so hard to get comprehensive information about what is going on in the West.[12] Second, it is hard to believe that substandard products will not be accepted. The consequences—for workers, enterprise managers, ministry officials, enterprises waiting for the equipment—would simply be too severe otherwise.

Other measures may have some bearing on the performance of the computer industry. For example, new organizational structures are being developed for scientific-production associations. Important issues, such as the extent to which Minradioprom should (or is able to) continue following IBM, must be decided. With the new profile given to computing by GKVTI and the large investments, the computer industry is likely to do somewhat better in the 12th FYP. The GKVTI will face powerful vested interests in Minradioprom, Minpribor, and so forth, but if it can start to fulfill its promise, the performance of the computer industry may improve markedly. Will the economy be able to respond by absorbing these machines?

Changes in the Surrounding Environment

It is more difficult to track the evolution of those reforms which will affect the enterprise environment, and consequently influence the way that enterprise managers perceive computing. Few of the measures will affect the fundamental incentives described in the second section of this paper. As mentioned above, Philip Hanson has described a planned switch to wholesale goods under the control of the State Committee for Material Technical Supply (Gossnab)

[12] Over the past few years, as the Soviets have increased compliance with international copyright laws, it has become harder to obtain foreign publications (Alek86). On the other band, ministries do produce small pamphlets which cover developments in the West. These are often issued, though, in press runs of 500 copies or less. These booklets themselves are prepared by researchers who have limited access to the Western press. Even if there were unlimited access, it would be rather difficult to pinpoint a target which is moving as fast as the Western computer industry.

(Hans86g). Even if this reform is fully implemented, which is doubtful given the record on wholesale supplies from the 1965 reforms, late supplies are more a function of taut planning and the transportation system than who controls their distribution. Unless Gossnab can significantly reduce supply delays, this measure is likely to have little effect on ASUP.

A second set of measures is designed to reduce ministry interference in enterprise affairs. The shift to superministries, large groupings for enterprises, and the elimination of all-union production associations are intended to promote autonomy by severely limiting the extent to which central bureaucrats can oversee their enterprises (Hans86g). The TsSU has recently announced that enterprises will have to provide 50 percent less information to state organs (R1rb86d). A provision for stable five-year plan targets, which has been on the books since 1971, would allow enterprises to get away from the influence of planning from the achieved level.

If enterprise directors are convinced that there will be less direct oversight, they may be more willing to use optimization routines and do more analysis with computers. If one of the means envisioned for controlling enterprises was to collect more and more data through the TsSU system, through branch automated management systems, and through the automated systems of other organizations such as Gosplan, Gossnab, and the Ministry of Finance, then the extent to which less data is being collected is one way to measure the success of Gorbachev's decentralization drive.

The Gorbachev administration is pushing for the collection of fewer statistics as a means to remove the stranglehold that ministries have on their enterprises (Koro86b). So far considerable reductions have been announced, but a further cut of 50 percent has been required, and all agree that much more work needs to be done (Vest86b; Vest86d; Vest86f). The reductions have probably not even been enough to offset the tremendous rise in the collection of statistics in the 10th and 11th FYP periods —70 and 60 percent respectively (Vest86d). Ministries have spent millions of rubles to build their automated systems (OASUs) which now collect huge amounts of data (Doma86; Guzh86; Koro86b; Shen86; Vest86c; Vest86d; Vest86g; Vest86k). There is a large bureaucracy associated with building the State Network of Computer Centers. All of these interest groups have reason to stand in the way of further decentralization. The Gorbachev administration has thrown down the gauntlet: ministries and departments have been forbidden from assigning indicators to associations and enterprises which have not been approved under the management conditions which are spreading as a result of the experiment started by Andropov a few years ago (Maye86).

Other measures which might ensure more autonomy are also moving slowly. Most ministries have so far remained intact, and it seems unlikely that they will be dismantled (in favor of any superministries) in the near future. Only Minpribor has so far eliminated all-union production associations. Philip Hanson is extremely skeptical about the prospects for stable plans; they would have to contain considerable slack, which is certainly not the case for the 12th Five-Year Plan. Gorbachev's initial campaign for discipline, which was "gleefully" taken up by the bureaucrats, may lead to greater interference (Hans86g). The ORMM-*uchet* program, which could lead to less enterprise autonomy, is still being pushed.

Another set of measures will allow a select group of enterprises to begin engaging in direct foreign trade (Hans86g). Only 70 of the larger associations and 20 ministries had been given this right as of October 1986 (Poli86q). The lure of foreign markets and hard currency may increase incentives for more sophisticated computer usage, although these enterprises are still subject to the same economic incentive system at home. Some joint ventures with Western firms may be permitted (Eg86e), which could provide a crash course in the management of information for the Soviet participants.

Conclusion

The ASUP program failed to live up to its objectives for two broad reasons. On the one hand, the computer industry failed to deliver reliable hardware and robust software. Service was poor. Technical limitations lowered the ceiling on the applications that could be implemented. Even more important was the lack of demand for computing services which went beyond accounting. Although it is prestigious to have a computer, it is not wise given the current economic incentive system to use it too well.

Several measures have been initiated by Mikhail Gorbachev to improve the computer industry. If the State Committee on Computers and Informatics (GKVTI) is able to perform all of the tasks it has been given without running into a lot of bureaucratic interference, the performance of the computer industry should pick up considerably. Producing a high volume of personal computers is considered to be a particularly high priority. History demonstrates that the Soviet system is well-suited for high priority, high resources projects. It would be hard to believe that they could not produce at least an order of magnitude more personal computers per year by the end of the FYP.

Continued progress will be made in the mechanization and automation of accounting. More and more enterprises will send their data out for processing, either by the TsSU or the branch. This will facilitate storage and use of the data for other purposes, such as by regional authorities. But these kinds of processing only satisfy the need for preparing reports for TsSU and Minfin. The voluminous internal calculations of the large majority of organizations which need computing will be done in a variety of ways which do not fit together very well. All of this perpetuates the use of the so-called "accounting approach," whereby enterprises are given and use only static reports. The accounting approach mirrors the traditional organization of the enterprise and leads to few changes in the way it is managed. The microcomputer offers a means, for the first time, by which large numbers of white collar workers can manage their own data processing directly.

One of the key issues for the Soviet economy is the extent to which the Gorbachev administration will be able to free up the enterprises from the heavy hands of their ministers. The less data collected, the harder to exert specific control. Yet ministries and regional agencies are in the process of building networks which will give them even greater access to all sorts of data. The construction of a nationwide network for collecting and dissemination information through OGAS and the State Network of Computer Centers continues. For the first time, the use of personal computers is giving smaller organizations a means to avoid this centralized processing, which may ultimately constrain the implementation of OGAS.

It is well-known that Mikhail Gorbachev is banking on technology to implement his intensive growth strategy. This can be done by process control, robots, and flexible manufacturing, but ultimately the problem of the wide-spread adoption of management information systems within enterprises must be confronted. Computerizing enterprise management is risky for managers not only because of possible interruptions in production, but also because it threatens some of the fundamental ways that the enterprise does business under Soviet conditions. The future of the ASUP program revolves around integration of all sorts of functions, which is actually harder to achieve than initial computerization of accounting. The construction of these systems will continue to proceed in enterprises that have traditionally been successful with ASUPs and in newly constructed enterprises, but the 12th FYP will continue to emphasize direct automation measures.

Numerous reforms have been initiated by Gorbachev which affect the enterprise environment. The implementation of the first reforms is uneven; others are still being formulated. The force of some will undoubtedly be blunted by the bureaucracy. What is needed most to spur the use of computers in enterprise management is real autonomy. Enterprises must have flexible, adequate sources of supplies, they must have good incentives for using optimization, and they must feel secure in maintaining realistic data in their computers. In principle, the combination of centrally controlled wholesale trade, stable five-year plans, elimination of all-union production associations, and collection of far less data might work together to provide a better atmosphere for ASUPs. The Soviets have a long way to go just to implement these measures.

Given the lead times involved in designing information systems and training personnel, the enormous number of enterprises that still have limited experience in data processing, and the time needed for the economy to absorb Gorbachev's reforms, there can be no quick, major, overall improvements from computerization of management. Hundreds of thousands of organizations are in the midst of a gradual evolutionary upgrading of the way their information is processed and used. Because organizational units have so little autonomy, the rate of change cannot be very fast. Computerization is a long-term structural change. It has occurred so quickly in the United States because of the pressures of the marketplace to keep up with the competition, because of corporate autonomy, because of considerable marketing pressure from the major vendors, because small vendors have filled the most varied niches, and because the vendors have generally delivered sufficient equipment for the tasks at hand. The ASUP, the IASU, and other Soviet computing applications, however, involve so many aspects of the external operation of the enterprise and the surrounding social-political system, that management-oriented computing will remain one of the hardest technologies for the Soviet enterprise to absorb.

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Appendix A

Acronyms Involving ASU

ASP-ASU	Automated System of Design of ASU
ASU	Automated Control System or Automated Management System
ASU-GPT	Automated Management System for City Public Transportation
ASU-GU	Automated Management System of the Main Administration of VUZes of the USSR Ministry of VUZes
ASU-IP	Automated Management System for Instrument Production
ASU-MTO	Automated Control System for Material-Technical Support
ASU-MTS	Automated System for the Control of Material-Technical Supply
ASU-NIOKR	Automated System for the Control of Scientific Research Work and Experimental-Design Developments
ASU-NT	Automated System for the Control of the Development of Science and Technology
ASU-PRIBOR	Automated Management System for the Instrument Building Industry
ASU-TSEN	Automated Management System for Price Formation - under Goskomtsen
ASU-VUZ	Automated System for the Management of Educational Institutions
ASUK	Automated Quality Management System
ASUKR	Automated Management System for Coordination of Developments
ASUM	Automated Assembly Management System
ASUNE	Automated System for the Management of Scientific Experiments
ASUNS	Automated Management Systems of the Non-Production Sphere
ASUNT	Automated System for Management of Scientific-technical Progress of the USSR State Committee for Science and Technology
ASUO	Automated Association Management System
ASUOP	Automated System for Management of Experimental Production
ASUOT	Organizational-Technical Automated Management System
ASUP	Automated Enterprise Management System
ASUPKR	Automated Management System for Design-Engineering Work
ASUPP	Automated Management System of Industrial Enterprises
ASURPO	Automated Management System for Republic Industrial Associations
ASUS	Automated Warehouse Control System
ASUS	Automated Management System for Construction

ASUT	Automated System for the Management of Trade
ASUTO	Automated Management System for Territorial Organizations
ASUTP	Automated System for Process Control
ASUTPP	Automated Management System for Production Engineering
ASUUR	Automated Management System for Accounting Operations
ASUVD	Air Traffic Control System
ASUVPO	Automated Management System for All-Union Industrial Associations
ASUVSH	Automated Management for Higher Educational Institutions
ASUZHD	Automated Railroad Management System
ASUZHT	Automated Management System for Railroad Transportation
IASU	Integrated Automated Management System
IASUP	Integrated Automated Enterprise Management System
KASU	Integrated Automated Management System
MASU	International Automated Management System
OASU	Automated Management System for a Branch of Industry
OASU-R	Republic Automated Management System for a Branch of Industry
OASUT	Automated Management System for the Trade Branch of Industry
RASU	Republic Automated Control System
TASU	Territorial ASU
VASU	Departmental Automated Control Systems
VASU-R	Republic-level Departmental Automated Control System

Appendix B

Selected Organization Acronyms Used in This Study

ANDRO-POV	Andropov Engine Building Production Association
CCITT	Consultative Committee on International Telephone and Telegraph
CEMA	Council for Economic Mutual Assistance
COCOM	Coordinating Committee for Multilateral Export Controls
CPSU	Communist Party of the Soviet Union
DEC	Digital Equipment Corporation, Maynard, Mass.
GKNT	USSR State Committee for Science and Technology, Moscow
GKVTI	All-Union State Committee for Computer Technology and Informatics, Moscow
GOSPLAN	USSR State Planning Committee, Moscow
GOSSNAB	USSR State Committee for Material and Technical Supply, Moscow
GOSTAN-DART	USSR State Committee for Standards, Moscow
GOS-STROY	USSR State Committee for Construction Affairs, Moscow
IBM	International Business Machines Corporation, White Plains, NY
INEUM	Institute of Electronic Control Machines, Moscow
INTER-PRO-GRAMM	Interprogramm Bulgarian-Soviet Scientific Research and Design Institute, Sofia
LENELEK-TRON-MASH	Leningrad Electrical Machines Plant, Leningrad
LIMTU	Leningrad Institute of the Raising of Qualifications of Industrial and City Workers in Methods and Technology of Management, Leningrad
LTP	L'vov TV Plant, L'vov
MINELEK-TRON-PROM	USSR All-Union Ministry of the Electronics Industry, Moscow
MINELEK-TRO-TEKH-PROM	USSR All-Union Ministry of the Electrical Equipment Industry, Moscow
MINFIN	USSR Union-Republic Ministry of Finance, Moscow
MINPRI-BOR	USSR All-Union Ministry of Instrument Building, Means of Automation, and Control Systems, Moscow
MIN-PROMS-VYAZI	USSR All-Union Ministry of the Communications Equipment Industry
MINRA-DIOPROM	USSR All-Union Ministry of the Radio Industry, Moscow
MINS-VYAZI	USSR Union-Republic Ministry of Communications, Moscow

MSB	Moscow Savings Bank, Moscow
ROBO-TRON	VEB Kombinat Robotron, Dresden, GDR
SIGMA	Sigma Production Association, Vil'nyus
SMSSSR	USSR Council of Ministers, Moscow
SOYU-ZEVM-KOM-PLEKS	All-Union Computer Systems Association
SOYUZS-CHET-TEKH-NIKA	All-Union Main Administration for Accounting Equipment
TASS	Soviet News Agency
TSEMI	Central Economics-Mathematics Institute, Moscow
TSENTR-PRO-GRAMM-SISTEM	Tsentrprogrammsistem Scientific Research Association, Kalinin
TSKKPSS	CPSU Central Committee, Moscow
TSNIITU	Central Design Engineering Scientific Research Institute of the Organization and Technology of Management, Minsk
TSSU	USSR Central Statistical Administration, Moscow
VGPTI	All-Union State Design-Engineering Institute for the Mechanization of Accounting and Computer Work, Moscow
VNIIPOU	All-Union Scientific-Research Institute for Problems of Organization and Management, Moscow
VNIPIU-CHET	All-Union Scientific Research Institute of Accounting

Appendix C

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