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TITLE: THE SOVIET UNION AND THE PERSONAL COMPUTER "REVOLUTION"

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SUMMARY

The basis for an evaluation of the current Soviet personal computing capability, and leading from that to an estimate of its potential through the end of the century, is a profile of personal computing resources in their generation and consumption by the Soviet economy. To this end, we examine the phenomenon in a four-stage process. The stages, (1) design, (2) production, (3) installation and (4) perception, proceed up from technical incarnation to application. This examination also needs to be aware of world developments applicable to the Soviet economy. At each stage, therefore, the internal developments are considered in parallel with external options.

The Soviet Union is experiencing great difficulties in all of the four stages discussed above, from design to incorporation into the economy. In many respects, the USSR is at square one in terms of matching the tremendous Western success at disseminating personal computing technology throughout the economy and society. Unquestionably, however, they have identified widely disseminated computing resources as a critical need, demanding increases in both resource production, and in technological awareness among the workforce. At the same time, there lies a substantial gulf between the words and the deeds.

In principle, the Soviets have received sufficient direction from Western achievements to enable them to begin the first major investment in PC resources, and the products of U.S. industry are being embraced as models. Particularly indicative of this is the decision to use the IBM PC as a CEMA-wide standard,

Despite the fact that the Soviets' design decisions have been in many ways made for them by the momentum of the world market, problems in production represent a bottleneck to any growth. Computer systems, with considerable requirements for quality control and precision assembly, have fared poorly in large-scale production. Such systems as are produced are poorly supplied with peripherals. Supporting industries such as service and software, whose growth in the West followed directly on that of the hardware supply itself, are rudimentary at best in the Soviet Union. In part this can be ascribed to the scarcity of hardware to demand the complementary industries, but one also gets the impression that a great many of the steps necessary to promote personal computing as a resource as a whole are not being taken.

Were the production problems to be solved, or sufficient economic flexibility acquired to make substantial imports from the West a viable alternative, there would still be a need for investment in the infrastructure. The poor operating environment in most Soviet facilities, including problems with reliable power, and sources for service and maintenance, is a considerable barrier to keeping a personal computer system up and running. The Soviet telephone system is poor at best, and the question of whether or not networked personal computing and PC bulletin boards might aid in the dissemination of dissident material is more or less rendered moot.

At their current rate of growth in all of the underlying and dependent technologies, the Soviets are failing to make personal computing available in the economy. The four stages discussed above only take personal computing to the level of first perceptions in society, but it is not possible to look much past that.

Only in the last year or so have there been signs of intent to begin serious production of PCs. If the models now being introduced for serial production prove to be viable as useful tools, we might expect personal computing in the Soviet Union to attain a solid foothold in the third stage of the model by the end of this century.

It is not clear that the Soviets are wholly prepared to make the commitment required to turn the domestic situation around. In some respects personal computing could be called a "critical but not necessary" technology for the USSR. Should it continue on the current path of economic development, personal computing will remain a nascent technology. The alternative is to institute considerable reforms and serious investment in a great many contributing sectors of the economy, all requiring substantial improvement before personal computing will be able to flourish.

The Soviet Union and the Personal Computer "Revolution"

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Introduction

The idea of a personal computer "revolution," specifically in the U.S. and other industrialized countries, is defensible on the strength of achievements in two areas. In terms of production, personal computing resources have become so profuse as to afford a considerable amount of "slack," or idle time, such that users are not constrained to routines or schedules, but are free to make use of the technology as they find convenient. Unlike early mainframe systems, to which human resources were sacrificed for the sake of keeping the expensive hardware fully tasked, personal computers are, for the most part, idle. When required they can be fully slaved to the needs of a researcher, or engineer, or executive, or housekeeper, or student, to make the individual more productive. The first component of the "revolution" is the realization of a sufficient mass of the resource to change its character from that of a scarce commodity demanding humans' time, to a widespread resource that can be employed at will.

The second component involves the social perception of personal computing. Simultaneous with the evolution from a scarce to an abundant commodity, there has been a steadily growing acceptance of personal computing as a universally applicable tool. Whereas computers have enjoyed extensive application in manufacturing and large business environments, personal computers are proving

themselves at all levels in business, in engineering, and throughout the economy as personal workstations. The two components together define a revolutionary transformation of computing, from an exotic technology to a widely consumed resource.

Personal computing in the U.S. has been far less directed from above than driven by various interests from below. The high degree of slack provided by the surplus of personal computing has served to make it a discretionary resource. Severe economic deficiencies hampering production efforts, and a generally poor infrastructure, preclude any such slack in the USSR. The Soviets are attempting to insinuate personal computing into the economy by fiat, in an environment that may not be ready for it. At the same time there is a degree of experimentation with personal computing by individuals, an introduction from below. A small but steady flow of resources from West to East is providing at least some nourishment to a grass-roots familiarity with PC technology in the USSR and throughout the CEMA community [1].

There is no evidence to discount the assertion that the Soviets are "responding" to Western personal computing achievements. Several official decrees, in particular the Politburo decision on promoting secondary school computer literacy, have set ambitious goals for the introduction of personal computers into the economy [2] [3] [4]. Attention is also being paid to Western systems, software and experience. Empirical study shows the Soviets willing to directly transfer Western technology, adopting many of the same architectures, in the interest of accelerating the development of personal computing resources [5] [6]. It is difficult, however, to see how fundamental obstacles can be overcome to permit a comparable, revolutionary advance in the Soviet economic and social environment.

The Scope and Character of U.S. Personal Computing

The PC production industry in the West has without question passed through its initial phases of growth, and personal computer hardware and supplementary software are well-established technologies. The industry leaders such as IBM and Apple have succeeded in promoting a viable set of standard systems produced in sufficient quantity to support subsequent software production [7]. The later success of "scavenging" second-source producers in duplicating the leaders' systems have given the industry a sufficient coherence and mass to project

personal computing systems into wide application [8] [9]. We are now seeing evolutionary changes in a considerably matured industry. A current concern of the leading U.S. producers is to maintain control in an environment fast becoming a commodity market, that is, to wrest back portions of the market lost to clone and compatible producers [10]. Regardless of whether the industry leaders manage to retain their share, the last several years have seen a strong growth in a market of proven architectures, and software to complement them. The supply of personal computing in the U.S. and elsewhere in the West has grown enormously as a result.

Looking at the scale of the industries as a whole, the value of the U.S. personal computer hardware and software markets in 1984 was in excess of $16 billion in 1984, and is expected to reach more than $53 billion by 1989 [11]. The number of PCs being absorbed by the U.S. business sector has risen steadily from some 300,000 in 1981 to an estimated 3.7 million new PCs in 1986 [12].

At the same time a sizable percentage of the personal computer market is devoted to home and school use. A 1985 Future Computing Inc. survey of IBM PC and Macintosh purchases placed 2 percent of the 1.8 million IBM PCs and PC/XTs, and 17 percent of the 292,000 Macintoshes, in the schools, and 20 and 49 percent respectively in homes [13]. A 1986 survey of U.S. public school districts showed microcomputers in 91.4 percent of all schools, up from 16 percent in 1981-82 [14]. At the same time the ratio of microcomputers to students increased from 1 per every 750 students in 1981, to 1 per every 30 in 1986 [15].

In terms of application, the latest PCs have enabled some work previously impossible or uneconomical. For example, office word processing and desktop publishing promise to make professional quality presentation affordable to small firms and even individuals [7].

A five-phase "pervasiveness" model may be employed to describe the progress of a technology from inception to complete absorption by society [16] (modified from [17]):

1. An experimental rarity, often an entrepreneurial or laboratory discovery.

2. An exotic tool or toy used by a small group of experts.

3. Products that are well known and manufactured in modest quantity, but

direct use is limited to a small fraction of industrial or other institutional environments.

4. Widespread production and availability, with direct use requiring little or modest training in a broad domain by a sizable minority of the population.

5. The technology has become part of the fabric and infrastructure of daily life, and its absence is often more noticeable than its presence.

Despite significant barriers that still exist to making PCs useful to (and usable by) all classes of people, personal computing in the U.S. is, by this model, squarely in phase 4 [16].

It would be optimistic to predict a rapid transition of personal computing to a phase 5 technology. The utility of the telephone and television is clear, but only a small part of the U.S. population has an immediate need for personal computing, or would suffer greatly from its absence. And the enormous reduction of prices seen over the last several years notwithstanding, a personal computer system configured to meet the average user's needs is still several times more expensive than the most expensive of "indispensable" household appliances. But personal computing, coupled with an enhanced communications environment afforded by such advances as Integrated Services Digital Network (ISDN) technology and various commercial network services, may closely integrate with, and certainly augment, both telephones and televisions as a component in the global information system in the decades to come.

Personal Computing in the Soviet Setting

The study of Soviet developments in personal computing should be considered not only with regard to the technical level achieved, but in comparison to the market success achieved in the West. That is, while the Soviets may have achieved an equivalent technical proficiency for a given system, the more important question is whether or not that system can be expected to be replicated in sufficient quantity, disseminated with sufficient support, and accepted in its application. By "sufficient" we mean at least in quantities to encourage wider use, and continued growth. A key component in the transition of a technology from phase 3 to phase 4 in the pervasiveness model is the widespread dissemination of the technology outside of an initial, narrow user community.

Some of the factors that have lead to the growth of personal computing as an industry in the West may have some bearing on future Soviet developments. For example, the rising level of participation by foreign producers of the industrialized and newly industrializing countries of the Pacific rim in the supply of the U.S. personal computing resource pool suggests a number of options heretofore unavailable to the Soviets.

Technically, the strategies of the U.S. industry leaders may exert considerable influence on Soviet choices. Like with previous programs in mainframe and minicomputer systems, the Soviets are basing many of their personal computing decisions on U.S. research and development, through replication of U.S. systems. Various deficiencies in the Soviet economy, and incentives to be risk averse in order to safely meet planned quotas, make the transfer of proven technology a reasonable course of action.

The basis for an evaluation of the current Soviet personal computing capability, and leading from that to an estimate of its potential through the end of the century, is a profile of personal computing resources in their generation and consumption by the Soviet economy. To this end, we examine the phenomenon in a four-stage process. The stages, (1) design, (2) production, (3) installation and (4) perception, proceed up from technical incarnation to application. This examination also needs to be aware of world developments applicable to the Soviet economy. At each stage, therefore, the internal developments are considered in parallel with external options. More than in other areas, the Iron Curtain is proving permeable to Western personal computing achievements and experience.

Developmental Stages

Design

Indigenous Technological Capability

Clearly Soviet developments will be in the context of their own domestic technological capabilities. Soviet R&D will not be designing systems Soviet industry is incapable of producing. Though import may help meet Soviet personal computing needs, a domestic production capability is critical given the USSR's position

as a military superpower, and desirable for a number of other reasons. From a pedagogical perspective the lack of Cyrillic-based programming languages and applications packages may have a negative impact on the acceptance of computing; the need to "Russify" Soviet computing has been discussed in the literature [18]. And even if the needs for computing resources could be completely satisfied through import, the PC production technologies are necessary to many other sectors of the economy. Neglect in promoting a domestic industry capable of PC production can be expected to impact on many of the other features that distinguish a self-sufficient industrialized economy. Telecommunications and production automation, both of which are relying more and more heavily on the microelectronics industry, grow from the same research and development roots. Indigenous system design will proceed apace with the supply of the necessary component technologies by that domestic industry. At the same time, the external developments of the West can be expected to have both "trailblazing" and "bootstrapping" effects on Soviet planning.

External Models

The West has provided "proof-of-concept" research and development in the successful systems now on the market. For example, Apple took considerable risks in its design of the Macintosh, with its then radical architecture. The market failure of the Lisa, the Macintosh's immediate predecessor, was a part of the price to produce one of the most successful personal computers now available. The now-proven Macintosh, with its successors, is a potential architecture for Soviet developments in the next decade. The Western industry leaders have presented the USSR with a set of technically sound options, in effect blazing a low-risk trail.

At the same time, the compatibility with existing Western systems permits a bootstrapping in an environment where all the supporting industries may not have been sufficiently formed to support a wholly indigenous effort. The Western software sector experienced its strongest growth only some time after the hardware industry, as might be expected. The success of such producers as Microsoft and Lotus Development Corp., once the hardware became available in quantity, has been considerable. Lotus' 1-2-3 spreadsheet software has been identified as one of the major contributing factors to the IBM PC's popularity, that is, the initial hardware base supported software that then demanded that level of power and functionality.

The Soviet software industry is primitive by comparison. For it to grow to match planned hardware growth from what is essentially a standing start would have to involve substantial modifications to Soviet economic practice. While there has been a good deal of experimentation in organizational and economic reform under Gorbachev, the USSR simply cannot match the enormous growth that such entrepreneurial corporations as the now major software producers enjoyed in the U.S. At the same time, while the lack of hardware has been commented on and used as a focus for economic reforms to enhance production, it is not clear that Soviet planners properly perceive the need for comparable growth in the software and supporting industries. By selecting compatible systems architectures, however, the Soviet PC producers can put their systems into use despite an inadequacy in domestic software production, making use of widely available Western software.

Three systems serve as illustrations: the IBM PC, and its clones and compatibles, the Apple Macintosh, and the Elektronika BK-0010. The IBM PC has been chosen explicitly as a standard model for both Soviet and CEMA production [19] [20] [21] [22]. Because of a high degree of correspondence between current Soviet microelectronics capability and the requirements of what is a proven Western design, the IBM PC almost ideally fits current capabilities [23]. The microelectronic basis for the IBM PC, i.e., microprocessor and its support chips, was probably identified by the Ministry of the Electronics Industry (Minelektronprom) as its next logical step after the introduction of the first major microprocessor families at the end of the 1970s [24] [25] [26]. The IBM PC was designed as basically an open system, with off-the-shelf technology. That is appealing given the the Soviets' component supply sector, which has offered little in the way of production of "equipment-oriented" circuits custom-designed for specific applications. The wide availability of IBM PC-compatible software only increases its suitability.

The Macintosh, on the other hand, while proven in the Western market, is unbuildable given mid-1987 Soviet technological capabilities. It has received almost no attention in the CEMA literature. As the Soviet microelectronics industry has closely followed the U.S. Intel line (8080 and 8086), and does not produce equivalents of Motorola microprocessors, this is not surprising [27]. It is possible that both the Motorola 68000 (the basis for the Macintosh) and the Macintosh itself may be pursued in the next decade, depending on the level of growth achieved in microelectronics production, which thus far is restricted in both volume and scope.

The BK-0010 represents a response based on a purely indigenous, current capability. While the BK-0010 is actually a derivation of minicomputer technology taken directly from Western developments (the DEC PDP-11 family), it is not patterned on a Western microcomputer design, and has minimal compatibility with Western personal computing resources. For example, the BK-0010's ROM-based programming language is DEC's "Focal," not Basic [28] [29] [30]. As such it is unable to achieve much in the way of bootstrapping, as discussed above. Consequently, it has been reported as being inadequately supplied with software and peripherals, poorly documented and is meeting with little acceptance [1] [29] [30] [31] [32].

An additional benefit accrued by adoption of an externally proven design is in the use of imports of complete systems to augment domestic production.

Responsibility

While the production volume of all Soviet PC models is very low, the number of ministries, institutes and other organizations experimenting with PC design is rather large, and can be attributed both to the ease of designing microprocessor-based hardware, and to the fact that no final distribution of responsibility for PC production has yet been seen in economic plans. Given that a PC might be little more than a microprocessor with some supporting components relatively easily acquired in small quantities, it is not surprising that such models as the Timur, Irisha and Mikrosha have been seen as prototypes, constructed by institute design groups, and individuals at scientific and academic organizations [31] [33] [34] [35] [36]. Additionally, the USSR has provided considerable support for amateur radio as a hobby, which could support "homebrew" efforts. The journal *Radio* detailed a microcomputer, the Radio-86RK, which could be built from schematics supplied in the magazine [37] [38].

The two ministries responsible for mainframe and minicomputer production, the Ministry of the Radio Industry, and the Ministry of Instrument Making, Means of Automation and Control Systems, produce personal computers in one form or another, as does Minelektronprom itself. Whereas minicomputers and mainframes have always been produced by Minelektronprom's consumers, the ease of microcomputer production coupled with the lack of specific tasking to any ministry or group of ministries has encouraged all related parties to make some efforts. Similarly, both East Germany's Microelectronics Combine and

Hungary's Microelectronics Enterprise have designed their own computers for the first time, in bids to enter the PC market [39] [40] [41] [42].

Production

One of the most significant barriers to the promotion of personal computing in the Soviet Union is the poor production capacity demonstrated by its domestic industry. The USSR suffers from low production rates, incoherence in production responsibility, and a generally poor level of quality control. To some extent difficulties in production have provided for more slack in the previous stage; there is no great pressure to apply CAD resources to computer system design for example, as even the simplest models have yet to go into large-scale production. On the other hand, production difficulties will seriously impact later stages.

At the same time, the world market's character has changed substantially toward a more "generic" or commodity perception of personal computer systems, and a freer market for lesser players and less-industrialized nations [10].

The commodity nature of PC technology has made it easier to freely substitute components by different producers, and to form secondary sources. The generic IBM PC is now the market standard in the U.S., and less and less distinction is being made between an original and a "clone." The enormous increase in personal computer imports by the U.S., both of complete and semifinished systems and components, is a measure of the degree to which the various technologies have been farmed out to alternate producers [43].

As of early 1987 no Soviet personal computer model has achieved a cumulative production of more than a few thousand units, with the possible exception of the BK-0010. While various production figures, and evidence of some sales may place the BK-0010 in the range of up to ten thousand units or so, the vast majority of machines mentioned in the Soviet press are at the prototype stage only [44] [45]. The Agat, an Apple II clone widely discussed as the first Soviet personal computer, has been discontinued, due to a problem of obtaining components like disk drives [46] [47] [48]. Total production of Agats probably did not exceed 2-3 thousand units. The BK-0010 represents a retrenching at a technical level more compatible with Soviet industry, and is reminiscent of the earliest U.S. PCs, using a television set as a monitor, and cassette recorder for program storage [20] [29] [46]. Such personal computer models as have been seen as

prototypes at exhibitions and trade fairs show little evidence of mass manufacture, and nothing has been seen in the literature to imply that any facility has begun serious production of PCs.

One step to try to rectify this problem was taken with the creation of an MNTK (Inter-Industry Scientific and Technical Complex) for Personal Computers (the MNTK PK) in December of 1985 [49]. A number of different MNTKs for critical technologies, e.g., fiber optics, robotics, membrane technology, have been formed. The MNTKs are intended to better integrate research organizations with production facilities, to cut across ministerial boundaries, with some reliance on Soviet Academy of Sciences institutes for leadership [50] [51]. There appears to be little interest in supporting the MNTK PK from the production ministries, however. [49]. The Academy institutes are only minimally funded for the task of organization of these complexes, and without strong support by the industrial partners may not have the resources to succeed.

At the same time, there is a growing possibility of beefing up the Soviet domestic production capability through acquiring complex components (such as Winchester drives, which have proved difficult to manufacture for all the CEMA countries which have attempted them), and purchase of production automation tools [41]. The acquisition of integrated circuit manufacturing technology and equipment has been ranked as high priority by most analyses of Soviet covert technology transfer policy and practice [52] [53] [54] [55] [56]. The Soviets have also evidenced some desire to purchase entire factories for PC production [57] [58].

While we know of no incidents of the Soviets making sizable purchases of PC production equipment from the West, or setting up a joint venture for PC production within the USSR under the terms of the new economic reforms, both have happened in other countries of the CEMA community. The Pravets Combine for Microprocessor Production in Bulgaria is using Japanese assembly and test equipment to produce IBM PC and Apple clones on the basis of largely imported components [59]. The Polonia enterprises are joint venture companies formed by Polish emigres supplying capital to enable Polish import and assembly of components unavailable in the CEMA [20]. Just why the Soviets have not done so themselves is not entirely clear.

Installation

The increased availability of systems and components on the world market would suggest benefits to the Soviets in the way of augmenting or preceding domestic production with imports. A number of economic barriers to this are not likely to be greatly diminished in the near future. These include (1) a monolithic organization of import/export practice, (2) a poor facility for the use of hard currency and investment capital, and (3) various trade and technology embargoes.

The first two problems make the purchase of PCs from abroad possible only to such massive organizations as Elorg (the Soviet foreign trade organization which covers computer technology), far removed from the area of application. There have been a number of changes begun under Gorbachev to widen the range of options, permitting smaller organizations to deal directly with Western corporations, but it is not clear if this will be much of a solution given the poor environment for capital investment [60]. It may be of little use for a Soviet institute to be able to contract directly with a Western PC supplier. Without the ability on the Soviet side to borrow against the anticipated profit, and with trade restricted to such mechanisms as barter, Western firms may not find the prospects attractive.

Export controls have done little to deny Soviet access to most personal computers products. Even before softening of COCOM restrictions on low performance PCs in 1984, Western PC systems were making their way east in modest numbers [61] [62] [63]. The Soviets have demonstrated an ability to acquire nearly anything, up to VAX systems and above, on a single unit basis, and there is no reason to believe that they do not have adequate "competitive" information on the relevant personal computing technologies with the exception of advanced microelectronics [64] [65]. The Soviet lag in basic production capability also relieves some pressure to acquire "state-of-the-art" information. If, for example, the Soviet Union chooses to clone the Apple Macintosh, it will have to widen its microelectronics base and master the Motorola 68000 (on the Western market since the end of the 1970s) before it needs to reproduce the rest of a system. That system itself is available for dissection and reverse-engineering now, and eminently suited to being smuggled across the border in a diplomatic pouch, if not merely trucked in across historically permeable borders in Austria or Finland. The ease with which the newly industrializing nations are cloning U.S. PCs is additional evidence of the lack of secrecy of the basic PC technology. Apple is pressuring the Brazilian government to curtail the cloning of the Macintosh by

Unitron. Unitron's copy of the Macintosh is a case of straightforward pirating of all of Apple's proprietary components [66].

Where the trade restrictions have had a much stronger effect is in making the large-scale purchase of systems and components a great deal more difficult. While systems have been trickling across East-West borders in ones and twos (in the more Westernized CEMA countries such as Hungary and Poland modern Western PC systems such as the PC/AT and its clones now number somewhere in excess of several thousand), coordinated purchases of powerful systems have been few [67].

Recently negotiations occurred between the USSR and two South American countries for the sale of personal computer systems. A purchase in the range of up to 100,000 microcomputers from Brazil ultimately fell through, and a comparable deal, totaling between $450-500 million, was signed with Novotec, a Peruvian company [68] [69] [70] [71]. The Peruvian agreement involved the purchase of 100,000 IBM PC-compatibles over a period of several years, in exchange for a package from the Soviets including cash, barter, and cancellation of Peruvian debts [71]. This requires that the Peruvian government act as an intermediary, with the Peruvian firm ultimately receiving payment in cash. The Peruvian sale illustrates the considerable difficulty in arranging for trade in computer systems; most Western corporations would be unwilling to undertake the lengthy negotiations, or be able to accommodate the Soviet problems with substantial hard currency expenditures.

Novotec's own success can be attributed to the same factors described above for possible increases in Soviet production with the growth of the world component market. While Novotec manufactures its own circuit boards, and required systems software, virtually all of the components, e.g., chips, disk drives, etc., are obtained on the world market. More and more countries are acquiring the ability to ship finished systems. As discussed in the previous section, even Bulgaria could be counted as a potential supplier of IBM PC-class machines to the Soviets [59]. Even if the USSR does not follow the same course, and augment its production facilities via component import, or acquisition of foreign manufacturing technology through direct purchase or the establishment of joint ventures, it will still be able to count on a much broader supply base for the import of finished systems.

With the availability now of IBM PC-class personal computers on the world market, the purchase of foreign systems is more appealing. The up to 10,000

non-IBM PC compatible MSX computers purchased by the Soviets in 1985 from Japan's Nippon Gakki, for example, proved to be suitable for little more than unsophisticated games [1] [47] [62] [72] [73]. With the adoption of the IBM PC architecture by the Soviets and the rest of CEMA, imported IBM PC clones could be integrated with domestic machines to provide PC resources better suited to the USSR's needs. The use of imported PCs, however, suggests certain caution. The Peruvian PCs have described as unreliable, placing additional demands on Soviet sources for service and maintenance.

Such service, and related infrastructural needs, are also of considerable concern to the installation of personal computing resources, perhaps as important as acquiring the systems themselves. The U.S. has had a very strong infrastructure, long before PCs required it, including a reliable telephone system and power network, and a flexible retail market that has taken over many of the needs of service and supply. Prior to freezes and cutbacks on their dealerships, as a result of the considerable price cuts that have occurred in the last few years, Apple and IBM each had in excess of 2,000 authorized dealers for their PCs [9] [74]. IBM's use of dealers to establish a wide sales and service base, instead of relying solely on direct sales, has been credited with the quick accumulation of several million IBM PCs in a wide range of applications [7].

The Soviet infrastructure, in contrast, is poor to nonexistent. The Soviet telephone system will require substantial investment merely to serve as a tool for person-to-person voice communications [75] [76]. Despite some increase in attention to the telephone system as a consumer need, it is likely to be some time, and probably not before the end of this century, before the system will be substantially improved. And that is only if current efforts can be kept up [77]. Comparatively, the Soviet telephone system handles far fewer calls than the U.S. system, with substantially fewer units (28 million telephones as opposed to 170 million for the U.S.), 2% of the U.S. volume in long-distance calls, and more than two orders of magnitude fewer international calls [77] [78]. And the quality of the connections is notoriously bad. Even in Moscow, where the system might be expected to be the most modern and best serviced in the USSR, the transmission quality is poor, to the point of being unable to support data communications, and wrong numbers are extremely frequent. The Soviet Ministry of Communications, Minsvyazi, has been singled out for severe criticism for the poor state of the system and the scarcity of telephones [79] [80] [81] [82].

Another likely bottleneck in the process of making PC resources usable is in

the area of service, including preventative maintenance and repair. Service even of large computer systems has been notoriously poor, and horror stories exist where several systems have been routinely cannibalized to keep one working [83].

The U.S. personal computer boom gave rise to, and in turn expanded on, a strong base of retail sales of hardware, software, and services. It is difficult to see potential for an analogous growth in the Soviet economy. The collection of ministries that share the responsibility for the PC infrastructure and production are far less cohesive than the producers in the U.S. market. Gaps, where a given need is not be filled by any of the ministries, have caused the supply of resources to be jerky and uncoordinated. The entrepreneurial opportunities in the U.S. economy that produced companies like Apple, and virtually all of the personal computer software firms, are absent in the Soviet economy. While the new Soviet reforms permit limited free enterprise, they do not address undertakings above the level of cottage industry. It should be noted that elsewhere in the socialist bloc, particularly in Hungary, entrepreneurial enterprises have been permitted to foster the growth of personal computing [84] [85] [86]. While the Hungarian economic work associations (GMKs) have been faulted for drawing skilled workers away from conventional enterprises, GMKs, and firms that have grown out of GMKs, have served to fill gaps in the economy [85] [87] [88] [89] [90]. Similar developments have occurred in Poland [91] [92].

Perception

The final stage of introduction of personal computing to the Soviet economy involves its perception, that is, given that systems have been selected, produced or otherwise acquired, and incorporated into work environments, they have then to be used. Personal computing being a mass phenomenon, one measure of the progress in this stage can be taken from the portrayal of personal computing in the media. In the U.S., substantial attention was paid to computing as it began to become pervasive outside of centralized data processing and strictly industrial applications. Recall that *Time* magazine named the computer as "Man" of the Year for 1982 [93]. The initial fascination with PCs in their own right may be considered as having passed; topics of interest have now passed on to desktop publishing and laser printing, powerful scientific workstations, and considerably expanded graphics capabilities. The PC itself is being submerged as a technology beneath the rapidly emerging applications it now supports. The final step will

be taken when PCs become so universally accepted as to be "more noticeable by their absence than by their presence" [16] [17].

Surveying the Soviet literature provides a very different perspective on personal computing. Of the few articles in the popular press as have been seen, the personal computer is portrayed as a very exotic technology. An article from *Sovetskaya Belorossiya* of this year discusses how the article was itself prepared on the personal computer being announced, a Soviet copy of the IBM PC, as if this were a novel occurrence [22]. The vast majority of personal computer articles in the more technical literature have to do with first uses of computing within an application, e.g., the use of PCs by pilots to calculate fuel consumption, previously done manually [94]. Almost nothing has been seen of PCs accessing electronic bulletin boards, or even using modems, or advanced peripherals.

One of the few areas where the Soviet government has been at least talking about a major effort to introduce personal computing into the economy is in the use of PCs in the secondary schools, and in the promotion of computer technology and programming as a "second literacy" (in reference to the push for universal literacy undertaken in the 1920s) [95] [96]. As part of a program for universal secondary school technical literacy initiated by the Politburo in 1985, a course on "Fundamentals of Informatics and Computer Technology" is now being taught in the 9th grade [2] [3] [97] [98] [99]. At the same time, plans for massive introduction of PC hardware in the form of microcomputer laboratories have achieved very little [100]. Some schools in the larger cities (Moscow, Leningrad, Novosibirsk) seem to have been well supplied. Moscow Public School No. 117, for example, was the beneficiary of 100 personal computer workstations supplied by the Institute of Cosmic Research [101] [102]. More commonly, stopgap measures, use of university and industry facilities, and "mobile labs" with computers bused to the schools, have been seen, and it is reasonable to assume that a great many schools have no computer resources at all [103] [104] [105] [106] [107].

The level of general "noise" in the media on personal computers may also be thought of as contributing to the non-formal computer literacy, in as much as it can create a demand for personal computing in the workplace to hasten its acceptance, and encourage an extracurricular interest among the youth, the next generation of the work force. So far the level of personal computer-related information in the media has been minimal, compared to the high levels in the West. The dozen or so magazines now in publication in the West devoted to each

of the popular PCs are matched by a small collection of articles in periodicals such as *Komsomolskaya Pravda*, or radio hobby journals [31] [37] [108] [109]. A number of personal computing clubs have been reported, in major cities like Moscow and Leningrad, where PCs can more readily be used, but they afford only a small fraction of Soviet youth limited access to computing [1] [107] [110] [111].

Conclusions

The Soviet Union is experiencing great difficulties in all of the four stages discussed above, from design to incorporation into the economy. In many respects, the USSR is at square one in in terms of matching the tremendous Western success at disseminating personal computing technology throughout the economy and society. Unquestionably, however, they have identified widely disseminated computing resources as a critical need, demanding increases in both resource production, and in technological awareness among the workforce. At the same time, there lies a substantial gulf between the words and the deeds. Without trying to stretch the analogy too far, the Soviet economic situation, of which the push for personal computing is a particularly potent indicator, is as that of an addict crippled by his condition, capable at the conscious level of seeing past his systemic problems, but incapable of overcoming them without great anguish.

In principle, the Soviets have received sufficient direction from Western achievements to enable them to begin the first major investment in PC resources, and the products of U.S. industry are being embraced as models. Particularly indicative of this is the decision to use the IBM PC as a CEMA-wide standard, dictated by the indigenous technical capabilities of the CEMA members, the increasing availability on the world market of components and experience, and confidence that deficiencies can be met via import.

Despite the fact that the Soviets' design decisions have been in many ways made for them by the momentum of the world market, problems in production represent a bottleneck to any growth. Computer systems, with considerable requirements for quality control and precision assembly, have fared poorly in large-scale production. Such systems as are produced are poorly supplied with peripherals. Supporting industries such as service and software, whose growth in the West followed directly on that of the hardware supply itself, are rudimen-

tary at best in the Soviet Union. In part this can be ascribed to the scarcity of hardware to demand the complementary industries, but one also gets the impression that a great many of the steps necessary to promote personal computing as a resource as a whole are not being taken. Certain major policy decisions have been made, for example, the creation of the MNTK PK to enhance interorganizational cooperation, but in too many other areas underlying problems are remaining unaddressed.

Were the production problems to be solved, or sufficient economic flexibility acquired to make substantial imports from the West a viable alternative, there would still be a need for investment in the infrastructure. The poor operating environment in most Soviet facilities, including problems with reliable power, and sources for service and maintenance, is a considerable barrier to keeping a personal computer system up and running. The Soviet telephone system is poor at best, and the question of whether or not networked personal computing and PC bulletin boards might aid in the dissemination of dissident material is more or less rendered moot.

At their current rate of growth in all of the underlying and dependent technologies, the Soviets are failing to make personal computing available in the economy. The four stages discussed above only take personal computing to the level of first perceptions in society, but it is not possible to look much past that. In terms of the five-phase model of technological introduction, personal computing in the U.S. is well into the fourth phase. The Soviets are at best just entering the third, slowly. A number of Soviet PC designs, like the Agat, were merely experiments with the technology, as if to make the claim that "we can do it too." Only in the last year or so have there been signs of intent to begin serious production of PCs. If the models now being introduced for serial production prove to be viable as useful tools, we might expect personal computing in the Soviet Union to attain a solid foothold in the third stage of the model by the end of this century. If, to be optimistic, the Soviets can manage to both reform the domestic economy and take advantage of the world market in the component technologies, it is even conceivable that it could be approaching the fourth.

The answers to two questions then should serve as indicators of the future for personal computing in the USSR: How will the USSR take advantage of a new world market in PC-related technologies?, and, What is the strength of its commitment to making substantial changes in the domestic economy? The enhanced opportunities for exploiting the world economy for components and

systems, should the USSR improve its flexibility and willingness to trade, could help it to fill in many of the deficient areas, while it organizes the rest of the sectors necessary for what is truly a massive new economic investment. The extent to which the USSR moves to take advantage of such opportunities to foster personal computing may be a gauge for many other economic areas. The few steps that have been taken need to be followed with concerted action. A third question is: To what extent will the West serve as a model for further Soviet developments in personal computing? There are strong indications that the evolution of world standards such as the IBM PC will be embraced by the Soviets due to their minimizing of research and development expenditures, and a bootstrapping effect through the availability of a pool of compatible resources already well-developed in the West.

It is not clear that the Soviets are wholly prepared to make the commitment required to turn the domestic situation around. In some respects personal computing could be called a "critical but not necessary" technology for the USSR. Should it continue on the current path of economic development, personal computing will remain a nascent technology. The alternative is to institute considerable reforms and serious investment in a great many contributing sectors of the economy, all requiring substantial improvement before personal computing will be able to flourish.

Expectations of personal computing's overall effect on the Soviet economy must necessarily be couched in rather pessimistic terms. Clearly, certain conditions will have to be met before some of the uses of PCs in the West can even be possible. For example, without substantial upgrades to the telephone system, and without the production of modems as PC peripherals, there cannot be personal access to subscriber networks, or the creation of bulletin boards. Whether or not that will come about remains a question. In a way, the severe deficiencies of the Soviet PC-related industries reduces the study of personal computing's impact by several dimensions. This work does not purport to deal with the larger question of an "information society," which the Soviets quite obviously are not, but which they may have incentives to try to become. The reader is referred to [16] for a treatment of that question. Personal computing by itself will probably not be a strong force for the creation of such an information society in the USSR; its considerable success in the U.S. has been based on previous strong growth of other sectors like those of telecommunications and the support infrastructure of the service industries. And, while PC use requires these components to be enhanced and integrated, the technology is more dependent on rather than deter-

mining of the progress toward their improvement. But personal computing has been recognized as a useful technology, as a component of the future economy, and steps are being taken to foster its growth.

The results of Soviet intentions toward the promotion of personal computing will only be evident some time in the future. It is not enough to make an evaluation that the Soviets have up till now "succeeded" or "failed" to equal, or compensate for, or absorb, Western achievements as if it were merely a question of relative success. It is clear even from the above, cursory examination that that sort of evaluation would find the Soviets sorely wanting. It is likewise probable that the Soviet technological lag will continue, and perhaps increase, as the West advances. An absolute comparison of the USSR with the West, while certainly valuable in its own right, is not the sum total of what we can take from an analysis such as the one above. What is equally as important is to determine how opportunities provided by both the development of new technologies, and new concepts, might be employed in the Soviet economy. It is important to note what the Soviets do or do not extract from the Western model, and to explore the degree to which Soviet choices are influenced by Western and world technological developments. Research in progress will also serve to better place the USSR within both the CEMA and world communities in terms of trade and transfer of PC technologies, and go into more detail on pre-PC small computer technology and its significance to the development of modern personal computing resources [112].

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