THE INFORMATION TECHNOLOGIES IN SOVIET SOCIETY: PROBLEMS AND PROSPECTS*

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July 29, 1986

* The author wishes to thank Dr. William McHenry for several valuable contributions and discussions.

Contents

0. Executive Summary

Will there be a Soviet-style information society?

The USSR will be compelled to develop and apply the information technologies on a wide national scale to support their own aspirations and to contend with foreign pressures. Much of this will be concerned with the preservation and enhancement of political and economic control and military power, and with economic modernization through both blue- and white-collar applications. It is also important for them to present the image of a progressive society to the world and to their own population, if only to maintain military credibility, proclaim ideological superiority, and to contend with Western influence and rising internal expectations.

What features might characterize a Soviet-style information society?

Roughly speaking, our model of a Western-style information society is described by general, intensive, somewhat unconstrained, problem-plagued, chaotic, and broadly debated and determined progress in many directions. The main trends are a result of driving forces which operate within the constraints and possibilities determined by systemic conditions.

Similarly, our model of a "Soviet-style information society" considers the driving forces, systemic conditions and constraints which are influencing the evolution of C&C (computing and communications) applications in the USSR. The combination of main Western trends is excluded under these circumstances; so a different compact characterization is necessary, and what is emerging is best characterized by goals rather than trends. Our analyses of past and current Soviet efforts and sensitivities identify four primary goals:

1. To attain real gains in productivity and to modernize the industrial base.

2. To maintain and improve the economic planning and control mechanism.

3. To support both military and internal security needs.

4. To present the image of a progressive society both to the people of the USSR and to the outside world.

These form an irreducible set in two senses: (1) Other goals, such as keeping up with the West or building a national computer education program, may be understood in terms of these four; (2) None of the four may be entirely understood in terms of the other three.

Compact models for both "information societies" are given in Table 3 (p.58).

A common thread that emerges from both models is the need and desire to improve control over increased complexity and opportunity and reduced time scales. Even fantasy and entertainment applications may be seen as quests for greater control. Both societies see the information technologies as increasingly necessary means for the control of production, distribution, and demand. Both see these technologies as means for the control of the dissemination of noneconomic information, for the control of military and intelligence activities, for controlling the volume and efficiency of communications, etc. Both are seeking to use the C&C technologies for greater concentration and greater distribution of control, but with different emphases. The trends in the Western model exhibit the very broad dissemination of controls for increased economic efficiency, for personal activities, and for more communications of all kinds. They also exhibit greater mixed centralization/decentralization controls in some government and economic activities. Prospective Soviet dissemination of controls is much more limited and focused. There is also a stronger element of political control and concerns in Soviet applications. But there is an increasing Soviet realization that some form of more distributed hierarchical control is necessary and desirable.

Prospective progress and problems to the Year 2000

Industrial modernization and gains in productivity

This is one of the Gorbachev administration's overarching goals, and success or failure here will greatly affect the extent to which the other three model goals are realized. The proposed means for achievement involve a combination of greater discipline, the elimination of waste, and automation. The C&C technologies have the potential for ameliorating the effects of a labor shortage, providing basic industrial modernization in both the manufacturing and the R&D sectors, increasing the volumes and quality of goods produced, imposing additional discipline, and helping to eliminate waste. These applications have the highest profile in the Soviet media, and are at the core of the program for computing to the Year 2000.

The most important questions concerning the effects of the systemic conditions on progress towards this goal are twofold. Will the Soviet information industries be capable of providing the technology to support industrial automation? Will the superstructure (general systemic conditions) problems that have plagued ASUP (enterprise MIS) for 20 years be much of an impediment?

There are two plausible views as to whether or not societally pervasive applications are necessary to support a sufficient infrastructure (the technical-economic-social environment of C&C applications) to meet this goal. The first holds that the Soviet C&C industries are large and not impotent. They cover the full spectrum of the relevant technologies. As long as they are not expected to meet the combined overall Western standards of extent of applications, technological level, sophistication of integration and service, the Soviet industries can perform at a reasonable level with the aid of foreign technology. They can be improved to where they at least better their undistinguished performance in support of the ASUP program. The need for a pervasive presence of microcomputers, entertainment applications, computer networks, etc. in Soviet society as a prerequisite for successful large scale industrial automation in the USSR has been exaggerated. One can learn to tend an FMS without having to have a microcomputer at home.

The second view holds that every stage of pervasiveness requires a corresponding support level from the infrastructure. The pervasiveness of applications (demand-pull) stimulates the infrastructure to respond, just as a healthy infrastructure fosters demand by making applications possible (supply-push). One can learn to tend an FMS without having to have a microcomputer at home, but can the infrastructure provide sufficient technologies and products without the demand base that home personal computers and other applications provide?

Our view is a hybrid. Significant resources will be added to the C&C industries to help them improve their performance and there will be improvements in infrastructure, but this will not be up to supporting pervasive applications across Soviet enterprises. However, pervasiveness in selected sectors might be possible and adequate. Demand pull has never been sufficient to prod the C&C industries into overcoming certain fundamental deficiencies in hardware reliability and service, and for software development and support. The Soviets therefore must unfetter the demand side by (a) unleashing some forces of private industry within the infrastructure, or (b) allowing enterprises to act more autonomously, or (c) by providing more and better equipment on the supply side to help stimulate demand.

Although it may not be as bad in some ways, almost all of the superstructural and infrastructural problems that afflicted the ASUP program during the last two decades will also handicap the industrial automation program. The main advantages CAM may have over ASUP are that measurable forms of Soviet-style, quantity oriented, productivity increases may be obtainable from localized use of industrial automation in the short term, and that Soviet managers and workers may perceive less risk from using CAM than MIS. But most of Soviet industry has not yet reached a level at which it is ready to try to reap the full benefits of of the information technologies. Within the Soviet environment, computing relieves some problems, but is an additional form of inefficiency itself and exposes others that it cannot correct.

The Soviets hope to overcome these problems through slow structural changes and technological improvements, and through the exposure of younger workers and managers to the information technologies at work and school. The latter may make more effective use of what there is and create some constructive demand from below in the short term, and perhaps see to better solutions in the long term. This seems to be the view held by several prominent academicians and technocrats, and they are gaining political support, perhaps because there is no better and feasible alternative.

This is not to say that little or nothing will be done. The Soviets have no choice but to try hard, and something will come of the effort. In the short term, there will be several prominent and perhaps exaggerated successes, but serious initial work and experimentation will take place both in high priority military-industrial and in lesser sectors. In time, islands of advanced industrial automation will emerge. The rest, perhaps most, of Soviet industry will be left behind in a backwater that will be more distanced from the advanced sectors and Western counterparts than is the case today. The selection process will reflect priorities given to the other three basic goals. We would expect to see the most rapid rate of introduction in ASUTP/TPC. The Soviets are adding more than 500 of these per year, and this rate can be expected to increase as a result of technical progress and emphasis placed on this area under goal 1. By the end of the century the most important, well-understood, and not exorbitantly expensive processes will be partially computer controlled. ASUP/MIS will continue to suffer from crippling problems, and will be introduced at the slowest rate. The introduction of robots and FMS will be at a rate between the first two, with the rate for robots being faster than that for FMS and more integrated forms of CAM. Even this level of success would help vindicate central planning and control and "discipline" as effective ways for running a country.

Even if the Soviets should be modestly successful in attaining the four primary goals, the gap between the relative Western-USSR standards of living may grow for the rest of this century. The information technologies have been contributing to some dramatic and high profile changes in this gap.

B. Economic planning and control

The USSR remains strongly wedded to comprehensive central planning. In the effort to maintain close control over an increasingly complex economic domain and planning process there is little choice but to turn to the C&C technologies.

The Soviets will continue to build national and and ministry-level systems. The fundamental problems to be faced again involve the ability of the infrastructure to deliver the necessary services, and the national ability to absorb the applications. However, by the Year 2000 there will probably be a substantial amount of data exchange via telecommunications and data base technologies will be widely used. Computers will be almost universally used to collect and process data from enterprises.

Three serious problems arise from the surrounding environment. First, the planning and control process is and will remain a highly political. Second, computerization has not substantially changed the nature of the data which is being collected, nor has it dramatically changed the way it is collected and processed. Finally, there is the problem of planning from the achieved level, on which much of the incentive system is based. Soviets at the highest levels have talked about these problems, but so far little has been done.

More pervasive use of computers for economic control might take some forms that would yield results by the Year 2000. For instance, the maintenance of large data bases of information may help the authorities uncover reporting inconsistencies and track down phony data. Planners should be able to make more use of the available data for analysis purposes. Faster reporting and analysis will be possible. But large scale optimal plans will remain out of reach.

It might be possible to solve some of the false data problems by using direct, sensor-based collection methods that are integrated with industrial automation. This would be enormously expensive, and would require that computing be used at all levels of the hierarchy, down to the shop floor, on a near-universal basis. It would also require a tremendous telecommunications infrastructure. This kind of universal and effective economic surveillance will not become reality by the end of the century.

Military and internal security and sociopolitical risk

Goal 3 exists in strong competitive-complementary relations with the others and with Western efforts and policies. If Western high-tech military systems are perceived to be the most important potential military threat to the USSR, then the Soviets will focus on developing the necessary technologies and industries to deal with this threat. This plausible long term response is consistent with our analyses, and is based on the premise that the Soviets value the other three primary goals for social and economic reasons that greatly transcend their contributions to military power. In this case, more resources will be poured into the C&C industries and important applications sectors to the benefit of all four goals, and less may be poured into more conventional military means which contribute far less to the other three goals. This would help preserve and modernize Soviet military power vis-a-vis the West, and it is also a sensible approach with regard to China.

Success in the pursuit of goal 3 will depend on aspects of civilian-military relations in the C&C industries. Ideally, there should be a mutually beneficial, complementary relationship between a strong set of C&C industries and strong user communities, as has been the case in the West. It can be argued that many of the problems of the Soviet C&C industries stem from the lack of a strong feedback relationship with a world-class user community, and that the Soviet military and military-industrial sectors fall short of being such a community. Conversely, it may be argued that Soviet military-related applications suffer because of the problems of the C&C industries. The military and military-related industry and R&D organizations enjoy many privileges, but these do not make them a C&C using community comparable to the general purpose users in the US, Western Europe, and Japan.

Some substantial part of the detailed technological push for the Soviet C&C industries comes from the examples provided by the Western military and civilian user communities. Does the Soviet military need a general computing base that is broader and deeper than the one it is capable of building and supporting entirely within itself? Yes, as is evidenced by the way it uses Western computing communities as a surrogate for what it does not have at home. Furthermore, for all its resources and privileges, the Soviet military cannot control all that is necessary to build a civilian computing base comparable to that in the West, or even to put pressure on the Soviet C&C industries comparable to the pressures that exist on Western industries.

For at least the rest of this century it is unlikely that Soviet progress in the C&C technologies will strengthen them to the point where they can broadly catch up with or surpass Western military applications. In order for that to happen, we believe the West must stumble or fall down.

There is little evidence to the effect that the KGB is doing particularly well in the use of the information technologies for for domestic surveillance. This may be the case because these applications would clearly be of value to such an agency; they are within current technical capabilities; the KGB can obtain the necessary resources to make them realities; and there are few constraints to prevent them from doing so.

In time, we would expect additional use of the C&C technologies in the form of embedded, somewhat transparent, surveillance in systems which are used by the population on a daily basis, e.g., the telephone system. It is important that the surveillance is not obvious, but that everyone be conditioned to think it might be there. In the past, resource constraints prevented the Soviets from making such surveillance really pervasive. Computers will not immediately bring this about, but may make the present system work more effectively and eventually lead to higher surveillance levels.

It is unlikely that the Soviet population will see Orwellian-like surveillance during this century. The reasons are threefold: they are well beyond current technology; a nationally pervasive system would be enormously expensive; and they could not be imposed on the population by anything short of a return to a neo-Stalinist regime. The effort to do so might even destabilize the political system.

Of the technologies and applications considered in this study, few taken alone present as much sociopolitical risk as some Western analysts have claimed or that the Soviets seem to fear. Soviet authorities remain very cautious with regard to the widespread introduction of any of the information technologies that have serious potential for being used to increase exposure to information from foreign sources, that may be willfully used for dissident activities, or which increase the volume of two-way communications. Soviet concerns for secrecy, and the importance they attach to presenting a unified front and showing that they can control information, will continue to severely retard the introduction of the information technologies and handicap the achievement of at least goals 1 and 4.

However, if there is to be substantial progress towards all four goals, it will be necessary for the Soviet leadership to permit and encourage the much expanded utilization of the information technologies. The inevitable result will be less effective containment controls over an expanding user base than had been possible in the past, e.g., when photocopy machines were the main concern. Control of photocopiers was relatively simple, and the economic cost of such control was easily acceptable against the potential risk. This will not be the case with some of the newer technologies of Table 2 (p.40).

On balance, for the rest of the century, expanding C&C applications will be more of a problem with regard to internal security and information control than it will be an asset for increased surveillance. In the past the Soviet authorities had all the technological advantages. This is shifting fairly rapidly, and uses for political dissent are becoming increasingly hidden or swept under by the much larger demand for consumer and entertainment applications. It will become increasingly difficult for the authorities to separate dissidence from entertainment, as may be seen in the definition of fantasy as a powerful form of control of one's private environment. By the Year 2000, the net result may be something of a semi-controlled opening up of information flows among at least the more educated elements of Soviet society. However, this will not result in a wholesale erosion of political power, although there may be significant modifications in intra-Party processes, and the Soviets will find these people to be mainly interested in their own well being.

Image and influence

The USSR has a long history of proclaiming its ideological and moral superiority over the West. These claims have been heavy with "scientific" justification and emphasis on the unparaleled progressiveness of Soviet society. Computing is one of the centerpiece technologies of the Scientific-Technological Revolution (NTR). Ideology is also of some practical importance, even if most officials and citizens are less than "true believers."

The information technologies have become so prominent that Soviet claims ring hollow to themselves and the outside world if they look backward and dependent on Western technology transfer. The population may become more disillusioned with Marxism-Leninism, driving a greater wedge between publicly maintained and privately held beliefs. This will not help the Soviets improve morale, confidence in centralized planning, work incentives, and interest in using computers. There would be serious negative implications for the other three primary goals, and the resulting frustration could be a factor leading to limited systemic changes.

Our models and analyses show that the USSR cannot or does not want to keep up with the West in many ways. But they are under pressure to look like they are. We can expect to see a lot of "we have that too" noise and examples, and the Soviets will try to make up in image what they lack or do not want to have in substance. In some cases, they want substance to go with image, e.g., for military credibility. In others, they want a little to go a long way, e.g., to meet some rising expectations and avoid further disillusionment of the population for consumer goods.

The Soviets have a conflict between the noble claims of the ideology, which should welcome the Western trends, and the realities of desired controls. In a sense there is a conflict between Marxist theory and Leninist practice. They want to retain the control and power structure, but present an image in keeping with the modernized ideology and realities elsewhere in the world.

To this end, they need to at least look like they are succeeding with goals 1-3. Beliefs about computing and the host social/economic system play a role in promoting or hindering its absorption into society. Conversely, nothing would contribute more to the image of a progressive society than significant progress toward the other goals.

The Soviet image has suffered severely, both domestically and internationally (in the West, in Eastern Europe, and in China), as a result of problems with the development and application of the C&C technologies. This is likely to continue.

Not only are the applications of the information technologies changing the basis of image and influence, but they are also the vehicles for making it more difficult for the Soviets to control information more generally. They expose the Soviet population to more of what is going on beyond their borders, and they expose much of the rest of the world to more of what is going on within the USSR.

The limits of systemic evolution

The Soviet system is not entirely inflexible. There are four commonly considered models of how the Soviet economy and polity might evolve during the rest of this century, and they collectively define the potential systemic boundaries within which progress will take place. These are: conservative (what the USSR has now), progressive (the GDR model), neo-Stalinist, and radical (the Hungarian model).

We have explicitly or implicitly assumed a hybrid of the conservative and progressive models for this study, and believe our model and assessments of a Soviet-style information society to be fairly insensitive under either of these two models or hybrids. A similar statement may be made for the neo-Stalinist case. The Hungarian model is a true hybrid of the two "information society" models, but a strong form is considered unlikely for the USSR.

Will the different uses of the C&C technologies in the US and USSR strengthen or weaken the relative position of the Soviet Union as a superpower?

The information technologies may be weakening the positions of both superpowers.

The analyses and syntheses in this study show that the different uses of of the information technologies in the US and USSR have weakened the relative position of the USSR as a superpower, at least within the domains where these applications influence such status, and that this is likely to continue for the rest of the century.

Relative US-USSR positions may also change due to a weakening of the US position. The information technologies will decentralize Western leadership. Japanese progress is such that they have already and will continue to partially displace the US as the most technically and economically advanced of the Western countries, and it is not hard to envision a future four-power world economic-technological order. This weakening of US leadership may make it more difficult for the West to act collectively on East-West matters.

There is some potential for Soviet gains against the US information industries and applications in manufacturing, but not against the West as a whole, because of the decline in US technological leadership. In particular, the US is in risk of losing important parts of domestic industries due to their inability to stand up against foreign competition in domestic and international markets. Soviet forms of control of their economy allow them to maintain a complete set of industries, even if they are not competitive by international standards. More generally, the US has some serious "information society" problems that affect its position in a tough, less remote, world.

I. Introduction

A. Scope of coverage

How will the USSR adjust to the dramatic and pervasive opportunities and pressures presented by the development and application of the information technologies? This study is an initial attempt to analyze the component pieces and synthesize an overview of the issues that underlie this critical question.

To this end, we define and partially answer a number of important questions covering: current Soviet progress and capabilities (Ch. II), a characterization of a "Soviet-style information society" (Ch. III), and prospects and implications for the rest of this century (Ch. IV). For our purposes, the information technologies are essentially the computing and communications (C&C) technologies for the transmission and processing of data.

Coverage of current Soviet progress and capabilities falls under three basic questions. A. Where does the USSR stand with regard to the development and application of the C&C technologies? Answers will be provided for six key areas: the structure and performance of the C&C industries, white- and blue-collar applications, some forms of communications, a few security-related issues, education, and consumer and entertainment applications. B. Where, and in what forms, are there gaps between the stages of development in West and East? Attention will again be focused on these six areas. C. What have the Soviets been doing to improve their capabilities? We consider: plans to increase efforts and resources, technocratic and organizational changes, "campaigns", and technology transfer.

Under the heading of Ch. III, we consider: A. Will there be a Soviet-style information society? Is it necessary for the USSR to venture into the information age at this point? Or does it possess sufficient scope for modernization below the threshold of an information society? B. What features might characterize a Soviet-style information society? What are the most important systemic determinants and goals? To what degree does the Soviet-style model require or permit the emergence of the trends that characterize a Western-style information society?

The final chapter is concerned with prospective progress and problems to the Year 2000. To what extent can the Soviets meet their goals within the means and boundaries set by past performance and the systemic determinants? What are the likely limits for systemic evolution for the rest of this century? Can Soviet prospects improve dramatically within these boundaries? We also consider a few of the broad implications for relative "superpower" status.

Some of the boundaries of this study should be noted. It is based entirely on unclassified work. The most important of these are 14 academic studies by members of our research group [Davi78; Dola85; Good79a; Good79b; Good79c; Good82b; Good84; Good84b; Good85; Good85d; Hamm84; Mche85; Mund81; Stap85b]. In total, this work is explicitly or implicitly based on more than ten thousand written and oral sources, equipment inspections, and several recent visits to the USSR and Central Europe. As an unclassified report, discussions of certain subjects, especially security-related applications, is severely constrained. Spatial restrictions have limited coverage to the USSR and topics strongly connected with computing. Two of the notable casualties in this regard are communications not related to computing (see [Shan85; Robe86]), and Eastern Europe, which deserves a separate study. A number of the questions in the outline are from [Good85g; Seit85].

For three reasons, this introductory chapter will end with a necessarily short and oversimplified perspective on Western-style information societies. First, some basic vocabulary and viewpoints should be introduced. Second, there are important and explicit comparative aspects to the analyses and overviews in all the later chapters. And, third, the development and broad application of the C&C technologies in the West are major factors forcing the USSR to come to grips with the issues considered throughout this study. Knowledgeable readers may want to move directly to Ch. II.

B. A perspective on Western-style "information societies"

1. Basic characteristics

There is no universally accepted definition or vision of a Western-style "information society," nor will there ever be. Even the term "West" needs to be augmented to keep up with rapidly changing developments in technology and international business. There is now a significant membership from the Far East where several countries have important places as producers and consumers.

Although it is clearly impossible for us to provide a comprehensive discussion, some loosely defined characteristics will prove useful. We consider two basic trends:

1. The pervasive application of the C&C technologies.

2. The expanded access to information.

The common denominator of all portraits of Western-style information societies is that a broad spectrum of C&C technologies will pervasively become part of a large number of products and processes that will be widely distributed throughout all of the major organizational components of advanced societies: offices, factories, farms, schools, government institutions, and the home. It can be argued that virtually all pervasive, or potentially pervasive, technologies pass through five rough evolutionary stages: (1) an experimental rarity, often an entrepreneurial 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 in limited 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; and (5) the technology has become part of the fabric and infrastructure of daily life, and its absence is often more noticeable than its presence (modified from [Birn85b]).

Each of these five stages involves technology and infrastructure in more general terms than that often associated with narrow technical developments. For example, the presence of TV at the fifth stage is dependent on an infrastructure and technology that includes the large and varied number of network and cable TV stations, program listings and reviews in the printed media, repair services, etc. There is also some domain dependence to these definitions. For example, by its nature computer aided manufacturing will never attain household pervasiveness, but it might reach stage 4 or 5 pervasiveness in a broad industrial domain.

The second frequently defined feature is the opportunity for much greater access and choice with regard to the range, volume, and time of information. This feature is often brought up in the context of greater democratization and decentralization, but this need not necessarily be so from a purely technical standpoint.

For both trends, three general forms of qualitative advancement in applications might be distinguished. In the first, systems do the same things that people did previously, but faster and more accurately; e.g., hand held calculators. In the second, they allow new or much enhanced applications to be developed; e.g., the solution of some previously unapproachable scientific problems or the ability to control processes in environments where humans cannot work. The third form brings previously unthinkable or exotic applications; e.g., when data, text, voice, and image processing are all integrated, C&C technologies may serve as greatly augmented senses for humans. A somewhat more troublesome form of application is the kind that replaces, rather than augments, humans.

A common element that emerges from this discussion and the specific areas covered in the next subsection is the pervasive need and desire to cope with and control increased complexity and opportunities, and reduced time scales. This is a key prospect that the information technologies hold for a wide spectrum of applications. Taken together with other economic and demographic trends, all of the elements of our discussion so far push for more control possibilities and a more rapid pace of life. The Western systemic environment encourages the broad dissemination of controls for increased economic efficiency, for personal activities, and for greater communications.

However, the C&C technologies themselves also generate additional complexity and opportunities and shortened time scales, sometimes to the point of making human capabilities inadequate. Players who do not keep up with this fast and more-or-less uncontrollable treadmill of technological improvement fall behind in an increasingly competitive world. The more powerful a C&C system, the more difficulties there are integrating it into the surrounding environment. Technology-related pressures and opportunities increasingly dictate how that environment has to be changed.

These control-oriented features are of such generality and importance that it may be as appropriate to use the term "control revolution" as "information society" [Beni86]. We address some questions of terminology in Ch. III.

Other often-cited characteristics are those generally associated with "post-industrial societies," e.g., the redistribution of the population away from agriculture and towards the service industries, near universal literacy, access to advanced education, etc. [e.g., Masu80]. The information technologies are increasingly contributing to the definition and achievement of these characteristics.

2. Some Western trends, driving forces, and problems

The information industries

The core of the information industries consists of private companies, universities, and government facilities providing research, development, production and services closely connected with the C&C technologies. Other "information industries," like publishing, are considered part of the applications world. The range, number, and spread of the units comprising these industries is enormous. The spectrum is densely filled with everything from tiny, local, single product/service companies to national and international giants like AT&T and Hitachi with strong and deep forms of vertical integration.

The single most overarching word that might be applied to these industries and the applications they fuel is "fast." The rates of appearance of new products and incremental innovations are awesome. There have been many spectacularly rapid business successes and failures. Personnel stress and burnout also appear faster than in most other industries. Cost/performance capabilities of new products frequently change dramatically over 2-4 years. Even service and software, whose productivity growth has been slow compared with other parts of the industry, have grown rapidly in total functions and size.

The driving forces for the industry and many of the applications areas come in three basic, interwoven, forms. First, the C&C technologies themselves offer unusually fertile ground for large and small, short and long term innovations. Second, there are huge and diversified markets for C&C products and services. Customer groups with massive, voracious, and continuously renewed appetites range from teenagers to the US Department of Defense. They have a tremendous pull effect on the industry. Finally, there is fierce domestic and international competition. Almost no unit or part of the industry, on any scale, is free from intense and possibly devastating competition. For example, large parts of the once overwhelmingly dominant US semiconductor industry have been more than decimated by Japanese competition and the future of what remains is seriously threatened [Ferg85].

White- and blue-collar applications

The four primary intra- and inter- organizational "workplace" applications areas are: management information systems (MIS), office automation (OA), computer aided design and manufacturing (CAD/CAM), and technical process control (TPC). Current and near-term use covers a wide spectrum of functions at stages 2-4 of our pervasiveness model. Visionaries see all four deeply integrated in the globally linked factories, corporations, and government offices of the future.

The range of functions supported by MIS runs from straightforward personnel record systems, through simple and sophisticated accounting and inventory systems, through high level decision support and strategic planning systems. Some of the most common OA functions include word processing, which is approaching the stage 4-5 status of the typewriter, and automated filing systems. CAD systems are becoming increasingly necessary for the design of very complex objects, most notably aircraft and integrated circuits.

CAM systems are for the manufacture of discrete items such as automobiles or batches of machined parts, and TPC systems are for the control of continuous processes, e.g., refining oil. Robots are often thought of as a subset of CAM, and most robots are used in CAM applications, but they have potential uses in the home and in the military as well. Of the four areas, CAM is the least widely used at present, and the US may be falling behind other countries in its effective and widespread use to modernize manufacturing industries.

In addition to these four internal applications areas, companies are becoming more heavily involved with putting C&C technologies into their products and services. An example of the latter is the direct use of computerized banking systems by customers. As to the former, the "intellectualization of dumb equipment" is well under way and can be expected to continue for a long time. The US alone may be producing over a million microprocessors a day [Birn85b].

Many serious problems are associated with these applications. A lot of expensive systems have been failures. There are threats of major economic and social shocks because of unemployment, productivity problems, management dislocations, and "techno-stress" [Shai84; Simo85; Thur85]. Are some "successful" computerized systems really contributing to productivity or just providing new forms of information flow wheel spinning? Cost-benefit analyses for the purchase and use of computerized systems should be made on the criterion of information value, but there is no information economics by which we can value information directly, and we only judge it in terms of influence on other measures of value, such as profit. It remains to be seen how societies will distribute the benefits and risks between haves, partial haves, and have nots.

Expanded communications

There is general agreement that developments in microelectronics, computing and optical technologies present opportunities for much expanded forms of communications, and that such expansions are a characteristic of both trends used to define an information society.

Some "older" communications technologies have attained stage 5 pervasiveness. These include radio, TV, the printed media, and telephones. New technologies continue to pump life into all four at impressive rates. Witness cellular radio, cable TV, computerized typesetting, videotex, and many recent telephone-related devices. More is on the way into the next century: e.g., interactive TV and perhaps automatic "bilingual" interpretation telephone systems [Koba86].

Other communications technologies have reached stage 2-4 pervasiveness since the early 1970s. A partial list would include photocopy, audio cassettes, video disks and cassettes, electronic mail, computer networks, videoconference, telefax, and CB radio. There have been major advances in satellite, microwave and optical transmission technologies. Transportation-communications systems, such as railroads and airlines, have also profited from advances in the C&C technologies.

Security-related applications

C&C technologies appear, or will appear, in almost all large weapons, C3I, logistic, simulation, training, and administrative systems in the US military. They are becoming omnipresent in tactical and strategic, nuclear and conventional, quick reaction and peacetime garrison systems, and in the military industrial sphere. Many of today's, and perhaps all of tomorrow's, large military systems cannot be designed, built or maintained without these technologies.

Part of the foundation of US national security policy has been that technological superiority can balance or defeat numerical superiority. While that view and policy has had a mixed historical report card, it is almost forced on the advanced industrialized democracies since their polities will not support very long term and large military manpower commitments comparable to those of the Communist countries. The electronics-information technologies have become the most pervasive group of technologies in the implementation of this policy.

This is not without problems. High technology and greater sophistication are making military systems much more costly, and there has been a sad history of expensive total and partial failures. Cost has severely limited the number of weapons and platforms, thereby increasing vulnerability should the uncertainties of combat result in the loss of a small number of them. Battle management has become much more complex and it is not clear that our C3I capabilities have been able to keep up with such factors as the reduced real time scales of the modern battlefield. For the first couple decades after World War II, military applications were clearly a driving force in the development and application of the C&C technologies, and there was considerable positive spillover to the general economy. There is now a greater flow in the other direction. While military-related R&D and production still results in a useful flow to the general economy, the Japanese experience argues that there may be better ways to use those resources to strengthen US technological and economic development and international competitiveness.

A partial list of other national-security related C&C applications would include: political and economic surveillance, intelligence analysis, and non-military C&C security. As with almost all of the rapidly expanding applications, there are serious unresolved problems, such as the protection of individual rights.

Education

The two basic national literacies, verbal and mathematical, seem destined to be joined by a third - computer literacy. At this time it would be pretentious to give computer literacy full status with the other two, and it might be argued that it is an extension of the others rather than a new form of literacy, but at least a weak form of computer literacy is emerging.

The achievement of computer literacy is taking place both within formal educational institutions and without. There has been a dramatic rise in the presence and application of C&C at US colleges and universities in the last 10 years. Computers are also showing up in the elementary and secondary schools. It will not be long before most high schools have at least a rudimentary computing facility. Much training also takes place at privately run technical schools, on the job, and in the home, and it is likely that more person-training hours are built up here than in the schools and colleges.

As always, there are problems. Colleges and universities are having serious difficulties recruiting and retaining faculty because of heavy teaching loads and competition from industry. There is a great shortage of well trained teachers at the pre-college level. Both college and pre-college educational programs are developed mainly by local private and government organizations. This has resulted in a wide spectrum of quantity and quality. Although this produces many stronger and better tailored programs than would be likely under a uniform national program, it also tends to spread the gaps between the haves, partial haves, and have nots.

Consumer and entertainment applications

There is universal agreement that a feature of any future Western-style information society will be the use of the C&C technologies in consumer products, services and entertainment. Much of what will come at pervasiveness stage 5 will be via such applications.

The entertainment aspect of the information society is not frivolous in human, technical, or economic terms. Like the thirst for communications, an argument can be made that indulgence in fantasy is a basic human need that may also be seen as a form of control [Kay84b]:

> [Fantasy is] that collection of worlds where things are simpler and more controllable. It is not just displacing ourselves from the real world when we go to the theater, or the movies, or watch TV. It is also things like mathematics and science. They are all simpler and more controllable than real life. Fantasy becomes much more powerful when we can control it. Video games are the triumph of control over detail. It is actually a way of enfranchising a disenfranchised society as far as being able to control things.

There are great technical challenges in these areas. A robot for household cleaning would have to be much more sophisticated than the robots used in industry today and probably for some time to come. However, the potential markets for some of these applications, and potential military and industrial spinoffs, are so great that they may serve as a technical driving force.

Such applications are rapidly changing the the size, structure, and orientation of the C&C industries themselves. "The computer industry is moving from a box selling industry to a service industry. If the leaders in the industry have any sense, the computer industry will become a way-of-life industry" [Kay84b].

If the C&C technologies are to become deeply embedded in the Western way of life, it will be necessary to rebuild and expand most of our physical communications systems. New developments, like fiber optics and powerful computerized switches, make the problem technically solvable, but the scale and price are enormous.

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Finally, it is clearly beyond the scope of this short discussion to consider different assessments under various possible domestic and international situations. More optimistic or pessimistic evaluations are possible. For the most part, these exhibit greater or lesser social and economic costs and different rates of progress, but they still reflect most of the features described above.

II. The Information Technologies and Their Applications: Current Soviet Capabilities

A. Where does the USSR stand with regard to the development and application of C&C technologies?

1. The structure and performance of the Soviet information industries

The major organizational players that are directly, and heavily, involved with research, development, production, training, and service functions include at least eight ministries (Minradioprom, Minelektronprom, Minpribor, Minsvyazi, Minpromsvyazi, Minstankoprom, Minpros and Minvuz), and a department of the Soviet Academy of Sciences (OIVTA). Several other ministries supply equipment and services whose importance has been underestimated in the USSR: air conditioners, power supplies, high quality paper, customized software, maintenance, etc. A large number of high level Soviet state and CPSU organizations, including the recently formed State Committee for Computing and Informatics (GKVTI), have important, long term, functions in the areas of policy, planning, trade, and technology transfer for the C&C technologies. All of the organizations in this last group are also serious users of the information technologies for their own purposes. A refined mapping of participating suborganizations and their inter-relations would be impressive.

On paper, this array of organizations gives the USSR a comprehensive set of industries and functional capabilities. Included, in particular; are the full range of computer systems from microprocessors to supercomputer and 5th generation machines; a complete set of telecommunications options; extensive educational, research and development facilities; and coverage of the CAM spectrum.

Furthermore, the Soviet Union has an internal user community with the size, range, and sophistication of applications to warrant and support all of this. Only two other countries, the US and Japan, exceed the total of Soviet capabilities.

In practice, the picture is not as bright, but is it not entirely dismal. It is arguably brightest in some areas of hardware. Respectable development and production programs exist for microprocessors, multiboard minis, and upward compatible general purpose mainframes. Much of what is most widely used throughout the Soviet general economy, and what is being produced in volume today, is in the form of functional duplicates of successful US systems that were in production from the mid-1960s to the early 1980s. In no case has Soviet production volume and system reliability reached that of US predecessors. Serious hardware weaknesses continue with regard to the quality and availability of ICs, main memory, secondary storage, peripherals, data communications and supercomputers. Average growth of the computer industry has been at least 10 percent per year since the early 1970s, and much greater for some subtechnologies during certain subperiods.

The massive reorientation towards Western technology in the late 1960s led to a decline in the level and relative importance of domestic innovation in computer systems hardware and software, and this continued into the 1980s. However, an enormous amount of on-site engineering development and implementation was necessary in order to assimilate Western technology and to produce respectable machines in quantity. Although unimpressive compared with Western states of the arts, they show substantial progress over the Soviet past. This may be seen as a form of improvement in "local" innovation. Global innovations, i.e., accomplishments that significantly advance world-level frontiers, have been essentially nonexistent. However, some recently announced projects may indicate a renewal of indigenous design efforts. It remains to be seen how far they depart from Western predecessors and to what extent they are global innovations.

At the weakest end of the performance scale, the industry is more impressive in the form of a static organization chart than it is as a dynamic entity caring for the myriad complex of day-to-day needs of a large and growing applications community. This shows up most pointedly in software, maintenance, and telecommunications products and services.

Soviet claims that they can achieve world levels across the complete spectrum of the information technologies and applications solely on the basis of their own indigenous capabilities are not supported by history, detailed technological assessments, or international trends. Soviet computing has been hurt throughout its history by various forms of of Western- and self- imposed isolation. In fact, no computing community, including that of the US, would be able to move at its current pace if it were to have its contacts with the rest of the world severely restricted. However, the Soviets have achieved a certain form of self sufficiency in that they run a large industry of their own, and produce most of what they use. They have also become less dependent on Western technology in the sense that, if all their overt and covert transfer opportunities were to suddenly disappear, they would be able to function indigenously at a level far above the one that existed in the late 1960s.

Also noteworthy is the substantial development and integration of the CEMA computer industries that has taken place during the last fifteen years. Economic and technological factors appear to have been at least as effective in bringing this about as Soviet pressure. Although involving a massive transfer of Western technology, and lagging behind Western achievements in important ways, CEMA performance has been impressive relative to its own past and in terms of some basic accomplishments. The most important of these include: a nontrivial international division of labor across a broad range of products; significant levels of compatibility, interoperability, and standardization; much improved products and productive capacities in some areas; considerable growth of the industries in almost all of the CEMA countries; much expanded trade; the creation of an effective system of contention whereby the participating countries carve out suitable niches for themselves without totally destructive infighting; and the creation of a reasonably effective CEMA-level Intergovernmental Commission for Computer Technology (MPKVT) that continuously oversees all of this, but which enables the national industries to remain fairly autonomous.

One could also produce a long list of what has NOT been achieved. We mention only the unimpressive progress toward more comprehensive and deeper forms of integration, especially those involving the broad use of the most active forms of technology transfer, and the poor level of integration of the national computer user communities. Rhetoric aside, activities to date indicate that neither the Soviets nor the East Europeans seem overly enthusiastic about what would have to be done to bring about the next big steps in these directions.

These serious shortcomings aside, the main point to be made here is that something substantial has been built in an important advanced technological sector through a cooperative CEMA effort. This relatively successful approach for one advanced technology is a model for others. Indeed, in the last few years CEMA has begun similar programs for microelectronics and robotics. So far, neither has achieved the success of the computer systems program.

2. The Soviet enterprise environment: white- and blue-collar applications

The most important problem facing the USSR under the scope of this study is the absorption of C&C technologies and products into the fiber of the Soviet economy. We define this to be the enterprise level: factories, research institutes, educational centers, service organizations, assorted forms of associations, etc. Almost everything else the Soviets do with computing will be substantially devalued if they do not make serious progress here.

The range of technologies that are of tremendous, long term, importance at the enterprise level includes: TPC, CAD, CAM, ASUP (Enterprise-level Automated Systems of Control and Management - roughly the Soviet counterpart of Western MIS), OA, data communications, and computing for small organizational and personal use. In principle, C&C could be used to create an enormous spectrum of centralized and/or decentralized systems across the entire economy of the USSR.

Soviet "automated management systems" (ASU) originated with the cybernetics "boom" of the late 1950s. It was hoped that the massive introduction of "economic cybernetics" would lead to significant improvements in the operation of the economy. In 1971 ASUs were embraced by the CPSU as a means of increasing productivity without fundamental economic reform. Over the course of the last twenty years, about 7,500 ASUs have been constructed at every level of the Soviet economy. These include about 3,400 ASUPs, 3,500 TPC systems, and systems at various state committee, regional, and ministry levels.

And what of "economic cybernetics"? One of the great expectations for ASU was the optimization of planning and management. However, a large portion of the calculations normally found in ASUP are for processing accounting data. Optimization methods have received little use in practice. The limited absorption of computing is not due to any one overriding cause, but represents a confluence of technical, organizational, economic, and political constraints affecting users, service suppliers, and higher-level organizations. These factors can be divided into the infrastructure and the surrounding environment. The entire ASU program has suffered both broadly and deeply from the problems of the information industry infrastructure noted in the preceding subsection.

Another great failing of the Soviet infrastructure has been in designer-user relations. ASUPs were not aggressively marketed to enterprises. Articles about leading users painted a bright picture which often led to later disillusionment. Users received insufficient training, both in computing and in management more generally, and exerted little influence over ASUP designs. The contact of designers with the enterprise was through the ASUP department, which itself was removed from the mainstream of enterprise activities. Pieces of ASUPs were farmed out to different organizations without the direct participation of high enterprise officials so no one in the enterprise could protect its overall interests. Design organizations were not interested in correct specifications, testing, maintenance, and enhancement; their plans were fulfilled once a certain number of tasks were built. Subsystems and tasks that were easiest or cheapest to develop were created first, even though they did not bring the largest returns. The result was that the old management system could not be dismantled because not enough of the new one had been implemented, and because technical and incentive problems discouraged the pursuit of complete conversion. The net result was additional work for management personnel, complication of the management system, and increased costs.

The enterprises themselves had few incentives to take advantage of even the limited services offered by the infrastructure. Computing threatened the way that business is done in Soviet enterprises on a number of levels, and has met with resistance at all of them. At upper management levels, an ASUP is viewed as a huge risk which can potentially interrupt production and cause plan targets to go unfulfilled. The data on the economic payoff of computer systems does not give the reassurance that great benefits will follow. Intangible benefits, such as improving the quality of decisions, have not been extensively realized and do not serve as additional inducements. Despite improvements in hardware and software, the enterprise director still faces a number of problems and uncertainties which make him reluctant to stake too much on the computer.

A comparison of the goals of the enterprise manager and the ideal goals set for ASUPs shows that, without guarantees that compensating resources will be given to an enterprise manager who accepts an ASUP, there is little incentive to adopt one (Table 1). Achieving many of the goals on the "idealized" side of the table would, in theory, be desirable, but he knows that the behavior on the "actual" side are necessary to function successfully on a month to month basis. If the manager, against all odds, did achieve the goals on the "idealized" side of the table and meet the plan, he would face the pernicious ratchet effect, or the tendency to "plan from the achieved level." The ministries increase plan targets every year, so enterprises that operate close to their true production capacities are likely to end up much worse off. Then he would be subjected to even more scrutiny, which would be facilitated by the detailed audit trail on the ASUP. An ASUP that does everything that it is supposed to do may be a frightening prospect to most managers.

In the Soviet economy, informal links through phone calls, ministry visits, expediters, "blat," and outright bribes are important. Sales departments know that they should first ship to customers that can return a favor, not to ones that are "optimal" based on idealized computer calculations. Accounting procedures which reveal how expediters are financed or any other computer operations which threaten these activities will be circumvented or rejected. Plans which are carefully constructed by computing may be amended by the ministry for a variety of reasons.

Table 1

Idealized ASUP and Actual Enterprise Goals Compared

Idealized ASUP	Enterprise Manager
Maximize and optimize production	Fulfill the plan so that next year's targets are fulfillable
Optimal, minimal levels of inventories	Acquire as many supplies as possible
Release labor	Hoard labor
Maximize plan flexibility	Minimize plan targets changes
Realistically evaluate capacity	Understate capacity
Realistically evaluate actual performance	Overstate performance if necessary
Use computer to audit, control, cross-correlate, analyze	Avoid dangerous revelations to superiors, find out as much as possible about subordinates
Improve data processing	Improve data processing

These and other perversities have led to the perception that enterprises that use computers are worse off than those that do not [Emm85c]. Demand for computing frequently results from outside, sometimes cosmetic, pressures. Further advancement of management-oriented applications will have to overcome widespread disillusionment about their efficacy.

Over the last decade, the rate of introduction of ASUP has declined dramatically, to an average of less than 200 per year. If this rate is maintained, then the majority of Soviet enterprises will still have no in-house MIS mainframe computing capabilities by the year 2000. Conversely, the rate of introduction of TPC, CAD/CAM, robotics, and FMS are all on the rise, and some new initiatives towards OA have begun. This shift was fueled by the creation of technologies which facilitated the development of numerical control machine tools, process control systems, and robots. In 1984, 700 new TPC systems were built, compared with 100 systems for management applications [Prav85c].

Soviet R&D in industrial robotics began in earnest in the early 1970's when a number of prototype models were created. Having established a base for the serial production of robots during the 1976-1980 period, the Soviets intended to significantly increase the rates of both production and user introduction during the Eleventh Five-Year Plan (1981-85). Production claims rose from 3,300 units in 1981 [Nark83; Comp83] to over 13,000 in 1984 [Rrc84c; Rrc84j], yielding a stock of over 30,000 robots and manipulators.

However, effective introduction appears to have lagged production badly. The reasons for this at least partly parallel those for ASUP. Poor infrastructure support and difficult horizontal and vertical external connections limit effectiveness and curtail demand. While robots do not threaten enterprise business in the same fundamental way that an ASUP does, their incorporation demands a highly organized production process which are difficult to deliver under Soviet conditions. The integration of CAD, CAM and MIS will be even harder to achieve.

Although the rhetoric of the Gorbachev administration indicates renewed and expanded support for technology-based solutions to Soviet economic problems, the experience of the ASUP program over the past 20 years indicates that the strong integration of computing into the

Soviet general economy will remain difficult. At present it appears that no one component in the various technologies which comprise flexible or computer-integrated manufacturing (FMS, CIM) can alone significantly improve the performance of the Soviet enterprise. What is needed is the complete restructuring of the enterprise (or building of a new enterprise) using integrated computer technology from bottom to top. But even this "factory of the future" cannot be completely isolated from the vagaries of the surrounding economic and political system.

3. Computer-related communications in the USSR

The drive to bring computers into the enterprise environment began in the early 1960s with plans for the State Network of Computer Centers (SNCC). In 1971, the SNCC proposal resurfaced in a stronger form as the Statewide Automated System for the Collection and Processing of Data for Accounting, Planning, and Management of the National Economy (OGAS). OGAS, which continues to be embraced by some top-level planners, represents the ultimate in centralized use of computers. It is eventually supposed to allow planning and statistical information to be sent up and down the economic hierarchy automatically, providing a flexible feedback mechanism by which the center can exercise finer control.

In spite of the plans and the improved availability and variety of equipment, it is only within the last several years that significant practical developments in networking have started to take place. This constitutes more activity than is often appreciated, but less than the impressions the Soviets would like to make, and far less than what might put them on the threshold of a broadly based information society or the realization of OGAS. We briefly consider four topics: local area networks (LAN), wide area networks (WAN), remote access to databases, and network support technologies.

LAN. The enterprise level integration of now-separate applications will try use LAN to bring together CAD, NC machine tools, robotics, FMS, TCP and MIS. This is seen as a crucial advance by leading Soviet advocates of expanded computer applications.

Soviet progress with LAN is unimpressive. A small, but growing, number of scientific research centers have managed to put together LAN of various sorts, but most would be considered rudimentary by Western standards. 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. Data collection often takes place using unsophisticated terminal devices, or consists of card punching from documents. A few more sophisticated systems are under development [Klim85; Sots85i].

WAN. WAN for the general economy have received the most publicity over two decades. The almost nonexistent state of networking into the early 70's stands in stark contrast to grand plans that were being put forth for developing an All-Union Data Transmission System (OGSPD), the SNCC, and OGAS. The drive to construct OGAS has had little effect on the day-to-day application of computers. Individual applications have been developed without regard to how they could be incorporated into OGAS, the number of enterprise computer centers proliferated, and the number of collective use computer centers (VTsKP) fell behind plan targets. Today the effort to link together VTsKP has finally begun in earnest. Nevertheless, the Central Statistical Agency (TsSU) has had trouble attracting industrial customers to the VTsKPs, and the proliferation of computer centers and isolated pieces of batch-oriented data processing systems continues.

Of the approximately 300 ministry-level MIS (OASU), only a few have so far made use of interactive computer communications. These include the systems of Minpribor, Minavtoprom (automobile industry) [Klyu84], and a few ministries in the energy sector. Other national organizations have their own networks, including the following mixed sample. TASS has a worldwide network. An experimental system developed in 1981 is now used by Gossnab. The railroads use data communications, often via the telegraph system. The Moscow Savings Bank network is hierarchical, uses minicomputers at lower nodes, and is said to include 3,000 terminals. Foreign technology is commonly found in some of the more successful networks.

Akademset′ is the USSR Academy of Sciences′ effort to link its institutes together with a packet switched network. The planned network backbone will connect regional centers in Moscow, Sverdlovsk, Tashkent, Leningrad, Riga, Kiev, Novosibirsk, Khabarovsk, Tashkent, and Vladivostok [Ntsa85]. According to the man in charge of its development, "all of the country′s scientific centers... will be linked by telephone" [Bbcw85i]. Reports indicate that sections of the network have begun to operate, though perhaps at slow speeds [Bbcw85i; Mds85102] and with weak inter-regional data flows.

Access to databases. We consider two categories: access to Soviet databases (by either Soviets or foreigners), and Soviet access to foreign databases. Both are suffer from severe technical limitations and political controls.

Effort has gone into the development of at least two types of domestic databases not directly related to national security. These are for library and economic-statistical applications. The Soviets have long given much publicity to the collection and wide distribution of scientific-technical information using modern technologies. So far, we have seen little evidence that such databases are readily and remotely accessible via computer-based telecommunications. Economic-statistical databases seem to be closely held, in many cases restricted and possibly classified, by their developing and using organizations. Such access as there is seems to be on an institution-to-institution, rather than on an individual, basis. Publicly available, general consumer databases, e.g., the directory, travel, or news databases that are common in the West, appear to be nonexistent in the USSR. Foreign - either Western or East European - access to domestic Soviet databases is extremely limited. In particular, a much advertised access to two Soviet databases through IIASA has yet to amount to anything.

A National Center of Automated Exchange of Information with Foreign Computer Networks and Data Bases (NTsAO), which is based at the All-Union Scientific Research Institute of Automated Applications Systems (VNIIPAS), has also been created. The tasks of NTsAO supposedly include: providing connections with foreign data bases and computer networks; providing reciprocal access to Soviet networks and data bases, including training for foreign users; coordinating socialist exchange programs; and helping foreign companies in the USSR and Soviet organizations access outside networks and data bases to send and receive information. Apparently, more than 15 USSR institutions have a direct or indirect connection to the NTsAO gateway [Ntsa85]. Other forms of access to Western networks also exit, including a reported packet-switched connection between Moscow and Helsinki [Taka85b].

Network supporting technologies. The state of the Soviet telephone and telegraph systems have severely handicapped the spread of network development and use. Data is still regularly transmitted at very slow speeds on telegraph and special lines. Use of the general telephone system for data communications is limited by statute to nine minutes an hour, and arranging a link on a switched line can take a few minutes or more because it may necessary to test several lines before one is found that is good enough for a data connection [Levi85]. Not infrequently, there may also be problems with the quality of line connections over long use sessions. The cost of either switched or dedicated lines for data communications is very high.

The computing environment for networking is not as bad as the telephone system, but has some problems. It is colored by the decision to follow IBM for mainframes. Much work has been done in connecting smaller computers to the IBM-like ES machines as front end processors. One of the puzzles has been to find out to what extent the Soviets are following IBM's Systems Network Architecture, but the evidence is mixed. Many computers in enterprises are IBM 360-like machines, which are poorly suited for networking applications. A number of modems, multiplexers, and terminals have gone into production, but these peripherals are often cited as being in short supply, and not completely compatible with each other.

Technically, fiber optics, satellite and other forms of nonwire transmission links hold the promise for much improved data communications - in terms of volume, reliability, transmission speeds and cost. The Soviets are doing work in all of these areas. For example, there are several fiber optics research and development programs and some fiber optics, including at least one short "permanent" line in Leningrad, with more extensive lines are planned for 1986-90 [Izv85120]. It remains to be seen how quickly, how widespread, and how effectively this is done. The technology to greatly improve phone and digital communications is well established in the West, and available to the Soviets through various sources. Although extensive modernization and expansion of the national communications means is supposedly a high priority goal, past performance is so bad that truly impressive progress is unlikely in the short term, but necessary in the longer term.

4. Security-related applications

It is beyond the scope of this study to explicitly review Soviet military or other security-related C&C systems. The discussion of this section will be limited to some aspects of the interdependence of the civil-military development and applications communities and domestic surveillance.

It would appear that some high level policy makers in the CPSU and industry have recognized the need for a better mix between several of the high technology ministries under the VPK (Military-Industrial Commission) and the general economy. It must be emphasized that there has been no great "opening up" of the VPK ministries, or any great "flowing together" of these two sectors. However, there are developments worth mentioning in the computer industry.

Soviet work on electronic digital computers began in the late 1940s, and much of this effort has been under the purview of the VPK ministries (or the organizational predecessors of the current ministries) and Academy institutes. Although computers found their way into the general economy, and although there were various forms of "borrowing" from the West, Soviet computing was cloistered and introverted in many ways. A good deal of this had to do with the nature of the primary development and production organizations. In contrast, the US computing industry, which also had important early roots in military activities, blossomed in the late 1950s when it began to spread out over a much larger user community. At this time, and for these reasons, the so-called US-USSR "computer gap" really started to open up. The Soviet industry remained conservative and introverted, and it was strongly oriented to the needs of a limited and somewhat myopic user community. In contrast, the US industry became more aggressive and innovative, and began to have an impact across a broad economic spectrum.

During the 1960s and 1970s, the Soviets had to face an assortment of military and economic problems. These included falling behind in the "space race," the use of advanced technologies for the upgrading of an extensive range of military systems, declining economic growth rates, increases in the administrative and clerical work forces, difficulties in managing large, dynamic systems like airports and railroad yards, and problems with the control of the economic planning process.

If computing was to help solve so many important problems spanning the entire economy, then it would be necessary to get computers into the entire economy, or at least to raise the extent of use to a much higher level than had been the case before. It also became clear that the small, introverted Soviet computer industry was not even capable of meeting the growing needs of the military-industrial sector. Sometime earlier, the US military had realized that it alone was not capable of nurturing the development of a computing community that would be able to meet its perceived needs, and it benefited greatly from the existence of a large and healthy US civilian computing community. The Soviet military had nothing comparable at home, so they used the US general computing community as a surrogate.

The Soviet approach to expanding and strengthening the computer and microelectronics industries was basically to pour resources into those organizations that were already in the business, although important new organizations have been created in both the Academy and many ministries, and to increase acquisitions from the West. At least three VPK ministries, and others that also deal with the military and its suppliers, were thus provided with more resources. This clearly helped the military-industrial sector directly. But much of the additional and qualitatively improved output from these ministries went into the civilian economy. The military benefited significantly from this as well through the proximity of a larger and improved general computing base with a vastly expanded software inventory, and the greater availability of computing in educational institutions.

Finally, the C&C technologies are the technologies for implementing any Orwellian vision of totalitarian control of people and information. However, the technological basis for (computerized versions of) Orwell's telescreens lies beyond the turn of the century. While it is difficult to find any well advertised evidence of KGB use of C&C for such purposes, it is not hard to imagine applications that would be within their interests and capabilities. To mention a few: mainframes for large centralized databases, microelectronic-based surveillance systems, and personal computer use by KGB case officers. We cannot judge the extent to which this exists today, but the potential is there. What is perhaps as important as the fact is the perception the population has or might have of the pervasiveness of these applications, of the enormous power they add to the state security organs, and of their own impotence to confront either the issue or the fact.

5. Education

Computing at Soviet universities and advanced research facilities in the Academy has a long history going back to the 1950s. However, the overall curricula, facilities and research results developed at these institutions for over 30 years are rather unimpressive for a country with the resources and aspirations of the USSR. This statement holds for computer science, the application of computing in other academic disciplines, and the general literacy training of university students. The poor track record at this level does not bode well for the much larger educational tasks to be faced in the future.

The Soviets are looking to improve computer-related training at all levels, but the highest profile program is for the secondary schools. Essentially no computer facilities existed at any significant number of Soviet secondary schools until the last 2-3 years, and not very much exists there now. In March 1985, the Politburo decreed that standardized computing courses are to be introduced at the ninth and tenth grades throughout the USSR. The ninth grade course and its text book have been highly publicized, and this course was to be universally taught during the 1985-86 academic year. It is not being taught at all schools, official claims to the contrary.

Politburo decrees notwithstanding, the program for the secondary schools suffers from basic difficulties that will not be easy to remedy. In spite of several publicized candidates, the USSR has yet to be able to produce a technically suitable microcomputer and related peripherals in anything approaching the necessary quantities for a national educational program of this size. Even if this equipment were to be produced some day, and it is hard to imagine that they will not be able to do so since the technology is well established in many other places in the world, the Soviets would still have to come up with a support infrastructure for millions of machines distributed over the entire country. Tens of thousands of teachers would have to be trained, and the Soviets presently do not have the personnel, in either the schools, industry or higher educational institutions, to do the training.

By comparison, problems with student samizdat, and other "dissident" activities which have received much attention in the Western press, are secondary. Currently, the hardware and software in Soviet schools appear to be tied down to unsophisticated use in varied technical fields, and are inadequate to serve as engines for politically creative thinking.

However, there may be some short term solutions to the technical, infrastructure, and potential political/ideological problems. Not surprisingly, the focus of these solutions is on collective and centralized use. There may also be some sizable purchases of small microcomputers from abroad. Equipment cost, availability, and maintenance constraints will make it impossible for the Soviets to provide well equipped laboratories for most schools outside the major metropolitan areas. Few labs will be well provided with the more troublesome technologies such as hard disks and certain kinds of printers and software. Laboratory configurations may be centralized around the teacher's terminal. Given the extent and hierarchy of

Soviet geography, there is reason to believe that the computerization of the secondary schools, if it is to succeed at all, will initially be in the form of local centers such as the one that exists in Tbilisi, where students are brought to the computers, rather than having the computerized classroom brought to the students. In theory, this would provide a strong form of control and more efficient use of equipment and trained personnel. Further efficiencies and geographical reach would be forthcoming with the extensive use of remote dial-in to such facilities, but technical problems will prevent widespread use in the short term. Slow growth of this kind will also give educational authorities and youth organizations the time and opportunity to "translate" foreign ideas on personal computers to fit Soviet "particular circumstances", and to create a new, modern, high-tech, "enlightened collectivism" [Yasm86].

These problems also limit the prospects for extensive, high quality, training programs in other parts of the Soviet educational establishment, including training in industry, in the military, and correspondence courses. Publicity has been given to computer training in the Soviet military in the last few years, but there is little evidence of sophisticated and widespread programs. Much of the potential of a national TV "open university," such as those that exist in the UK or Hungary, is lost because of the lack of computers in the home. Broadcast TV lessons would still be helpful for school and industrial courses.

6. Consumer and entertainment applications

A few consumer service systems, e.g., for transportation ticketing, appear to exist in the larger cities, and there are microelectronics-based consumer products available, e.g., hand held calculators and some "personal" computers. Even games are by no means disdained. Pong-like TV-set games were announced in 1979, and Soviet children are often shown playing microcomputer games. Games have been recognized as an important part of the national computer literacy program and their development and use is encouraged.

But one has to look fairly hard to find even traces of the uses that have reached stage 4-5 pervasiveness in the West, e.g., relatively "low tech" items like touch tone phones or digital cash registers. There have been rumors that private access to electronic entertainments has become one of the perks of the elite, and a few public VCR and calculator stores have appeared in the major metropolitan areas.

7. A summary-overview

We conclude this section with a rough summary-overview of a broad range of information technologies and applications in the USSR as evaluated by two criteria: state interest, and technical and economic capacities. Table 2 is significantly modified from [Dibe84]. Evaluations are based on current capabilities and short term future prospects.

Additional comments on Table 2 are in order. Western technical and economic capacities are defined as "high," and by this standard no Soviet capacity is rated above "medium-high" for any technology or application. There is a certain amount of subjectivity inherent in the judgments of this table. Other analysts might argue that several of the evaluations are one level too high or too low by either or both of the primary criteria, but such perturbations do not change our general assessments. Except as labeled, the listing of criteria and technologies/applications is not meant to imply relative ranking within categories. "Advanced transmission technologies" refer to satellite, microwave, and fiber optic transmission. uE = microelectronics.

Table 2

Summary Evaluation of Current Soviet Information Technologies

Evaluation Criteria

State Interest
- Functions fulfilled and types of information processed
- Geographic/demographic factors
- Direct productivity gains
- Propaganda and "progressive image" value
- Catching up with the West
- Military value
- Pervasiveness
- Value for economic/social/political control

Technical and Economic Capacities
- Investment and operating costs
- Technological levels and complexity mix
- Distance behind the West
- Volume production capabilities
- Support infrastructure
- Possibilities of substitution for older techniques
- Pervasiveness

Evaluation

State Interest	Technical & Economic Capacity: Low	Low-Medium	Medium-High
Low	Videodisk Electronic mail Smart consumer products	VCR Telephone augmentations Foreign radio/TV	Photocopy
Medium	Interactive TV	Video games Videoconference Telefax Videotex	Mail CB Cable TV Audiocassette
High	Local TV Computer networks	Telephone Large computers Microcomputers CAM MIS/OA Databases Software CAD uE/optical components	National radio Local radio National TV Adv. trans. tech. Press Cinema TPC

B. Where, and in what forms, are there wide gaps between the stages of development in West and East?

There are wide East-West gaps in every area considered in Section II.A. In spite of substantial Soviet and East European progress in some areas, the greater pace and range of Western developments and applications is such that few, if any, of the major gaps are closing rapidly, if at all.

The Western industries maintain leads in volume of production of semiconductor, computer, and telecommunications hardware; reliability; sophistication of manufacturing and quality control processes; the variety, quality and availability of products and services; the variety, inventory, and sophistication of software; software production capacities; the number and sophistication of R&D facilities; and the quantity and quality of what is already in operation at user installations. For many quantitatively measurable differences, Western leads are by at least an order of magnitude in volume and 2-16 years in time. Some of the largest gaps may be in areas, like software, where quantitative measures are less meaningful and more difficult to estimate.

We have not been able to clearly identify any major areas where the Soviet bloc is clearly ahead of the West, or where a gap is rapidly closing. This includes computer science theory broadly, a field where some analysts expected the Soviets to do well because of general mathematical strengths, and so-called "older" technologies like printers and telephone equipment (but not more-or-less obsolete technologies like paper-tape equipment). Two areas where analysts have conjectured that the Soviets are even or ahead of the West have been parallel processing and optical computing. For parallel processing, we do not believe this is the case for broad practical capabilities, and as of at least 1982 this was not true for theory. This assessment for optical computing appears to be based primarily on Soviet research programs. So far, it has not been explained how the Soviets are going to overcome the post-research deficiencies of the present electronics-based industries when the time comes for building a full optical computing/telecommunications industry.

More generally, if we were to put together a Western version of Table 2, with suitable modifications to the "state interest" criteria, almost all evaluations relative to the Soviets would be "high" by both sets of criteria and this was clearly a factor in the judgments of Table 2. Furthermore, with the partial exception of large scale economic planning, the Soviets are almost never clearly innovative in developing and disseminating qualitatively new applications.

Some of the most important and dramatic differences relate to pervasiveness. In the US most of the technologies and applications listed in Table 2 are in pervasiveness stages 3-5, with many firmly entrenched in at least stage 4, and often with rapid movement from stage 2 to stage 4. In contrast, in the USSR, most are in stages 2-4, with few in stage 4 and only national radio/TV and the press weakly in stage 5. Several examples will illustrate these differences.

Small calculators have become discretionary and "throw-away" items in the US, with universal availability and dramatically improving performance/price ratios. In the Moscow metropolitan area, with more than 10 million people, there are probably less than a half dozen stores with more than several hundred units of a half dozen hand held calculator models in stock at any given time. Even this level of availability deteriorates rapidly with city size and geography. And this is the status of a useful, cheap and fairly "old" technology, with no "sociopolitical risk" element, that should have been sweepingly embraced by a society that glories in having far more engineers and scientists than any other in the world.

In 1985, there were approximately 25-30,000,000 telephones in the USSR. Only 23% of urban families and 7% of rural families have phones, and there are 260,000 coin-operated phones [Bbcw85d]. Essentially all are rotary dial. In 1986, it is nearly impossible to find a touch-tone phone (push button phones shown at exhibits are not touch-tone). Infrastructural and support deficiencies include poor service and the lack of public phone books and consumer options. Problems with long distance, and especially foreign, calls are well known. The service infrastructure is poor.

There are dozens of American universities that are quantitatively and qualitatively far better provided for in the C&C technologies than the best Soviet universities. Most of these US universities are also using their equipment more effectively. Hundreds of US colleges and universities are better equipped than all but a small handful of the best Soviet universities. The volume of hands-on computer literacy training for technical and nontechnical students at US colleges and universities is incomparably greater than in the USSR.

At the pre-college level, Soviet schools are probably doing at least as well, on a nationwide basis, as their US counterparts in the areas of basic verbal and especially mathematical literacies. This is partially because of serious problems in US school systems; the Soviets are probably not doing as well as the Japanese or West Germans. These US deficiencies probably at least partially neutralize substantial qualitative and quantitative advantages in the hardware and software available and in place at US primary and secondary schools. The centralized and relatively disciplined Soviet pre-college school system has the potential to eventually develop a minimally respectable national computer literacy program. We say this in spite of serious shortcomings noted earlier.

Outside of the mainline school tracks, US training programs are far stronger than those of the Soviets. This is the result of the much greater quality and quantity of available hardware and software, experienced teachers, and home use of computers.

Not surprisingly, the most striking gap between US-USSR use levels in the information technologies is in the areas of consumer and entertainment applications. The reasons for the differences encompass technical, economic and political factors. The Soviet information industries lack the orientation and the combined technical/cost-performance capabilities to provide the range of applications and the widespread distribution of hardware, software and services in these areas. The Soviet leadership also clearly does not trust its own population with these technologies at this time. As a result, overall Soviet progress lacks much of the volume, color, flavor, and spirit that has come to characterize what is happening in the West.

C. What have the Soviets been doing to improve their capabilities?

1. Plans for increased effort and resources

In early 1985 a "nationwide program of creation, development of production and effective use of computer technology and automated systems to the year 2000" was approved by the Politburo [Eg85d; Prav85; Yasm86]. It has yet to be published in full, and it may not even exist as a single document, but it apparently calls for better service, more hardware standardization, specialized computers, new training measures, the integration of TPC, CAM and ASUP, and the introduction of computer workstations at the sub-enterprise levels. Significant increases in production are also mandated.

The largest development area within this program is at the lower end of the spectrum, emphasizing applications such as CAM and TPC. The program continues to support the development of the SNCC and OGAS, which are directed towards improving centralized control of the economy and better utilization of computer resources by enterprises. While pushing expanded usage of computing in society, the program apparently does not envision reaching stage 5 pervasiveness in any major areas. We do not know to what extent this plan encompasses all aspects of the C&C industries, and it may be weak on specifics, particularly in the areas of computer-related communications and software.

As noted earlier, one of the most interesting developments during the last couple of years has been the big increase in attention paid to national computer literacy, especially within the formal educational system. This is seen as a necessary means to help attain the more general goals of using the information technologies to help modernize the Soviet economy and military.

In the 12th FYP, special effort is to be devoted to the telephone situation, which remains extraordinarily poor by the standards of advanced industrialized societies. This may be the most important and rudimentary area to watch for large scale, short term improvement in the quality and access of the public to the information technologies. By Soviet standards, these are ambitious plans. In 1986-1990, 12,200,000 new subscribers are to receive phones. The new Five-Year Plan calls for the addition of 10 million numbers by 1990, 75 percent of which will be for private citizens. The Soviets hope to have one phone per family by 2000; by 1990 all collective and state farms should have at least one phone. By 1990 it is planned to have automatic exchanges which allow direct inter-city dialing in 85% of country's 3,600 rayon centers. 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 [Bbcw85d]. The past and recent performance of Minsvyazi inspires little confidence. Nevertheless, we expect that a much expanded and improved centralized voice phone system will be built by 2000. It will not support anywhere near the volume of private and business traffic that has existed on the US system for many years, but there are so many compelling economic, and perhaps military, reasons for improving and expanding the system that it will be done. We have seen no comparable information on improving the telephone system for data communications applications.

2. Organizational and technocratic changes

In the past two years the Soviets have made a number of organizational changes with a direct impact on the C&C technologies. These changes extend from the top levels of government to the ordinary user. A new State Committee for Computing and Informatics (GKVTI) was formed in early 1986, and it joins at a Council of Ministers-level "Buro" for machine building [Hans86c; Izv85i; Prav86c]. The Machine Building Bureau has the power to issue mandatory decrees for its ministries. It remains to be seen exactly what power will be given to the GKVTI. At least four new Deputy Chairmen of the Council of Ministers have held high level positions with purview over the development and application of the C&C technologies.

A new Department for Informatics, Computers, and Automation (OIVTA) has been created within the Academy of Sciences, finally giving these technologies the position they deserve and promising more involvement by the Academy in applied research. The Academy is sponsoring cross-organizational task forces for special projects, for example, the "Start" program to develop a parallel computer that may be part of the Soviet 5th Generation program.

One of the most significant developments may be the Inter-Industry Scientific Technical Complexes (MNTK), which consist of scientific research and design engineering institutes, and experimental enterprises, all of which may fall under the jurisdiction of several ministries, and Academy institutes. An MNTK for personal computers is being formed under the Institute of Informatics. Other relevant MNTKs include one for robotics, to be headed by the Experimental Scientific Research Institute of Metal-Cutting Machine Tools under Minstankoprom, and those for lasers and fiber optics [Izv85o; Pank85]. Some of these organizations will have direct ties with CEMA-wide programs, especially in the field of robotics.

Changes have taken place at lower levels as well. Within ministries, the all-union industrial association level of management is to be eliminated, leading to a two-tiered form of management [Hans85f]. More scientific-research-production associations will be formed. The first branch to undergo this change has been Minpribor. A small number of consumer electronics stores and "microcomputer consulting centers" are beginning to appear in major cities.

The Gorbachev administration inherited a useful legacy from Brezhnev that is likely to be continued and strengthened. The latter greatly expanded the technical elites who had a voice in policy formulation and implementation [Hoff85]. The Brezhnev leadership acknowledged the complexity of C&C-related problems and the need to have more experts investigate feasible options. So much information is necessary to manage a large, advanced industrial society that an information monopoly among a very small elite is no longer necessary nor possible if such a society is to be efficiently run. The leadership can more effectively retain power by controlled devolution of information and secondary decisions. The top political leadership will still retain ultimate decision making power, but there is plenty of room to expand the political communications system to come closer to "democratic centralism."

As noted earlier, CEMA cooperative programs in microelectronics and robotics have been launched to complement the program in computers. A new cooperative program in telecommunications that would progress well beyond simply producing standardized data communications hardware may be taking shape. Plans have been made to create an inter-CEMA network called Interset', but little is known about it.

Taken together, all of these changes represent an attempt to overcome serious problems of the centralized economic system, such as departmentalism, gaps in the R&D-production cycle, appropriation of experimental production facilities for series production, poor overall coordination of research and production, and too much interference from higher levels. The leadership may well consider them essential if the USSR is to avoid falling even farther behind the West in the C&C technologies. Whether these measures prove effective will depend on the extent to which the old mechanisms are truly dismantled, rather than simply transplanted, as happened with the original all-union industrial associations.

3. "Campaigns"

Policy changes in the USSR are often enacted as part of campaigns, or large scale efforts on the part of Soviet authorities to promote new techniques or programs which are portrayed as having potentially great benefits. The typical life cycle of such an effort is initial advocacy, determination, and mainly positive press reports about early results; a middle stage where the positive statements are gradually replaced by accounts of isolated difficulties and then more general conclusions about problems with the program; and a final stage in which the subject fades from view. At this point incrementalism takes over, and slow improvements are made, but without the hope of the massive returns at the early stages. Although such returns are never realized, the campaigns usually do help to produce some modest positive results. It can be argued that the ASUP program is in the final stage, the robotics program has reached the middle stage, and the drive for computer literacy is still in the first.

Why are the campaigns seemingly destined to make a big bang and then fizzle out? If significant changes are not made in the host political, social and economic environment (superstructure), the incentives for using the new technology will remain cosmetic. Knowing that in fact little has changed, Soviet managers are used to waiting out the storm of a campaign until clear skies return. In addition, the objectives of campaigns are severely limited by the ability to shift extra resources to enterprises once they are introduced on a broad scale. Constraints on the enterprise infrastructure imposed by the superstructure must be released before the changes can be effectively implemented on a wide basis.

On the other hand, the campaigns tend to drag on and are never fully abandoned because the power of the symbolism attached to "progressiveness" remains. This phenomenon is particularly acute for the information technologies. The ideology of the so-called Scientific-Technical Revolution (NTR) has placed computing in the forefront of technologies which will put social management on an even more scientific, Marxist-Leninist basis. Therefore, the ASUP program specifically, and the computer-related technologies more generally, persist as symbols of Communism which cannot be abandoned or significantly altered. The Soviets have greatly limited the extent to which the discourse on such topics as ASUP or robotics or computer literacy can involve questions of the superstructure. Nevertheless, the campaigns serve as a useful form of national dialogue and a means for the leadership to present its goals to the population.

4. Technology transfer

From the perspective of this study, the most important form of technology transfer has been the broad exposure to and partial appreciation of Western computing activities at the national level. This helped lead to the change of Soviet perceptions that has evolved over the last two decades, to the dramatic changes in policy that affected much of what we have described above, and has had profound influence on the development of the Soviet and East European industries. Western activities are taking place at a rate, and on a scale, that is impossible to hide from the Soviets. What is most important is most readily accessible to them.

The detailed implementation side of the technology transfer picture is the acquisition, duplication, and assimilation of Western systems, applications, etc. Soviet accessibility to this level of technology has increased dramatically during the last decade, and world technological and business trends are such that this accessibility will continue to increase for some time. These trends include: new system architectures, impressive sustained rates of microelectronic miniaturization, the explosive growth in availability of computing in all sectors of the US economy, the variety and rate of emergence of new products and incrementally innovative ideas, and an increase in the number of capable non-US firms. Collectively, these and other trends are making it easier for the Soviets to find alternate solutions to their needs, to acquire and transport products, and to approach a larger number of potential suppliers for what they want.

But acquisition is not necessarily assimilation, and Soviet progress should be considered in both absolute and relative terms. It may be instructive to view this rapidly changing world from the Soviet side.

The Soviets are observing an incredible range of computer-related activities in the West, particularly in the US and Japan. In roughly the last half dozen years alone, in addition to rapid progress in many "older" areas like microelectronics and disk stores, there has been an extraordinary combination of interwoven technical development and widespread absorption in areas that have "taken off" during this period, including: CAD, CAM, MIS and OA, data communications and networks, and computing for small organizational and personal use.

All of this makes for an acquisition bonanza. Each year the Soviets obtain many thousands of Western research papers, new product announcements, products, descriptions of new applications, etc. These are being used by the Soviet computer industry more effectively than has ever been the case before. This outpouring of Western activity is making it easier for them to get around Western export controls. But it is also making it necessary for the Soviets to acquire much more just to try to control the rate at which they are falling behind.

The Soviets are increasingly being forced to contend with these pressures and opportunities. But the enormity and range of what is involved precludes getting most of what is needed through a few transfers on the "atomic bomb secrets" or "turnkey plants for the automotive industry" models. What the Soviets are seeing are very broad and rapid rates of incremental innovation, and they are not fully capable of understanding or coping with it.

Perhaps worst of all from the Soviet standpoint, it is precisely at the level of the national "big picture", where Western computer technology is most exposed and where past claims regarding the advantages of the "Soviet system" were most pronounced, that technology transfer has been least successful. This is also the level where the Soviet industry has been almost impotent in its ability to perform broadly and innovatively. Rhetoric aside, the combination of Soviet leadership, industry, and user community has never been able to generate massive, innovative, qualitatively new directions in computing such as those described above as "take off" areas. Furthermore, they have difficulty making the technical and systemic adjustments necessary to move in directions defined by the West, the confluence of computing and telecommunications being an important example. These difficulties seem to have become more pronounced since the mid-1970s, with the rapid expansion of Western activities in several major directions, and are likely to continue even if the Soviets should become more innovative at the detailed technical level.

III. A Soviet-style Information Society

A. Will there be a Soviet-style information society?

It is clear from our analyses in Chs. I-II that the Soviets will be compelled to develop and apply the information technologies on a large scale to support their own aspirations and to contend with foreign pressures. Much of this will be concerned with the preservation and enhancement of political and economic control and military power, and with economic modernization through both blue- and white-collar applications. It is also important for them to present the image of a progressive society to the world and to their own population, if only to maintain military credibility, proclaim ideological superiority, and to contend with Western influence and rising internal expectations.

Progress toward all these ends may be made through the use of more traditional means. But the information technologies hold out the promise for significant gains in productivity and control which could not be achieved by other means. If the USSR is to do well by international standards it will have no choice except to pursue much more effective and widespread use of the C&C technologies.

Because of the range, scale, and importance of these problems, there will have to be a "sovietized" nationwide presence of the information technologies by the end of this century. We next consider some prospective features of this presence.

B. What features might characterize a Soviet-style information society?

1. Trends vs. goals

Roughly speaking, our model of a Western-style information society is described by general, intensive, somewhat unconstrained and chaotic, and broadly debated and determined progress in many directions. The nature of the evolving society is beyond the control of any small number of centralized or strongly hierarchical organizations.

The Western-style information society is therefore best characterized in terms of rapidly emerging major trends as outlined in Section I.B. The trends are a result of driving forces which operate within the constraints and possibilities determined by systemic conditions.

Similarly, our model of a "Soviet-style information society" considers the driving forces, systemic conditions and constraints which are influencing the evolution of C&C applications in the USSR. The combination of both main Western trends is clearly excluded under these circumstances; so a different compact characterization will be necessary. We believe that what is emerging in the USSR is best characterized by goals rather than trends. Our analyses of past and current Soviet efforts and sensitivities identify the following four primary goals:

1. To attain real gains in productivity and to modernize the industrial base.
2. To maintain and improve the economic planning and control mechanism.

3. To support both military and internal security needs.

4. To present the image of a progressive society both to the people of the USSR and to the outside world.

We emphasize the importance of all four. They form an irreducible set in two senses. (1) Other goals, such as keeping up with the West or providing selected improvements in education or the standard of living, may be understood entirely within the context of these four. (2) None of the four may be understood entirely within the context of the other three, unless one is prepared to believe (which we do not) that the military dominates the the entire polity. The goals are not determined in a simple dictatorial fashion, but rather through a fairly long and multifaceted process involving the broad participation of a growing technocratic elite.

Our analyses in Ch. II have also identified the most important driving forces, systemic conditions, and development and applications areas for the Soviet Union. This enables us to construct a compact model similar to the one discussed for the West. Both models are summarized in Table 3.

In our view, the contrast between trends and goals as very important relative Western-Soviet features is the most pointed short statement that can be made to illustrate what is happening and how things are happening in the two kinds of societies. Western progress is chaotic, rapid, highly pluralistic and relatively unplanned and unconstrained. A mish-mash of a large number of independent, interrelated or conflicting goals emerges in some gross statistical sense in the form of major trends. The trends may themselves be considered overall goals, but they also have the stronger status of established trends, and so we prefer that term. Soviet progress must await the cautious consideration and approval of the central authorities, and suffers from relatively backward production and distribution capacities and options. Soviet goals are comparatively less complex and more easily enumerated. Soviet trends are comparatively underdeveloped, and prospects have to be assessed in terms of past performance and goals.

A common thread that emerges from both models is the need and desire to improve control over increased complexity and reduced time scales, as discussed in Section I.B. As noted there, even fantasy and entertainment applications may be viewed as a quest for greater control, in this case for building private worlds and of having the control to occasionally escape from the rest of society. Both societies see the information technologies as an increasingly necessary means for the control of production, distribution, and demand. Both see these technologies as means for the control of the dissemination of noneconomic (e.g., political or entertainment) information, for the control of military and intelligence activities, for increasing the volume and efficiency of communications, etc., etc. For both societies, there is a strong control element in all these applications, but the emphases and subgoals are often very different. Most of the differences, e.g., those that govern access to and the dissemination of noneconomic information, are deeply rooted in the ways Western and Soviet societies have functioned for many decades.

A Model of a Western-style Information Society	A Model of a Soviet-style Information Society
Best characterized by emerging trends:	**Best characterized by centrally formulated goals:**
Pervasive application of the C&C technologies	To improve industrial productivity and to modernize the industrial base
Expanded access to information	To maintain and improve the economic planning and control mechanism
	To support both military and internal security needs
	To present the image of a progressive society to the people of the USSR and to the outside world
Driving forces:	**Driving forces:**
Opportunities for innovations inherent in the C&C technologies	National-level political processes
Large and diversified push-pull markets	Western achievements
Fierce domestic and international competition	
Systemic conditions:	**Systemic conditions:**
Little national level control of social change	Powerful national level controls on social change
Organizational flexibility	Organizational rigidities
Relatively weak controls on access to and dissemination of information	Strong controls on access to and dissemination of information lower level controls
Supports the broad dissemination of controls for economic efficiency, private activities and for more communications of all kinds	A strong form of centralized planning and control
	A leadership that distrusts the general population
Development and application of the C&C technologies:	**Development and application of the C&C technologies:**
Interest in all technology areas	Interest in most technology areas
Technological strength in all areas	Modest technological capabilities in most areas
Interest in all applications areas	Interest in a relatively small number of applications areas narrowly related to goals
Near universal user community	Restricted, semi-isolated, relatively small user communities

Table 3

Nevertheless, it should be noted that both are seeking to use the information technologies for both greater concentration and greater distribution of control, but of course in vastly different proportions. The trends in the model of a Western-style information society strongly exhibit very broad dissemination of controls for increased economic efficiency, for personal activities, and for more communications of all kinds. They also exhibit greater mixed centralization/decentralization controls in such areas as military C3I and corporate management. Prospective Soviet dissemination of controls is much more limited and focused. There is also a much stronger element of political control and concerns in Soviet applications. But there is an increasing Soviet realization that some form of more distributed hierarchical control, in contrast to the strong forms of centralization of the past (in graph theoretic terms, a hierarchically layered tree vs. a star), is necessary and desirable.

At some point, we would like to do a more extensive comparative study of Soviet and US societies that more broadly, in the technological, social and historical senses, considers these aspects of control.

Clearly, all the Soviet goals are subsumed under the Western trends, but with differing emphases and different approaches to their achievement. One should be careful not to draw conclusions on Soviet prospects that are based exclusively on Western precedents.

It is not clear if the four primary goals are fully achievable by the end of the century under the given driving forces, systemic conditions and constraints. Ch. IV assesses Soviet prospects and problems for each of the four goals, and discusses some international implications to the Year 2000.

C. Terminology

The term "Soviet-style information society" appears to be a contradiction of terms since it excludes so much of the Western-style model. Although there are many other terms used in the West to label the aggregate of the kinds of C&C-related activities described in Section II.B - information age, computer revolution, microelectronics revolution, telematic society, to name only a few - none applies particularly well to the Soviet model. Neither do terms like the Scientific-Technological Revolution or "enlightened socialism" or the "lack-of-information society" or the "surveillance society."

In discussing this subject with a number of Soviets and Central Europeans (Hungarians and East/West Germans), we asked if they had a name for what was emerging in the CEMA countries. The answer was always "no," and conversations continued on the basis of their agreeing to use any name of our choice which they would simply adopt as a working term for the purposes of the discussion. They seemed content with "information society." The impression we got from each such conversation was that few people in these countries have given the subject the breadth of thought presented here, and that none felt the information technologies would be so pervasive and dominant among the mix of new technologies to the Year 2000 (e.g., nuclear energy, biotechnology and materials in addition to computing and other automation technologies) to warrant a technology-specific name for describing the whole society.

As discussed in the preceding section, in some important ways, the common point of departure for both models is "control." Progress in both the US and USSR can be seen as different forms of a "control revolution" as much as these countries can be seen as different forms of societies that are partially characterized by how information is treated. But a term like "controlled society" or "control revolution" sounds too harsh and misleading for the Western model, and adds nothing that is C&C specific in the case of the USSR, which is a strongly controlled society in many other ways.

So, more or less by default, we will use the term "Soviet-style information society" for the model on the Soviet side of Table 3.

IV. Prospective Progress and Problems to the Year 2000

A. Industrial modernization, gains in productivity and living standards

1. Industrial modernization and gains in productivity

This is one of the Gorbachev administration's overarching goals, and success or failure here will greatly affect the extent to which the other three goals of our model are realized. The proposed means for achievement involve a combination of greater discipline, the elimination of waste, and automation. The information technologies themselves, primarily in the forms of CAD, CAM, TCP and MIS/OA, have the potential for ameliorating the effects of a labor shortage, providing basic industrial modernization in both the manufacturing and the R&D sectors, increasing the volumes and quality of goods produced, imposing additional discipline, and helping to eliminate waste. These applications have, by far, the highest profile in the Soviet media, and are at the core of the program for computing to the Year 2000.

The most important questions concerning the effects of the systemic conditions on progress towards this goal are twofold. Will the Soviet information industries be capable of providing the technology to support industrial automation? Will the superstructure problems that have plagued the ASUP program for 20 years be much of an impediment?

There are two plausible views as to whether or not societally pervasive applications are necessary to support a sufficient infrastructure to meet this goal. The first holds that the Soviet C&C industries are large and by no means impotent. They cover the full spectrum of the relevant technologies. As long as they are not expected to meet the combined overall Western standards of extent of applications, technological level, sophistication of integration and service, the Soviet industries might be able to perform at a reasonable level, both qualitatively and quantitatively, with some foreign technology transfer and additional resources. The Soviets should be able to build them up to the point where they at least better their marginal and undistinguished performance in support of the ASUP program.

According to this position, the need for a pervasive presence of microcomputers, entertainment applications, computer networks, etc. in Soviet society as a prerequisite for successful large scale industrial automation in the USSR has been exaggerated. The lack of private automobiles and telephones has not prevented Soviet industry or the military from having a large number of trucks and tanks and field communications systems with adequately trained operators. Similarly, one can learn to tend an FMS without having to have a microcomputer at home.

The second view holds that every stage of pervasiveness requires a corresponding support level from the infrastructure. It is the pervasiveness of applications (demand-pull) that stimulates the infrastructure to respond, just as a healthy infrastructure fosters demand by making applications possible (supply-push). One can learn to tend an FMS without having to have a microcomputer at home, but can the infrastructure provide sufficiently reliable microcomputers and other technologies without the demand base that home personal computers provide?

Our view is a hybrid. Significant resources will be added to the C&C industries to help them improve their performance and there will be improvements in infrastructure, but this will not be up to supporting stage 5 pervasiveness in Soviet enterprises. However, stage 4 in selected sectors might be possible and adequate. Demand pull has never been sufficient to prod the C&C industries into overcoming certain fundamental deficiencies in hardware reliability and service, and for software development and support. The Soviets therefore must unfetter the demand side by (a) unleashing some forces of private industry within the infrastructure, or (b) allowing enterprises to act more autonomously, or (c) by providing more and better equipment on the supply side to help stimulate demand. To some extent, the efforts described in Ch. II represent progress along the lines of (b) and (c).

The creation of small, perhaps private, enterprises would help fill in the cracks in the infrastructure. Small software companies or service vendors might be allowed in order to promote technological innovation and improve the quality of services. Such companies would surely provide some services better, but might well run into the same barriers that would-be users now suffer from, especially with respect to obtaining and repairing hardware.

Although it may not be as bad in some ways, almost all of the superstructural and infrastructural problems that afflicted the ASUP program during the last two decades will also handicap the broader industrial automation program. The main advantages CAM may have over ASUP are that measurable forms of Soviet-style, quantity oriented, productivity increases may be obtainable from localized use of industrial automation at the shop level and in the short term, and that Soviet managers and workers may perceive less risk from using CAM than MIS.

But most of Soviet industry has not yet reached a level of organization at which it is ready to try to reap the full benefits of of the information technologies. For example, consider the technique of just-in-time production (JITP). JITP requires that production processes be so highly coordinated, well-timed, and well-executed that there is practically no margin for error and, as such, has given some US companies fits. But the Soviets, with their erratic supply system, could obtain greater gains merely by ensuring consistency in the arrival of most supplies and by making sure that everything supplied was of good quality. The USSR is said to be facing a labor shortage that will supposedly be relieved by automation, but anybody who has ever visited a Soviet store knows that there is plenty of underemployed labor. Within this environment, computing relieves some problems, but is also an additional form of inefficiency itself and exposes others that it cannot correct.

The leadership may hope to overcome these problems through slow structural changes and technological improvements, and through the exposure of younger workers and managers to the information technologies at work and school. The latter may make more effective use of what there is and create some constructive demand from below in the short term, and perhaps see to better solutions in the long term. This seems to be the view held by several prominent academicians and technocrats, and they are gaining support, perhaps because there is no better and feasible alternative at this time. Consider, for example, the frustration and hope expressed by the director of a major Georgian ASU institute:

> Unfortunately, today the real interest in ASU has significantly diminished, and this is at the moment when we have sufficiently powerful hardware and software and data processing technology to make it possible to satisfy the needs of economic management. Sharp changes in the practice of the use of ASU can be expected with the arrival of the new generation, the new type of manager-commanders of production and workers of the management apparatus, who today, in the 9th and 10th classes, are grasping general ´computer literacy´ [Emm85c].

There are risks that such programs might lead Soviet society further away from computing if they are not carried out well. Many experienced enterprise directors have more misgivings about using computers now than they did 20 years ago [Emm85; Emm85c]. Potential for similar disillusionment exists in the program for industrial automation.

The limitations of the Soviet C&C industries, and the more important superstructural/infrastructural problems, will make it impossible for the USSR to automate - in both the MIS and CAM senses - most of its industry and commerce by the end of the century. Strong testimony to this effect is given by the legacy of the introduction of computing into Soviet enterprises and R&D organizations over more than 20 years [Mche85]. It is questionable if they will do much better with the larger, more complicated, and riskier problem of industrial automation.

This is not to say that little or nothing will be done. The Soviets have no choice but to try hard, and something will come of the effort. In the short term, there will be several prominent and perhaps exaggerated successes, but serious initial work and experimentation will take place both in high priority military-industrial and in lessor sectors. In time, we would expect islands of advanced industrial automation to emerge, and some are already emerging. The rest, probably most, of Soviet industry will be left behind in a backwater that will be more distanced from the advanced sectors than is the case today. The selection process will no doubt reflect the priorities given to the other three basic goals in our model. We would expect to see the most rapid rate of introduction in ASUTP/TPC. The Soviets are adding more than 500 of these per year, and this rate can be expected to increase as a result of better and cheaper hardware, and the emphasis placed on this area under goal 1. By the end of the century they may reach the point where most important, well-understood, and not exorbitantly expensive process will be partially computer controlled. The introduction of

ASUP will continue to have problems along the lines already discussed, and will be introduced at the slowest rate and perhaps with the least effect. The introduction of robots and FMS will be at a rate between the first two, the the rate for robots being faster than that for FMS and more integrated forms of CAM. Even this level of success would go far to vindicate central planning and control and "discipline" as effective ways for running a country.

2. Gains in living standards

An improved standard of living should be more than just a positive incentive towards achieving state goals. It is an important goal in itself, and the most important the vast majority of citizens see in their one pass at life.

Even if the Soviets should be modestly successful in attaining the four primary goals of Table 3, the gap between the relative Western-USSR standards of living may grow for the rest of this century. The information technologies have been contributing to some dramatic and high profile changes in this gap. This trend may be accelerated in spite of prospective Soviet improvements, the Gorbachev administration's real interest in increasing domestic consumption, and the need to come up with entertainment options to fill some of the time that has until recently been spent with vodka.

Most of the West is now well beyond minimum subsistence levels for housing, food and education. Standard of living is increasingly a matter of range of choice and availability of services and products, greater career and leisure time opportunities, more personal communications, the quantitative and qualitative expansion of entertainment possibilities, etc. In these terms, a more efficient industrial economy as defined by our model of a Soviet-style information society will not provide a great improvement in standard of living for most of the Soviet people.

The information technologies are making it possible for the Western set of products, services and opportunities to expand rapidly in both quality and quantity. The Soviet subset is expanding much more slowly. In a world where the variety and volume of electronics-based consumer products and services are growing at unprecedented rates, the USSR is producing little and exporting less of what anyone really wants to directly improve their standard of living. Imports are limited to items for the elite or near elite and for the never ending, never really successful, goal of strengthening industrial sectors that need more than what Soviet indigenous technology can provide. The USSR chooses to constrain its citizens' opportunities by remaining outside of a world that is increasingly capable and increasingly inclined to communicate among it components. To do otherwise would be to weaken the internal position of the Party and the ruling elites, and to inevitably permit some "dissidence." In the past, when the stakes were more modest technologically and in the more limited extent of the technological interface with daily life (e.g., photocopying machines), it was relatively easy for the leadership to impose strong and fairly effective controls. Now the cost and pace are much higher, and this East-West gap is growing.

> The vigor of a society can, in the short run, be stimulated by revolutionary ardor or wartime discipline. But over the long haul, social vigor is a function of fun, in this sense: People will be more energetic, creative, productive, fecund when they are

enjoying themselves. A capacity for enjoyment is grounded in self-esteem. That is difficult to develop in a society in which the individual is considered a mere manifestation of this or that collective category ("worker," "peasant," "vanguard"). Individual attributes and achievements are made to seem trivial in comparison with ideological goals [Wil186].

In terms of this view of societal "vigor" and changing world-wide standards of living, the four primary goals of Ch. III, and the likely Soviet means for achieving them, do not offer much for the average Soviet citizen, although it would be an exaggeration to say they offer nothing. Conversely, under the circumstances it may be too much to expect the average Soviet citizen to rise to heroic efforts to help the state achieve those goals.

B. Economic planning and control

The USSR appears to be more strongly wedded to comprehensive central planning than China or most of Eastern Europe. The reasons for this are historical, ideological, and political. In particular, this may be the Soviet Union's most notable economic innovation, and it would be very difficult for the Soviets to back away from it. Some continue to see centralized planning as having great potential to help use resources optimally, and to increase output and productivity. Others may see it as an important form of political and information control. In any case, in the effort to maintain close control over an increasingly complex economic domain and planning process there is little choice but to turn to the C&C technologies. If there is anything that could be seen as a singularly Soviet element of an information society, this is it.

We expect that the Soviets will continue to build OGAS and other state committee and ministry-level systems. The fundamental problems to be faced again involve the ability of the infrastructure to deliver the necessary services and the ability of the host environments to absorb the applications. However, by the Year 2000 there will probably be a substantial amount of data exchange via telecommunications between these systems, and data base management technologies will be widely used. Computers will become almost universal in the TsSU system, which will be used to collect and process data from the vast majority of enterprises.

Three serious problems arise from the surrounding environment. First, the whole planning and control mechanism is a highly political process. Despite efforts to computerize Gosplan since the early 60s, most of the automation simply replaces the calculators of yesterday without changing the methods used in order to balance the plan. Are Soviet planners really ready to allow a computer to make decisions for them when their decision making power is their most valuable possession? Will planners who are concerned about gross inconsistencies be interested in using computers to fine-tune plans?

Second, computerization does not substantially change the nature of the data which is being collected, nor does it address the problem of collecting data in machine readable form. The TsSU collects the same data and simply processes and delivers it faster. To what extent is this data accurate? This question cannot be answered with any certainty, but at any given time there is probably a good deal of incorrect data in circulation. Branch autonomy may also hinder links between various systems and the sharing of accurate data, which may be one reason superministries are being created.

Finally, there is the problem of planning from the achieved level, on which much of the incentive system is based. It is too difficult, even with computers, to determine from scratch what each economic unit should be producing. Solving this kind of problem involves repeated iterations of balancing global and local optimal solutions across tens of thousands of organizational units; it has not even been solved for organizations as simple as a single oil company with multiple refineries. Supercomputers that would be capable of doing this over many sectors of the Soviet economy will probably be unavailable for some time to come. Planning from the achieved level results in an enormous amount of inertia and has given rise to gross structural imbalances in the Soviet economy. The choices which could be made by using computers are severely limited. Soviets at the highest levels have talked about changing this aspect of the system, but so far no clear and effective alternatives are being widely implemented.

More pervasive use of computers for economic control might take some forms that would yield results. For instance, the maintenance of large data bases of the reported information may help the central authorities uncover reporting inconsistencies and track down phony data. Planners should be able to make more use of the available data for analysis purposes. Faster reporting and analysis will be possible, so that some decisions which now come too late to be of any use will be made on time.

It might be possible to solve some of the false data problems by using direct, sensor-based collection methods. This would be enormously expensive, and would require that computing be used at all levels of the hierarchy, down to the shop floor, on a near-universal basis. It would also require a tremendous telecommunications infrastructure. This kind of universal and effective economic surveillance will not become reality by the end of the century.

We expect that there will some improvements in the overall performance of the economic control and planning mechanism, but that these gains will fall far short of what the Soviet leadership desires. Computers will help the central planners to keep up with the growing volume of data and to have somewhat more control over the complexity of the economy. But the planning process will still be constrained by all the problems just noted, and will still be shot through with politics. Large scale optimal plans will remain out of reach.

C. Military and internal security

We consider certain aspects of civilian-military relations in the C&C industries, some US-USSR military implications, and internal security and sociopolitical risk.

1. Civilian-military relations in the C&C industries

Goal 3 exists in a competitive-complementary relation with the others and with Western efforts and policies. If Western high-tech military systems are perceived to be the most important potential military threat to the USSR, then the Soviet Union should focus on developing the necessary technologies and industries to deal with this threat. This plausible long term Soviet response is consistent with our discussions of Chs. II-III, and is based on the premise that the Soviets value the other three primary goals (Table 3) for social and economic reasons that greatly transcend their contributions to military power. If this is the case, then more resources will be poured into strengthening the C&C industries and important applications sectors to the benefit of all four goals, and less may be poured into more conventional military means, such as in the numerical growth of existing forces, which contributes far less to the other three goals. Not only would this help preserve and modernize Soviet military power vis-a-vis the West, but it is also a sensible approach with regard to China.

In our view, and within the scope of this study, success in the pursuit of goal 3 will depend on certain aspects of civilian-military relations in the C&C industries. Ideally, there should be a mutually beneficial, complementary relationship between a strong set of C&C industries and strong user communities, as has been the case in the West. Each should help bootstrap the other.

In our model, most of the user community strength in the USSR is heavily concentrated in the production enterprises of the Group A economic branches, including the Soviet military and military-industrial (VPK) enterprises. The centralized planning and control mechanism exists in part to guarantee and reinforce the status of these high priority portions of the Soviet user community. In theory, all of this is well connected and expedited through the VPK since a large part of the core of the Soviet C&C ministries and this part of the user community fall under its purview. These relationships look fine in theory, and seem to work well for areas like the production of armored vehicles. They do not work as well for the C&C applications because the complexity and competition are different.

Looking at the Soviet civil-military high-tech relationship from a different perspective than we did in subsection II.A.4, it might argued that many of the problems of the Soviet C&C industries stem from the lack of a strong feedback relationship with a world-class user community, and that the Soviet military is not such a community. Conversely, it may be argued that Soviet military-related applications suffer because of the many problems of the C&C industries. The military, and military-related industry and R&D organizations, enjoy privileges: they have advantages over normal civilian organizations with regard to recruiting and rewarding capable people; they may have priority in tasking covert acquisitions and greater exposure to Western technology; military representatives are in a position to exercise quality control functions at computer production facilities; and the Soviet military is in direct competition with Western counterparts in a way that has no strong parallel in the civilian economy. But all of this does not make the Soviet military-industrial establishment a C&C using community comparable to the general purpose users in the US, Western Europe and Japan.

Consider the following three "meta C&C user communities:" the Soviet military, the US military, and the US civilian communities. The first is the smallest, most conservative and risk averting, and least well supported. The second is much larger, considerably less conservative in its computer-related activities, e.g., it is inconceivable that the Soviet military would have been the first to take an ARPANET-like initiative, and is much better supported and more experienced in almost every important sense. The third is far larger than the first two combined, extraordinarily diversified across a mind-boggling range of users and applications, is extremely well supported and provides most of the support for the second, and is a main prize of what may be the most singular technological competition in history between the US and Japanese C&C industries.

So where does the detailed technological imperative or push for the Soviet industry come from? From the high reaches of the Party-Government pyramid? From the relatively impotent, general civilian user community? From the the military? Where does the Party-Government or Soviet military get many of their perceived needs? Some substantial portion comes from the examples provided by the Western military and civilian user communities. Does the Soviet military need a general computing base that is broader and deeper than the one it is capable of building and supporting entirely within itself? Yes, as is evidenced by the way it uses what is available in the West as a surrogate for what it does not have at home. Furthermore, for all its resources and privileges, the Soviet military cannot control all that is necessary to build a civilian computing base comparable to that in the West, or even to put pressure on the

Soviet information industries comparable to the pressures that exist on the Western industries. The complexity and scale of what is involved is well beyond that for building an atomic bomb or launching a Sputnik.

The Soviet military and C&C industries are far from impotent, but both are at a considerable disadvantage relative to their Western counterparts. The East-West gap here may not be as great as in other C&C applications areas, but the gap exists. It is one of the few areas where the relative advantages bestowed on the Soviet military have not overcome Western advantages.

The successful pursuit of goal 3 will be strongly dependent on how well the Soviets contend with the problems and relative disadvantages discussed above. Their past record is such that they will be doing well if the East-West gap does not widen.

2. Some US-USSR military implications

The US is increasingly setting the pace and directions with regard to the military applications of the information technologies. US successes and failures determine the relative Soviet position and the way the game is played at least as much as anything the Soviets themselves do. In our view, the converse statement, i.e., regarding Soviet determinants on the US, is weaker.

For at least the rest of this century, it is unlikely that Soviet progress in the C&C technologies will strengthen them to the point where they can broadly catch up with or surpass Western military applications. In order for that to happen, we believe the West must stumble or fall down. For example, if the West fails in the development of SDI, the Soviets may be able to close some of the gaps in military applications because the West will have wasted scarce resources that would have been better used elsewhere. On the other hand, if the West succeeds with SDI, the USSR will not have the overall C&C capabilities to match it. The most sensible plan, given Soviet accomplishments, prospects and the importance of these technologies to an SDI-like effort, would seem to be to invest the necessary resources to counter, rather than match, an SDI system. An obvious possibility might be to try to overwhelm it by using less sophisticated technologies than SDI itself employs. It is possible that, in the case of SDI, the West might be trying to press it's technological advantages too hard, and the net result may be poorer risk-to-gain prospects than what the US is, in effect, forcing on the Soviets.

The Western lead across a broad spectrum of security-related applications of the C&C technologies is such that the USSR will continue to have to rely on a wide range of technology transfer mechanisms to keep this gap from growing more rapidly than it is.

Finally, We do not seem to have a good understanding of Soviet-American perceptions of the real military value of each other's C&C-based systems. We would speculate as follows: The Soviets know how weak their own systems are. They probably have an exaggerated perception of what US has, given the sources they probably have and use. We probably have a much exaggerated perception of what they have because of our sources. But the two sides' view of US systems most likely is closer than the two sides' view of USSR systems. The net result is that the Soviets may see larger gaps than really exist, and the US may be seeing smaller gaps.

3. Internal security and sociopolitical risk

We know of no strong evidence to the effect that the KGB is doing particularly well in the use of the information technologies for the applications described in subsection II.A.4 for domestic surveillance. This may be assumed to be the case because: these applications would clearly be of value to such an agency; they are within current technical capabilities; the KGB can obtain the necessary resources to make them realities; and there are few constraints to prevent them from doing so.

In time, we would expect additional use of the C&C technologies in in the form of embedded, somewhat transparent, surveillance in systems which are used by the population on a daily basis, such as the telephone system or possibly industrial electronic funds transfer systems if they ever come into common use. For such applications, it is important that the surveillance is not obvious, but that everyone be conditioned to think it might be there. In the past, manpower constraints have prevented the Soviets from making such surveillance really pervasive. Computers will not immediately bring this about, but may make the present system work more effectively and eventually lead to higher surveillance levels.

It is unlikely that the Soviet population will see Orwellian-like telescreens during this century. The reasons are threefold: they are well beyond current technology; a nationally pervasive system would be enormously expensive; and they could not be imposed on the population by anything short of a return to a neo-Stalinist regime. It is also possible that the effort to do so would destabilize the political system.

Will the expanded use of the information technologies open a social/political Pandora's Box, or will the authorities be able to maintain control? Of the technologies and applications considered in Ch. II, few taken alone present as much risk as some Western analysts have claimed or that the Soviets seem to fear. Nevertheless, Soviet authorities remain very cautious with regard to the widespread introduction of any of the information technologies that have serious potential for being used to increase exposure to information from foreign sources, that may be willfully used for dissident activities, or which increase the volume of private two-way communications. A small number of dissidents with typewriters were able to have a disproportionate effect, at least on the Western media and the KGB, during the 1970s. From this standpoint, the prospect of a prominent academic with Sakharov-like thoughts and access to hundreds of domestic and foreign colleagues through computer networks must be unnerving. Soviet concerns for secrecy, and the importance they attach to presenting a unified front and showing that they can control information, will continue to be an important factor that will severely retard the introduction of the information technologies and handicap the achievement of at least goals 1 and 4.

However, if there is to be substantial progress towards all four goals, it will be necessary for the Soviet leadership to permit and encourage the much expanded utilization of the information technologies. Given the potential of C&C applications, the inevitable result will be less effective and more flexible controls over an expanding user base than had been possible in the past, e.g., when photocopy machines were the main concern. Control of photocopiers was relatively simple, and the cost of such control, in terms of lost economic opportunities, was easily acceptable against the potential risk. This will not be the case with some of the newer technologies of Table 2. For example, at first attempts were made to exclude VCRs, but so many were imported that the leadership chose to co-opt the black market with its own regulated supply of machines and cassettes [Taub86; Yasm86b]. Nevertheless, VCRs remain a troublesome technology for the authorities. The microcomputer could become the next most-coveted item by the elite, and its importance to all four goals will force even greater accommodations than has been the case with VCRs. Both the education program and the broad distribution of work stations among professionals may create a large pool of knowledgeable people who are demanding access to computers. To a certain extent this is exactly the result that the leadership hopes to achieve. And this is the quandary in which the leadership finds itself: educating people to use computers effectively in order to meet its goals will inevitably lead to increased expectations for private ownership and use.

The one area where the Soviets have achieved stage 5 pervasiveness is in the control and distribution of domestic radio, TV, and the press. In a sense, this has been the first "information society" achievement in the USSR. The development and spread of other technologies - VCR, technologies for the reception of foreign radio and TV, microcomputers, etc. - have the potential to weaken Soviet controls over the volume and nature of information flows. Fairly significant increases in all forms of Soviet information controls - legal, manpower, propaganda, vigilance, product shortages, etc. - will be necessary to keep even a porous lid on all of this, and a porous lid is all that can be expected.

On balance for the rest of the century, expanding C&C applications will be more of a problem with regard to internal security and information control than it will be an asset for increased surveillance. In the past the Soviet authorities had all the technological advantages. This is shifting fairly rapidly, and uses for political dissent are becoming increasingly hidden or swept under by the much larger demand for consumer and entertainment applications. It will become increasingly difficult for the authorities to separate dissidence from entertainment, as may be seen in Kay's definition of fantasy as a powerful form of control of one's private environment (Section I.B). By the Year 2000, the net result may be something of a semi-controlled opening up of information flows among at least the more educated elements of Soviet society. However, we believe that this will not result in a wholesale erosion of political power, although it may lead to significant changes in intra-Party processes, and that the Soviets will find these people to be mainly interested in their own well being.

More generally, Gorbachev's growing technocratic "elites" may be more secure in their power than their predecessors, and less distrustful of the population. On the other hand, the KGB "elites" may find these problems to be opportunities for their own further growth and employment.

D. Image and influence

The USSR has a long history of proclaiming its ideological and moral superiority over the West. It is inconceivable that the Soviets will drop these claims, which have been heavy with "scientific" justification and emphasis on the unparalleled progressiveness of Soviet society. In particular, computing is one of the centerpiece technologies of the Scientific-Technological Revolution (NTR), perhaps the most important augmentation to and modernization of Marxist-Leninist theory in decades. Ideology is a significant consideration in the formulation of policy, at least to the extent of precluding actions which would seriously contradict or subvert it, and it is important to the official self-image and to the legitimacy of the regime, even if most officials and ordinary citizens are something less than "true believers."

The information technologies have become so prominent that Soviet claims ring hollow to themselves and the outside world if they look backward and dependent on Western technology transfer. If the population observes that the NTR is not working according to official plans and pronouncements, it may become more disillusioned with Marxism-Leninism, driving a greater wedge between publicly maintained and privately held belief systems. This will not help the Soviets improve morale, confidence in centralized planning, work incentives, and interest in using computers. There would be serious negative implications for the other three primary goals, and the resulting frustration could be - in fact, has already been - a factor leading to limited systemic changes (see sections II.C and IV.E).

It is difficult for the Soviets to swallow the appearance of not keeping up with the West. This is a matter of defending the ideology and of national and ethnic pride. With regard to the development and application of the information technologies, our models and analyses show that the USSR cannot or does not want to keep up with the West in many ways. But they are under pressure to look like they are so as not to appear backward. We can expect to see a lot of "we have that too" noise and examples, and the Soviets will have to try to make up in image what they lack or do not want to have in substance.

In some cases, of course, they genuinely want a lot of substance to go with the image, e.g., for military credibility. In others, they want a little to go a long way: to meet some rising expectations, or at least to avoid further disillusionment, of the population for more and more interesting consumer goods.

The Soviets have a conflict between the noble claims of the ideology, which among other things should welcome the Western trends with open arms, and the realities of desired controls. In a sense there is a conflict between Marxist theory and Leninist practice. They want to retain the control and power structure, but present an image in keeping with the modernized ideology and realities elsewhere in the world.

To this end, they need to at least look like they are succeeding with goals 1-3. Beliefs about computing and the host social/economic system play a major role in promoting or hindering its absorption into society. A good self-image will help progress towards goals 1-3. Conversely, nothing would contribute more to the image of a progressive society than significant progress towards the other three goals.

Soviet image has suffered, both domestically and internationally, in recent years as a result of problems with the development and application of the C&C technologies. This is likely to continue for the rest of the century.

The Soviet leadership and significant parts of the general population will see their society become increasingly backward relative to the West. The differences in host conditions for and applications of the information technologies will provide broad, high profile contrasts that cannot be ignored. This will be true even if the Soviets are modestly successful in their pursuit of the four primary goals discussed in Ch. III, but it will be much worse if they are not. Pressure towards a more negative self image will be maintained by the rate and scope of change in the West. Doubts will continue to arise about the scientific and progressive claims made on behalf of Soviet ideology and achievement. They may seek a certain solace in claims that Western uses of the information technologies make for more immoral, corrupt, and unstable societies.

Compared with the West, the USSR has always been relatively backward technologically. Time and various forms of exposure (see below) are making it look worse. Much of the world has become more consumer and entertainment oriented to the relative disadvantage of the Soviets. The Soviet system has shown itself to be slower to adapt to a much quickened pace. Western styles, products, and culture catch people's imagination more thoroughly and more rapidly than ever. This has been, and will continue to be, greatly accelerated by the information technologies.

The East Europeans see growing gaps between what is going on in the West and the USSR. Even taking into account differences between and within the so-called CEMA-6 countries, most would want to move towards many Western-type applications. Self- and Western-imposed constraints limit East European access to what they want from the West. They are pulled to the Soviet Union by political, military and economic conditions, and will have to be wedded to Soviet progress for these reasons. In some ways, Soviet influence is growing as its image weakens.

With regard to the C&C technologies, Soviet image and influence have both suffered in China. Perhaps in no other technological area have the Chinese so clearly shown dissatisfaction with Soviet ways [Pol185]. If the Chinese are very successful, and it is by no means clear that they will be, this could have a profound effect on Soviet and Chinese self perceptions.

Much of the Third World population craves the entertainment and other benefits, such as improved health care and education, that the information technologies can help bring. Western applications may become increasingly more attractive and available to them. Soviet alternatives should be comparatively much weaker. They may also increasingly perceive the USSR as being backward. However, most Marxist Third World governments should be capable of suppressing this craving, and it is not likely to be an important factor. Furthermore, parts of the Third World, especially among the Islamic societies, are very ascetic, and probably see Western information societies as increasingly bad models, with more chaos, less God, greater personal freedom and immorality, etc. Countries like Iran and Libya have even less reason to want to have anything to do with Western-style information societies than the USSR.

Not only are the applications of the information technologies changing the basis of image and influence, but they are also the vehicles for making it more difficult for the Soviets to control information on these and other changes and pressures. They expose the Soviet population to more of what is going on beyond their borders, and they expose much of the rest of the world to more of what is going on within the Soviet Union. When the Soviets resist or seem oblivious to or contemptuous of such things, as in the cases of the KAL 007 and Chernobyl incidents, their image and credibility suffer even further.

E. The limits of systemic evolution

The Soviet system is not entirely inflexible. We briefly describe four commonly considered models of how the Soviet economy and polity might evolve during the rest of this century [Berl84]. It is likely that they collectively define the potential systemic boundaries within which progress must take place. The Soviets themselves are experimenting with one model, and the East Germans, Hungarians and Chinese with two of the others. The C&C technologies may be seen as the most difficult test arena for all four models and for all four countries. We briefly consider whether the experiences of these other countries under these other models hold much promise for Soviet progress well beyond the assessments of this study.

The conservative model is essentially what evolved under Brezhnev and appears to be what has been reaffirmed for the near term. The commitment to central planning remains solid. Various incremental changes may be made in planning, success indicators, discipline, size of firms, contracts, labor and price policy. Some measures to promote technological improvement are possible, like the creation of new organizations or organizational bonds, but it is accepted that the USSR will always lag by some years behind the West, except perhaps in a few high-priority areas. It may be argued that such a society will remain stable as long as consumption is above a minimum threshold and there is enough growth to support sufficient incentives.

If, in time, the conservative model simply cannot provide minimally acceptable levels of progress, the Soviets may find a palatable alternative in what might be called the progressive model. This is roughly what is used in the GDR. In comparison with the conservative model, the ministerial system is relatively weaker and state enterprises have more autonomy. It permits the selective use of small private enterprises in certain sectors, recognizing that there are some areas in which strong centralization does not promote incentives for productive work, and that the central planning process cannot cope with all the detail of all levels of the economy. Yet central planning remains a powerful factor. From the Soviet perspective, a stumbling block of this model may that it would lead to greater inequalities in income distribution which could force the political and technocratic elite to share power with "capitalists," and there may be fears that any form of private enterprise will lead to an unacceptable erosion of central planning and social control. So far, the record in the GDR has been such as to dispel these fears for the most part.

The neo-Stalinist (reactionary) model posits a return to a system with a stronger police state, reduced foreign contacts and greater emphasis on discipline and order. In this scenario the information technologies are used extensively for surveillance and control. Central planning would be strengthened, and further organizational centralization likely. Control would be much more sophisticated, and the excesses under Stalin would be avoided. This model may bring short term gains through better discipline, a high-investment growth strategy, a slow growth in consumption, a drive against the second economy, and a purge of the less productive. In the long term, it would only accentuate the worst faults of the current system as far as the development and application of the C&C technologies are concerned. Its resuscitation could follow from several possible scenarios of failure and popular discontent.

The so-called radical model is essentially what exists in Hungary. It incorporates significant private ownership and a decentralization of planning and management, leading to changes in supply, performance evaluation, prices, labor, finance, etc. Party and government control is maintained through investment, prices, continued central ownership and control, taxation. The Hungarian experience shows increased quality and service, but overall Hungarian performance in the six C&C development and applications areas has had severe problems. From the Soviet perspective, it seriously compromises centralized control of the C&C technologies and economic planning, and opens the door for greater social diversity. Because it changes both the infrastructure and the superstructure, it means abandoning a significant part of the Soviet system as it exists today.

We have explicitly or implicitly assumed a hybrid of the conservative and progressive economic models for most of the analysis in this study, and believe our model of a Soviet-style information society would be fairly insensitive under either of these two economic models or hybrids. We would expect little change in the four primary goals, the driving forces, or the systemic conditions of our model. There might be differences in rates and levels of achievement, but our overall assessments to the Year 2000 would remain essentially unchanged. Much the same might be said about some evolution towards the neo-Stalinist model. Obviously, there would have to be major changes to the model if the Soviets were to move to a strong form of the Hungarian (radical) model, but we consider this unlikely in spite of the apparent presence of advocate groups within the USSR.

Some brief comments about evolving information societies in other Communist countries are in order. The GDR operates its information industries within a fairly well established progressive model, and China is moving in that direction [Econ86e; Pol185]. Both are giving the C&C industries very high priority. On a per capita basis, the GDR is doing better than any other Communist country in the development and application of the C&C technologies, and the regime is surviving its inability to control the availability of West German TV. This has certainly been noticed by senior members of the Gorbachev administration, and is likely to have some influence on and appeal to the Soviets. However, the progressive model is only one factor in the relative East German success. Other factors to be considered are scale, the special relationship between the two Germanies which provides for the most effective hard currency and technology transfer arrangements in CEMA, differences in national characters and experiences, and the superpower position of the USSR. All of its relative advantages do not make the GDR's C&C industries first rate by Western technological and commercial standards, but they do keep them from becoming third rate.

It is too early to draw conclusions about China, and we do not claim to be experts on developments in China. To date progress appears to be modest, but significant. The Chinese experience is of interest both because of the size of the country and because it is a truly independent Communist power. In our view, Chinese achievements have been less impressive and more dependent on Western technology transfer than some analysts believe. The PRC also seems to have better technological relations with the West than does the USSR.

Hungary is the only Communist country to exhibit a real hybrid of both the Western- and Soviet-style information societies. It does so through weak forms of most of the trends, goals, driving forces, and systemic conditions on both sides of Table 3. Within its technical, economic, and political means, and these are very serious limitations, Hungary has opened up to the C&C technologies. It has, by far, the highest per capita private and small institutional ownership of microcomputers in CEMA. It may become the first CEMA country to have something approximating a broadly accessible national computer network. Within the last few years, a nontrivial fraction of the Hungarian computing community has been privatized, partially privatized, or at least freed from strong forms of centralized control. The lack of modems and printers for micros is more of a problem of not being able to build or pay for them than a political limitation. Unfortunately, what has been happening in Hungary may be approaching its limits, and prospects for continued progress leave much to be desired. Nevertheless, this more colorful and spirited form of absorption of the information technologies in Hungary has contributed to that small country's positive self perception of the way it runs itself and of its standard of living.

F. Will the different uses of the C&C technologies in the US and USSR strengthen or weaken the relative position of the Soviet Union as a superpower?

The analyses and syntheses in this study have shown that the different uses of of the information technologies in the US and USSR have weakened the relative position of the USSR as a superpower, at least within the domains where these applications influence such status, and that this is likely to continue for the rest of the century. We conclude by briefly noting that relative US-USSR positions as superpowers may also change due to a weakening of the US position.

The information technologies will tend to decentralize Western leadership. For example, Japanese progress is such that they have already and will continue to partially displace the US as the most technically and economically advanced of the Western countries. More generally, capabilities in the C&C technologies are diffusing rapidly among the advanced, and some not-so-advanced, countries, and it is not hard to envision a future world economic-technological order dominated by four powers (Europe, the Far East, the US and USSR). This weakening of US leadership may make it more difficult for the West to act collectively on East-West matters.

There is some serious potential for Soviet gains relative to the US information industries and applications in manufacturing, but not against the West as a whole, because of the decline in US technological leadership. In particular, the US is in risk of losing important parts of domestic industries due to their inability to stand up against foreign competition in domestic and international markets. This has already happened in semiconductors, computer peripherals, CNC machine tools and other areas. The US is becoming increasingly vulnerable and building undesirable dependencies in this sense. Soviet forms of control of their own economy allow them to maintain a complete set of industries, even if they are not competitive by worldwide standards.

Finally, American society might do well to learn to deal more effectively with problems induced by these technologies. What are the the information technologies doing to internal US social strengths? The emerging information society has strengthened dissent and the power of the media in the US. Is this providing us with a better form of democracy, or is it permitting so much diversification that the US is becoming increasingly incapable of acting with the full power and backing of the nation for sustained periods in a tough, and less remote, world? Is the US capable of regaining its declining technological and economic leadership and controlling its appetite for imports?

The information technologies may be weakening the positions of both superpowers.

GLOSSARY

AI	Artificial Intelligence
AN	Academy of Sciences
ARPANET	Packet Switched Network Sponsored by ARPA
ASU	Automated Control/Managament System
ASUP	Automated Enterprise Management System
ASUTP	ASU for Technological Processes (TPC)
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
C&C	Computing and Communications
CEMA	Council for Economic Mutual Assistance (also CMEA and COMECON)
CIM	Computer Integrated Manufacturing
CPSU	Communist Party of the Soviet Union
FMS	Flexible Manufacturing System
FYP	Five Year Plan
GKNT	State Committee for Science and Technology
GKVTSI	State Committee for Computing and Informatics
GOSPLAN	USSR State Planning Committee
GOSSNAB	USSR State Committee for Material and Technical Supply
GPKIASU	State Design Institute of ASU, Volgograd
IC	Integrated Circuit
IIASA	International Institute of Applied Systems Analysis, Laxenburg, Austria
JITP	Just In Time Production
KGB	USSR Committee for State Security
LAN	Local Area Network

MINAVTOPROM	USSR All-Union Ministry of the Automotive Industry
MINELEKTRONPROM	USSR All-Union Ministry of the Electronics Industry
MINPRIBOR	USSR All-Union Ministry of Instrument Construction, Means of Automation, and Control Systems
MINPROMSVYAZI	USSR All-Union Ministry of the Communications Equipment Industry
MINPROS	USSR All-Union Ministry of Education
MINRADIOPROM	USSR All-Union Ministry of the Radio Industry
MINSTANKOPROM	USSR All-Union Ministry of Machine Tool and Tooling Industry
MINSVYAZI	USSR Union-Republic Ministry of Communications
MINVUZ	USSR Union-Republic Ministry of Higher and Specialized Secondary Education
MIS	Management Information System
MNTK	Inter-Industry Scientific-Technical Complex
MPKVT	Inter-Governmental Commission on Computer Technology, CEMA
NTR	Scientific-Technological Revolution
NTSAO	The National Center of Automated Exchange of Information with Foreign Computer Networks and Data Bases
OA	Office Automation
OASU	Branch Automated Management System
OGAS	All-Union System for the Collection and Processing of Information for Accounting, Planning, and Management of the National Economy
OGSPD	Statewide Network for Data Transmission
OIVTA	Department of Informatics, Computer Technology, and Automation, USSR Academy of Sciences
POLITBURO	Politburo of the Central Committee of the CPSU
SNCC	State Network of Computer Centers
TASS	Telegraphic Agency of the Soviet Union
TSSU	USSR Central Statistical Administration

TPC	Technical Process Control
VCR	Video Cassette Recorder
VNIIPAS	All Union Scientific-Research Institute for Applied Computerized Systems, Moscow
VPK	Military-Industrial Commission
VTSKP	Collective-Use Computer Center
WAN	Wide-Area Network

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