Issues Paper

Summary of Selected Readings

Background for the 12 November Evening Session

What is the Information Revolution?

Advances in computing and communications promise to transform global society in the 21st century. The massive, sustained increase in the capability to access, process, analyze, and transmit large amounts of data has emerged as a major force in technological innovation and a key determinant of national economic health. Information technologies have remolded existing and created entirely new industries. Cheap yet powerful computers have dramatically expanded information available to the ordinary citizen and simultaneously placed his privacy at risk. Military programs like the Strategic Defense Initiative call for successful integration of computing and communications activities of unprecedented scope and complexity.

Ingredients

The pace and thrust of the information revolution hinges on a handful of interrelated technologies:

Microelectronics: Advances in semiconductor manufacturing have increased exponentially the density and performance of integrated circuits (ICs)--the basic ingredient of all modern computer and communications hardware. Some IC prices have remained stable, but mass production of inexpensive, general purpose ICs has caused the cost of memory and logic functions to plummet, fueling an explosion in the use of microelectronics-based computing and communications by the military, industry, and the public. Continuing advances in manufacturing methods ensure that this trend is unlikely to stop soon. Globally, electronics--broadly defined--is reportedly a $300 billion-a-year business that is slated to triple by the year 2000 (see reading 1, "The High Tech Race: Who's Ahead?"; and The Information Technology Revolution, Forester, "Editor's Introduction," pp. xiii-xvii).

Computers: Although advances in the power, speed, and efficiency of large mainframe computers were fairly predictable, the surge in the use of minicomputers and personal computers (PCs) was largely unforeseen. In 1985, US business bought 2,000 mainframes for $6.9 billion while 84,000 minicomputers were sold for $9.5 billion. Sales of minicomputers are expected to grow at an annual rate of 8 - 9 percent for the balance of the decade, while mainframes are to grow at 2 percent. Meanwhile PC sales in 1985 stood at $3.6 billion worldwide and are expected to grow at 20 percent through 1987. A modestly priced PC typically used in an office today often outperforms the large costly mainframe computers used as recently as a decade ago.

Telecommunications: In addition to making traditional communications services less expensive and more flexible, the advent of digital transmission and switching systems served to link rapidly proliferating computers and data bases in commerce, government, and industry. In 1983 sales of communications equipment--such as communications satellites, cable television, cellular radio, videodata systems, and local area networks--totaled almost $60 billion worldwide and was expected to climb to $90 billion by 1988. In 1983, one large telecommunications network was linked to 100,000 computer terminals, and required 4000 minicomputers and 300 mainframe computers to operate.

Software: Perhaps the most rapidly growing and changing aspect of the information industry is the software that generates the myriad of instructions that operate, link, and apply computers and telecommunications hardware. Global sales of software totaled $26 billion in 1985 and were growing at an annual rate of more than 17 percent. In the United States alone, PC software sales have doubled annually since 1980 and now account for one third of total software sales of $18 billion. By 1990, business is projected to spend more on computer software than on hardware.

Software increasingly determines the function and performance of digital systems, enables hardware to be ever more generally applied, and serves as the nervous system of national and local telecommunications and information networks. Development of software for artificial intelligence largely governs prospects for the major US information processing challenges--whether battle management for SDI or the "thinking machine", the 5th generation computer (see reading 2, "Information Technology" and Forester, "Software: The New Driving Force," pp 27-44).

Most authors hold that Western technological progress has depended in large part on a hospitable economic system, providing both support and incentive. In the United States, computer-related training is the most rapidly growing component of high school and college curricula. Venture capital has facilitated rapid pursuit of high risk avenues of technology development for commercial use, while government funding has generated a massive effort directed at defense needs. Government decontrol of telecommunications has intensified competition, ostensibly encouraging innovation and efficiency. In Japan, the educational system supplies impressive numbers of skilled engineers, and the government nurtures a dialogue with industry aimed at gaining international competitive advantage. Japan is attempting to spur development by privatizing its national telecommunication research and development system (staffed by half a million employees), and by purchasing innovative US firms--in essence, keeping venture capital initiatives "in the family" (see Forester, "Chips: The US versus Japan," pp. 45-55, and reading 3, "The Information Revolution: Trade in Services").

Applications

Intensifying global technological and economic competition makes the effective exploitation of these information technologies a key feature of military and economic survival. Most modern weapons, command and control, and logistical systems are otherwise unfeasible.

Information technologies already pervade Western science, industry, and society, aiding analysis and decision making, managing industrial operations, and providing convenience and entertainment for the consumer. Scientists use large, high-performance, mainframe computers to access and analyze enormous streams of data, while engineers routinely use minicomputers to grapple with more modest problems and PC networks to share information. Desktop terminals and PCs provide executives and white collar workers in government and industry with rapidly growing capability to access and analyze statistical, financial, and operational data. Telecommunications links within and between organizations can provide an almost unlimited ability to share information (see Forester, "The Mechanization of Office Work," pp. 298-311, and reading 4, "The Soviet Lag in High Tech Defense").

Information technologies have moved on to the plant floor. In the US, purchases of factory automation systems doubled between 1980 and 1985 to $18.1 billion, and are expected to double again by 1990. Minicomputers and microcomputers routinely control manufacturing processes, machine tools, and robots. Flexible manufacturing approaches link one or more machine tools and programmable robots under the supervision of a computer to further automate manufacturing processes. Local area networks integrate production scheduling, procurement, and material handling. Computer-aided design terminals host complex and often specialized software packages to create designs in hours that would require months to complete manually. Many larger manufacturers are developing computer-integrated manufacturing

(CIM) approaches that would eventually integrate many of these functions into a "lights out" factory. (see reading 5, "High Tech to the Rescue: Can Automation Save American Industry?" and Forester, "Computers in Manufacturing", pp. 260-272).

Information technologies have rapidly expanded the variety and quality of services available to private citizens. Smart appliances, pocket calculators, automatic teller machines, and laser scans at stores and supermarkets save time. Cable television and video cassette records bring in high quality entertainment and in some areas even make it possible to shop in the home. PCs and telephone modems that can link to remote data bases or local and national networks enable professionals to work at home, help students with their homework, allow hobbyists to readily share information and support video games. Application of information technologies in medicine has created more precise, non-intrusive diagnostic tools to monitor individual health, directly linked service paramedics to diagnostics available at their base hospital, and created minicomputers on a chip for smart implants such as pacemakers. Fire and police departments increasingly control their vehicles with the aid of computer networks, while local governments use office automation to speed customer services.

The impact of advancing information technologies on US economic productivity, growth, and international competitiveness is debatable. Some analysts argue that productivity for white collar workers, comprising three fourths of the US labor force, is no greater than it was in the 1960s. They postulate that managers and workers either have not yet learned how to use computers, or that the burden of meeting more intrusive government demands for tax, fiscal, and labor relations reporting have overwhelmed productivity gains. Other assessments point to the clear advantages major airlines and financial services firms have gained over domestic and foreign competitors by raising productivity through office automation. There is general consensus that the introduction of information technologies has streamlined manufacturing operations in the U.S., renewing growth even in mature industries like automobiles and aircraft. Nevertheless, manufacturing productivity gains in Japan--even in critical elements of the electronics industry--have outstripped growth in the U.S., inciting fears that America is losing the high tech race (see reading 6, "A Puzzlingly Poorly Productive America").

Information technologies are increasingly important in weapons development and production. Prowess in smart munitions, avionics, missile guidance, fire control, and surveillance and command and control systems--rooted in advances in microelectronics, microcomputers, and software--is widely viewed as America's primary military advantage. Computers and software accounted for less than two percent of development costs for the F-4 Phantom, the mainstay US fighter aircraft of the 1960s and early 1970s. The figure for the F-15 was over 40 percent, and that for the F-18 even higher. In 1985 the Department of Defense spent $194 million for the very-high-speed integrated circuit (VHSIC) project with the goal of increasing the density and performance of silicon-based ICs a hundred fold by 1990. The Pentagon has plans to use the first generation of VHSIC chips in 37 major weapons systems by 1992. Military software demands will also be fueled by the 250,000 military computers estimated to be in military operation in 1990.

Computer and communications security is a vital concern throughout government, business, and industry, given the danger of espionage and sabotage. A recent survey of more than 17,000 computers used in the Department of Defense concluded that one half required better access control. Disaffected engineers or programmers could insert a few lines of code among the millions of lines of operating code a large computer may use and severely disrupt the machine functions. Hackers--often teenagers--share information on techniques for illegally accessing computers on some of the roughly 1,000 computer bulletin boards operated in the U.S. The question of how to proceed against hackers has raised unprecedented issues in jurisprudence.

The information revolution is also placing, at least potentially, the security of the individual at risk. Some estimate that the individual is referenced on average in roughly 40 local and federal government agency files and about the same number of private sector files. The Internal Revenue Service is obligated to pass its records to 38 different government offices. A 1984 Gallup poll revealed that two thirds of the US population believed that they had lost or are likely to lose some privacy. A 1983 Harris poll revealed that 86 percent of the citizenry felt it was possible for the government to use available information to persecute its "enemies" (see reading 7, "Privacy Protection in the United States in 1984: Is it Adequate?").

Although there appears to be general agreement that the information revolution is likely to bring about sizeable changes in the world economy, how much, how soon, and in what direction are hotly debated. Some analysts make the point that it is difficult to forecast the effects of these new technologies, because their application will be determined more by economic, political, and demographic conditions than by the intrinsic merits of the technologies. In any event, the importance of product "intellectual content" is likely to increase the dominance of the services sector in national economies. Dislocations of workers in aging smokestack industries, the semiskilled, and, increasingly white collar workers, may be a substantial force as well.

How Do the Soviets View the Western Information Revolution?

Soviet officials actively follow developments in Western information technologies and applications. Like many aspects of the East-West competition, two themes frequently arise in their statements and writings: concern over the potential threat, and a carefully crafted balance of admiration and criticism as they move to emulate Western progress. Although different factions in the Soviet establishment may place varying emphasis on each theme, nearly all officials toe the official line: Western development must and can be matched, borrowing positive aspects and side-stepping the negatives.

Concern

Soviet leaders--especially Gorbachev--have been blunt in depicting the threat posed by the Western information revolution. They have criticized the lethargy of the 1970s, implicitly charging that the Brezhnev leadership failed to act on the promise of information technologies and to appreciate the pace and consequences of Western advances. They have specifically criticized the practice of overreliance on a follower strategy--adopting Western advance. Officials have noted the difficulty of reverse engineering, and the accelerating progress in many of the key technologies. They express concern over the prospect of being condemned to a permanent lag.

The economic consequences are frequently highlighted. Leaders and officials talk about achieving international competitiveness in manufactures, both in the high technology products themselves and especially in the broad array of product groups--like vehicles and machine tools--where applications of information technologies are driving cost and quality. Other officials--frequently scientists--talk about the importance of maintaining prestige as a first rate technical power.

More broadly, and more seriously, Soviet officials cite the contribution of information technologies to productivity growth and economic development in all advanced industrial countries. Noting that productivity must fuel virtually all Soviet growth for the remainder of the century, they have argued that information technologies are a linchpin in their efforts to match Western industrial prowess, international influence, and consumption levels.

> "Economic competition between the two systems is more noticeably moving into the scientific and technical sphere. The result of this competition will be decided precisely in that sphere."

They also acknowledge the "bandwagon" effect in the West--that information technology advances rapidly reinforce further advance-- as a way of highlighting the danger of playing catch up.

Military concerns also surface. Generally, Soviet military and political leaders always have acknowledged the role of a strong economy in supporting military power. More specifically, Soviet military leaders have cited the contribution of information technologies to advancing Western weapon capabilities--most recently in "smart" conventional weapons and SDI. They note that Soviet progress is essential to emulate and, in many cases, also to defeat (see reading 4, Gannes).

Admiration and Criticism

Active Soviet proponents of information technologies and applications, probably encouraged by Gorbachev's admonition to confront and acknowledge shortcomings, speak and write favorably about Western accomplishments. They are impressed by Western dynamism, particularly in rapid industrial assimilation and mass production, and admit that they were caught by surprise. They cite Western cost advantages--comparing, for example, Western computers costing in the hundreds of dollars with the 8-bit Agat, "costing up to 3,000 rubles." They have praised Western innovators like Stephen Wozniak. And some have even acknowledged that Soviet systems--like the Agat--are modeled after Western systems and basically use Western developed components.

Open criticism seems to come from two quarters. Some officials with a clear vested interest criticize aspects of Western development--like decentralized computing--that are "incompatible" with Soviet approaches. Other writers in the popular press frequently use Western experience with information technologies to criticize the capitalist system. Information technologies are variously accused of causing bankruptcy, unemployment, alienation, and invasion of privacy and of supporting Western militarism and espionage (see readings 8, "American Capitalism Criticized for Use of Computers," and 9, "USSR: Academic Journal Takes Up Debate Over Computers").

Soviet officials confidently reassure their people that socialism can reap the benefits and avoid the pain: "We, of course, do not have these problems and cannot have them."

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What Are Soviet Goals For Their Own Information Revolution?

Gorbachev has embraced the information revolution. He has called for the "technical restructuring" of the Soviet economy and singled out information technologies and their supporting industries for highest priority development in the USSR and Eastern Europe (see reading 10, Excerpts from Gorbachev's June 1985 Speech on Science and Technology). He expects information and other advanced technologies to reverse the decline in the growth of Soviet labor productivity and GNP, acknowledging that the prospect of very little increase in the Soviet labor force makes this even more urgent (see The Soviet Economy Under a New Leader, p.2) Over all, he wants to launch the Soviet Union onto a new development course and holds out the hope that the USSR will be in the same league as the US and Japan in the year 2000.

In the economy, he has set ambitious targets for the suppliers of information technologies, while prominent officials promise substantial gains from information technology applications.

- Production of computer equipment is slated to grow annually by 18 percent through 1990. By that time the Soviets are to produce 1.1 million personal computers, after producing virtually none until the mid-1980s.

- Output by the main producer of instrumentation equipment is slated to grow by 19 percent per year in the 1986-90 period, up from 6 percent in the previous five-year period.

- Production of robots in the 1986-90 period is to increase by 2.2 times, NC machine tools by 1.9 times, and machining centers by 4.3 times compared with 1981-85 production.

The Soviets are counting on flexible manufacturing systems and other computer-aided machinery to provide the necessary precision to achieve the increasingly complex designs required by advanced military systems, including subsystem miniaturization, increased structural strength, and reduced weight.

Installation of CAD/CAM is to dramatically increase. Optimistic Soviet officials have claimed that CAD systems will shorten product development times by 50 to 80 percent. Other officials have claimed that automation in engineering industries will increase labor productivity 2-2.5 times, while automation of continuous processing can free up to one-half of the laborers.

In the military, specific Soviet goals are less clear. It is evident, however, that the Soviets have not become any less aggressive in meeting the challenge of advancing Western weapons technology. As weapon costs skyrocket and technology breakthoughs offer large performance gains, there are indications that the Soviet military is pressing harder than in the 1970s for weapons of better quality even at the cost of reduced quantities. Information technologies are central to this strategy, both in the weapons and in the factory (see The Soviet Weapons Industry: An Overview).

In society, the authorities promise an improvement in the quality of life, and a smooth transition to the new information society. In the near term, the regime emphasizes education and training, with the introduction in 1985 of a mandatory course on the basic principles of computers and computer programming at the 9th and 10th grade level. The Soviets are planning to supply 500,000 personal computers to the schools by 1990--or about 40 percent of total production-- and 5 million by the year 2000. Mass communication services, as well as home personal computers and VCRs, are expected to increase in number and improve in quality. Advocates claim that citizens' lives will be enriched and creative forces unleashed throughout society. Other officials point to the need to mobilize control organs to guard against "infection" by "bourgeois" ideas, but--at least openly--express confidence that infection can be contained. In all, as an architect of the computer literacy program promises, information technologies "will change our life, making it fuller, wiser, more sensible, and, in the end, happier than now".

Where Are the Soviets Starting From?

Soviet and Western observers generally agree that the USSR lags Western nations considerably in the development and application of information technologies. These lags have persisted--and in some areas lengthened--despite a massive commitment of resources to information technology R&D dating back to the 1960s. As in many areas of Soviet technology, the quality of R&D is sometimes impressive--the USSR claims, for example, to have "invented" the transistor. While this competence has enabled Moscow to erode certain Western leads at the laboratory stage, familiar Soviet problems in industrial innovation and application are the major brakes on Soviet progress.

Technologies

Western experts generally hold that Soviet microelectronics, computer, and telecommunications technologies lag Western state-of-the-art by anywhere from zero to 15 years, depending on the specific technology (see readings 11 Stapleton and Goodman, "Microcomputing in the Soviet Union and Eastern Europe," and 12, Selin, "Communications and Computers in the USSR: Successes and Failures"). In general, the Soviets are said to fare better in major hardware development than in the developmental support technology such as computer peripherals and software. Where advance is more amenable to a massive, focussed campaign--like certain programs in telecommunications and microcircuit development--the Soviets do relatively better and the Western lead may shrink; where advance depends more on coordinated and mutually reinforcing development in a host of interelated technologies, such as in computers or computer-aided manufacturing, the Western lead is more likely to be sustained or even increase. Across all information technologies, however, it has been demonstrated that Soviet advance has depended significantly on imported or stolen Western technology (see <u>Soviet Acquisition of Militarily Significant Western Technology: An Update</u>, and reading 13, Goodman, "Technology Transfer and the Development of the Soviet Computer Industry").

In the last several years Soviet officials appear to have become more acutely aware of the need for much improved coordination of interrelated information technologies. Support services--software, peripheral equipment, maintenance, and user training--have repeatedly been singled out as the most serious problem areas (see reading 14, "Microcomputer Repair Service Excoriated"). Soviet leaders have responded by creating organizations to coordinate development and foster compatibility among the hundreds of independent product lines (see reading 15, "Computerization Encounters Difficulties"). To date, the response appears to be largely bureaucratic--new oversight committees, expanded technical standards, and formal quality certification.

Moreover, on the hardware, software, and support fronts the Soviets are trying to capitalize on the resources of Eastern Europe, part of the Council for Mutual Economic Assistance (CEMA). This also is not new--computer development (initially the Ryad Series) was the first major product of CEMA integration of R&D in the early 1970s. Recently, the CEMA has announced the S&T 2000 program, singling out key information technologies for much expanded cooperative development efforts. Soviet organizations will lead these development efforts and stand to gain particularly in areas where East European countries are leaders (see reading 16, "Computer Bang-or Whimper"). The Soviets also gain by using Eastern Europe as a conduit for Western information technology.

Applications

According to Soviet official data, information technologies are being applied on an increasing scale throughout the economy. R&D and industrial customers are receiving preference in the allocation of computers. Mainframes used for inventory control, payroll, and other management support functions are fairly common in large plants, while minicomputers are held to be applied extensively in process control. Soviet and Western authors, however, claim that Soviet computers are generally used less intensively than those in Western firms.

Western authors have described the Soviet telephone system as primitive by Western standards and notorious for poor-quality transmission and unreliability. The plan for 1985 called for increasing the level of existing network automation--switching of long distance calls without the assistance of an operator--to a mere 55 percent. The Soviets also have a large but unsophisticated communications satellite network. They have launched six times as much payload weight as the US Intelsat system, but have less than one-fifth the communications capacity. Leading edge technologies such as optical fibers for data transmission, network control programs, and digital switching presently appear in Soviet literature as problems that must be solved before widescale use begins. At the same time, the Soviets make more modest demands on their telecommunications system than is typical in an advanced Western country. (see readings 11, Selin, and 17, Selin, "Ma Bell's Spirits Alive and Well in Moscow").

The development of the computer, microelectronics, and telecommunications industries allowed the Soviets in the mid-1970s to begin introducing automated management systems (ASUs) on the plant, regional and national levels. The Soviets use ASUs for economic, administrative, inventory, product planning, and process control applications. By 1985, the USSR reported they had installed over 6,300 systems of all types. Difficulties in applying largescale systems apparently have convinced the Soviets to deemphasize ministerial and enterprise level systems in favor of lower-level process control ASUs, as illustrated in the chart below.

	1971-75	1976-80	1981-85
ASUs for technical processes	564	1306	2611
ASOIs (automated data processing systems)	108	133	259
ASUs for ministry management	168	92	60
ASUs for enterprise management	838	389	296

Source: Narodnoye Khozyaystvo SSSR, 1985.

In general, both Soviet and Western analysts say that the range and intensity of Soviet applications remain well behind those in the West. The Soviets have highly automated factories, but many are islands in a sea of aging industrial plant. Uneven development--especially in services--also contributes to failure to achieve the hoped for gains in efficiency (see reading 18, "Problems of Production Automation"). The Soviet system itself also weakens the Soviet manager's interest in embracing the information age, whether he provides or uses information services. Soviet authors acknowledge that these shortcomings significantly reduce the economic benefits they obtain from automated management systems (see reading 19, "The Great Soviet Computer Screw-Up" and reading 20, "Problems in Acceptance of Computers Reported"). Information technologies have made limited inroads into the schools.

Information technologies have had varying impact in the home. The USSR has significantly upgraded and expanded its television and radio broadcasting capabilities (see reading 21, "The Rapid Expansion of Soviet Satellite TV Broadcasting"). Soviet surveys reveal that most citizens obtain an increasing share of their information from broadcast media at the expense of print media and lectures. Video cassette recorders are in great demand; an estimated 300,000 are already in homes (see reading 22, Yasman, "The Collectivization of Videos"). Personal computers appear to have made the least impact, due to shortages of equipment, maintenance, and training (see reading 23 "Home Computers Have Gone On Sale").

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Information technologies also have the potential to be used by organs of political and social control. Western analysts have assumed that the privileged position of the KGB, police, and Communist Party apparatus would assure them ready access to the best available technology for communications intercept and surveillance.

Discussion Questions

1. Do the Soviets view the Western information revolution as a threat, an opportunity, or both? What threats do they foresee--to military power, international competitiveness, and/or domestic control? What opportunities do they foresee, particularly for capitalizing on Western advance?

2. Where are the Soviets starting from? Where do key Soviet technologies stand relative to Western technologies, and is the gap widening or narrowing? What aspects of the Soviet political and economic system particularly favor or impair advance? What interest groups will most forcefully press for or resist the information revolution?

3. What are Soviet goals for information technology development and application, and how do goals for economic, military, and social programs rank in importance? Are Soviet goals realistic by the standards of Western experience?

4. How important are Soviet information technology goals for their overall economic, military, and social programs? Are there any feasible alternatives to these goals--i.e. can they sit out aspects of the Western revolution, and/or rely exclusively on a follower strategy?