Defense Horizons

Number 43

A publication of the
Center for Technology and National Security Policy
National Defense University

JULY 2004

Global Networks: Emerging Constraints on Strategy

by Bob Fonow

Overview

If current trends in communications technologies and services persist, the United States will be hard pressed to keep a strategic advantage in network capability. The international telecommunications system is rebalancing into four major centers of influence and innovation. Within ten years, Europe, India, and China will have the same technological and innovative capabilities in telecommunications as the United States. This shift is problematic for U.S. national security, because the global telecommunications infrastructure is becoming an important strategic battlespace—the physical battlefield of information warfare. Understanding the dynamic of regional balancing is critical to shaping U.S. responses

Underscoring this dynamic is a shift from hierarchical science and technology development based on U.S. educational dominance to globally distributed centers of technological development facilitated by the international telecommunications network.

This article assesses the changing geopolitical structure of the international telecommunications system and analyzes the problems and opportunities for the United States in a vastly different telecommunications environment. Much of the writing on U.S. network-centric warfare and information warfare capabilities reflects unbounded enthusiasm, with little emphasis on vulnerabilities and the capabilities of potential adversaries. A thoughtful evaluation of new strategic constraints is imperative.

Regional Telecommunications Hegemonies

At present, the United States is the leader in telecommunications technologies, but its leadership is being challenged. A trend toward a subsystem of regional telecommunications hegemonies is emerging under the umbrella of the global telecommunications and Internet infrastructure. Aggregations of technological capability are taking place in Europe, under European Community legal and regulatory prescriptions. China is aggregating capability around Asia and between Asia and the United States via China Netcom and China Telecom, the two major Chinese carriers with global aspirations. An Indian firm, Reliance, recently purchased the assets of the global undersea services provider FLAG, the first infrastructure purchase of assets outside India by a private Indian telecommunications company.[1] This supports a longstanding Indian political and economic goal of equality in global information technology (IT).

Within these subsystems, or hubs, communications clusters develop in which a set of countries communicates predominantly with each other. Islamic countries communicate with one another, and the former Soviet republics still communicate with each other far more than they communicate with other countries of the world. These clusters are becoming regionalized under the umbrella of globalization. This will lead, for example, to the extension of Chinese culture throughout East and Southeast Asia and to a solidification of a regional Islamic culture.[2] The research and development capabilities of the regional telecommunications hegemonies will be much more balanced than today.

India—Software Services

In the last three years India has emerged as a global IT power, with Wipro, Infosys, and other companies taking significant shares of software development from American companies. Most of this work takes place over the international telecommunications network, and much of it relates to telecommunications. Reliance Gateway, a subsidiary of Reliance Infocomm—the telecommunications arm of Reliance and one of the largest industrial conglomerates in India—recently purchased the assets of FLAG Telecom Holdings. This gives India its first corporation with ownership of international assets, other than leases on satellites and paraticipation in undersea cable consortia, and positions the company to provide a wide array of global telecom services to Indian and other clients.

Outsourcing of American and European software development to India is a politically sensitive issue, but little emphasis is given to emerging telecommunications patterns that indicate a strengthening of relationships between India and the Middle East. It is easy to discount this by noting the conflict between Hindu and Muslim nationalists, yet India has the second largest Muslim population in the world, after Indonesia.

Even though India still has one of the lowest teledensities (telephone main lines per 100 people) in the world, the main focus of India's industrial policy for the last twenty years has been on IT provided over advanced telecommunications services. Recent reform of its regulatory apparatus and the privatization of state assets are leading to accelerated access to new services. Arguments are beginning to appear in the Indian press comparing India's industrial policy to China's and positing an argument that India may surpass China in entrepreneurship and innovation, and already has done so in the software industry.[3]

Indian business journalists argue that economic development initiated by homegrown entrepreneurs may give India a long-term advantage over China, which is considered hamstrung by reliance on foreign direct investment (FDI) and by inefficient banks and capital markets. Indian executives believe that China's export-led manufacturing boom is largely the creation of FDI, which has served as a substitute for domestic entrepreneurship. Indeed, India has approximately 3 percent of China's recent annualized FDI, but it is weighted asymmetrically toward information technology, which is much less capital dependent than are manufacturing investments.[4]

To many Indian observers, China's economy is large and dynamic, but it doesn't support transnational entrepreneurial success. Only recently have a few local Chinese firms, such as ZTE and Huawei, become significant international companies. China's private sector still has very few domestic companies capable of rivaling large multinationals. China's wealthy diaspora has been eager to fund development of the mainland, so Chinese entrepreneurs have become spoiled by easy money.

India's diaspora, in contrast, was resented for its success until recently and mostly did not invest in the homeland. New Delhi took a dim view of Indians who had gone abroad, and of foreign investment generally, and preferred to create a more nurturing environment for domestic entrepreneurs. In the process, India spawned a number of indigenous companies that compete internationally with the best American and European companies. Many of these firms are on the cutting edge of knowledge-based industries, such as software (including telecommunications software), pharmaceuticals, and biotechnology.

China—Manufacturing and Services

Chinese companies are likely to replace Western companies as vendors of choice for infrastructure expansion in developing countries, based on China's rapid development of its own infrastructure. The list of major competitive wins for telecommunications infrastructure projects in developing countries in Asia, Africa, and Latin America by Huawei and ZTE in 2003 and early 2004 indicates a focused and well-financed export program. The low cost of equipment manufactured and increasingly designed in China provides an attractive financial alternative to equipment manufactured in Europe, Japan, and the United States. Western companies will become an increasing small part of the value and revenue chain of infrastructure development.

Money spent on research and development (R&D) frequently is taken as an indicator of the efforts by companies to innovate and develop knowledge-based industries. According to the OECD, R&D spending in China has been expanding at an inflation-adjusted rate of 10-15 percent per year, a much higher rate than that for most OECD countries.[5] Chinese R&D spending has grown from 0.6 percent of GDP in 1996 to 1.1 percent in 2002, with 60 percent coming from companies and the rest from the government. The OECD ranks China third in the world in total R&D spending in 2001 at $60 billion. The United States was first at $282 billion, Japan second at $104 billion, and Germany fourth at $54 billion. At current comparative rates of GDP growth and R&D spending, China will begin to approximate American GDP and R&D capabilities between 2015 and 2020 and will spend more than the United States in both these categories by 2024. Should an international event push China into a strategic relationship with India or Russia, or even into an alliance with a number of smaller regional powers, the United States would be at a great competitive disadvantage.

In a very interesting development, several large Indian IT service companies have decided to tap into China. Gartner Group predicts that Indian firms eventually will control 40 percent of China's IT service exports. Satyam Computer Services, India's fourth-biggest supplier, set up a development center in Shanghai last year, with plans to expand, believing that China presents more opportunity than any other country, mainly in working with multinationals that need reliable software support for their expanding mainland businesses.

Europe and Russia—Subsidiary Roles?

Information technology is an important factor in the U.S.-EU productivity gap; real annual growth rates in the EU have stagnated at about 1 percent for the last three years.[6] Europeans seem reluctant to use telecommunications and IT to operate more efficiently and to exploit market opportunities, especially in cross-border service industries. One obvious reason is a state preference for job retention, which leads to high structural barriers to market efficiency. In many European countries, residual state socialist policies place more importance on welfare than on market efficiency.

European technological development in telecommunications also is hindered by national protection of dominant state carriers, which puts a brake on entrepreneurship and on the aggregation of regional intellectual property. European interstate telecommunications charges rank among the highest in the world and are not necessarily related to distance or technical complexity. However, a European technological momentum is developing as more countries comply with common regulatory policies implemented by the European Commission. This will accelerate as more countries join the European Community.

Nonetheless, Europe has sectors of innovation in telecommunications that lead the world. Finland is the most "wired" country in the world and is home to Nokia, the leading innovator in cell phones. GSM, the European cell phone standard, is the most widely used standard in mobile networks outside the United States and has the widest international roaming capability.

In Russia, banks are stabilizing and investment is returning, but as yet there are no indigenous global telecommunications or IT

Robert C. Fonow is managing director of Revenue Growth International, Ltd. He may be contacted at rcf@rgiltd.com.

companies to drive innovation and bring capital into the sector. We know, however, that Russian scientists produce innovative technologies in a number of industries when capital resources are available. The important development to watch is R&D collaboration between Chinese and Russian companies. ZTE, a leading Chinese telecommunications manufacturer, established a research facility in Moscow in 2004 to exploit Russian engineering expertise. Technical ties between India and Russia are long standing.

The Periphery—Indonesia, Brazil, and Romania

Indonesia has a substantial technical education capability at university level. Many of its best engineers are sent to the United States for postgraduate education. Although many Indonesian engineers working for American companies return to Indonesia because of restrictions and visa policies introduced in the United Stataes after 9/11, there are few jobs for them back home. Indonesia, which recently was rated the fifth most corrupt country in the world, has little foreign direct investment other than in mineral extraction enterprises. Absent a positive outlet for Indonesian technical capability, there is a concern that Indonesian engineers will turn to hacking, cracking, and other criminal cyber activities to make a living.

This is already happening in Brazil.[7] According to the *New York Times*, Brazil is becoming a laboratory for cyber crime. For the last two years, Brazil has been the most active base for hackers and cyber criminals. Last year, the world's ten most active groups of Internet vandals and criminals were Brazilian, according to mi2g, a communications intelligence company based in London. More than six times as many overt Internet attacks—those that are reported and validated—have been traced to Brazil as to Turkey, the next most frequent source. The rise in Brazilian cyber crime is attributed to lax laws. A crime has to be proven before an arrest can be made. Just hacking into a system is not enough.

Information technology has been a Romanian strength since the Ceausescu regime. The late dictator saw computers as a tool for advancing communist ideology. Software piracy took firm hold during the Soviet era, when Romanians too poor to buy licensed software simply copied it. Today Romanian universities have top notch IT programs whose graduates are recruited heavily by Western companies. Microsoft Corp. recently acquired GeCAD, a leading Bucharest security firm.[8] Thirty-six universities teach computer science, producing a surfeit of highly trained programmers.

The Emerging Telepolitical Infrastructure

The international telecommunications system is one of the most complex achievements of human science and technology. Yet it is still in a nascent stage of development, controlled primarily by Western business and government interests and serving only 60 percent of the world population.[9] It is a work in progress, and there is a growing symbiotic relationship between the development of the telecommunications infrastructure and the international political system. Increasingly, they feed off one another. The political system defines the scope of market growth and economic geography; the telecommunications network sets the pace of international integration.

During the Cold War, there were two competing telecommunications systems. One was owned by Western interests, primarily in the United States, Western Europe, and Japan. The other was owned and operated by communist bloc governments, with their own indigenous design, equipment manufacturing capability, and satellite system, Intersputnik. The competing systems facilitated competing political goals, for example, in Africa where the Soviet Union and the United States competed for political advantage in the 1960s and 1970s. Many African countries still maintain close relationships with former executives of Intersputnik.

The breakdown of the Soviet system led to the next stage of integration, in which massive network investment, first in Russia and then in China, facilitated the switch from command to putative market economies in both countries. Of course, the development patterns of Russia and China are culturally unique, but each bloc decided to integrate its telecommunications systems into the global telecommunications infrastructure with surprisingly little regulatory interference. There is now a unitary global telecommunications system outside the complete control of any one political sovereignty.

The international telecommunications system is rebalancing into four geographically and technologically balanced centers of influence and innovation supporting a new supranational international relations regime. Three aspects of the international telecommunications infrastructure are factors in the rebalancing of the system. Each of the elements either contributes to the expansion of global network capability or is a consequence of it and, by extension, supports political integration and the economic goals of the most powerful users of the network.

Global Technical Infrastructure

The global technical infrastructure consists of the physical layer of routers and switching equipment, fiber optic cables, and satellites. Although the international telecommunications network is an increasingly interconnected global phenomenon, many of its basic units are still domestic networks that are connected via national and international gateways to other networks in the system.

Historically, governments supported their national telecommunications networks, much as they supported their flag airline carriers. British Airways and British Telecom, for example, were protected from domestic competition until the mid 1980s, when competition began to be introduced slowly and with limits to protect the solvency of the utility. As national governments began to deregulate their telecommunications utilities, international carriers were forming for the first time, often under corporate umbrellas. Infonet, the prototypical international network service provider, was formed by Computer Sciences Corporation (CSC) in the late 1970s. To spread risk and raise capital, CSC quickly sold substantial equity in Infonet to Telefonica of Spain, Singapore Telecom, and Kokusai Denwa Denshin (KDD) in Japan and sold smaller equity positions to companies in Scandinavia.

In the early 1990s, several national companies began to imitate the Infonet model of strategic alliances. Global One (Sprint, Deutsche Telekom, France Telecom) and Concert (British Telecom and ATT) were notable examples. Concert eventually failed, but Global One was eventually merged with Equant under the umbrella of France Telecom. Today, Equant is the largest international carrier, with revenues in excess of $3 billion per year. Several domestic companies, such as Verizon, SBC, and Southern Bell in the United States, as well as NTT, Deutsche Telecom, and British Telecom, maintain substantial international wholesale businesses. Aggregation has been typical in both the domestic and international carrier segments, with the result that commercial and investment power resides in fewer companies.

Within the global telecommunications architecture, domestic and international networks are integrated with one another through a complex system of undersea cables and satellite transmission systems. Undersea cable systems must be laid and maintained by fleets of cable ships that maintain repeaters and amplifiers and repair frequent breaks in the cable systems. Very few companies have the financial resources to build such systems, with the result that such projects usually are undertaken by consortia.

The international satellite consortia (such as Intelsat, until recently owned by government signatories) and private satellite systems (such as PanAm and Loral) are consolidating. Advances in launch technology, satellite transponder capacity, and fiber optic cables have led to massive overcapacity in global infrastructure capability and to falling prices, which ultimately are reflected in lower consumer telecommunications costs for long-distance services and in profit-margin pressure on the service operators.

As a result, in the last two years there has been a significant rebalancing in infrastructure ownership. In Asia, for example, two years ago as much as 85 percent of the Asian undersea services infrastructure was owned by American investors; today the situation is reversed. Chinese interests have bought the assets of Level 3, PSINet, Asia Global Crossing, and Global Crossing, all at substantially reduced prices from the initial capital investments.

When describing this infrastructure, the Internet is increasingly described as the essence of the telecommunications network. It is not, however, and it is important to understand the distinction within the global infrastructure. In an information warfare environment, the most vulnerable and productive targets are in the physical layer. Without the physical layer there is no Internet. It is a faddish and dangerous intellectual vanity to conceive of the Internet as something separate or unique.[10] The Internet is a subsystem of the telecommunications network, much as the satellite broadcast television and ordinary telephone service are subsystems, or applications, of the international telecommunications network. The Internet is essentially innumerable individual repositories of knowledge, digitally residing in serving computers at nodes interconnected by the physical telecommunications layer of cables and satellites.

This does not diminish the importance of the Internet. The technical infrastructure of the Internet is closely integrated into the architecture of the international telecommunications network. Within this architecture it has its own operational hierarchy based on domains and domain root servers, tier-one and tier-two carriers, interexchange hubs and network access points, and other components that are important to developing information warfare tactics. However, it should be seen as part of a greater whole, within the mesh of the international telecommunications network that carries all the diverse traffic of rapidly converging voice, video, and data applications. The Internet depends on the international telecommunications network for its existence and continued development.[11]

In mid-2002, Internet geography consisted of an estimated 600 international IP carriers that owned, leased, or otherwise managed transborder network capacity. IP carriers placed routing computers at either end of this capacity and used these segments to cobble together logical networks. Analysis published in the Telegeography Internet Report suggests a highly concentrated market. Only 42 percent of international carriers manage more than one cross-border Internet connection, and just 11 percent have six or more international links.[12]

At the top of the chain are the 50 IP carriers that manage ten or more links on their international Internet backbones, which are large bandwidth circuits within the international telecommunications network. The global backbone market is also concentrated on a capacity basis. Only a third of the world's international Internet carriers internally manage at least 155 Mbps on international Internet capacity. Furthermore, in most regions the top ten carriers control more than 70 percent of the Internet bandwidth. This suggests that the Internet and the global telecommunications infrastructure are susceptible to disruption at a surprisingly few number of key nodes.[13]

Innovation and Intellectual Development

R&D is no longer an exclusively national function. The international telecommunications network has facilitated the rise of international scientific research consortia in a variety of disciplines, including research in telecommunications technologies.[14] There is a growing, global dispersion of skilled engineers, scientists, and researchers—many trained at American universities—who work together via the telecommunications network. The exchange of information on this scale is impossible to control.

Scientists from around the world are collaborating on difficult areas of fundamental and applied research to more rapidly achieve a shared scientific objective, whether for commercial or strategic interests. This is in part a result of the decline in national government funding for R&D, which is being replaced by funding from multinational corporations, which have a very strong competitive edge closely aligned to profit goals. Hundreds of global technology alliances among corporate partners are formed each year in the telecommunications and information industry. Most of these are not limited by security concerns. Scientists from developing countries and potential adversaries are participating in the design of information and technical systems that are increasingly difficult to separate from classified U.S. technical projects.

The race for product innovation has led multinational firms to seek the competitive advantage gained from round-the-clock round-the-world R&D. Time is money. The information and telecommunications revolution has made this possible. The telecommunications network is both a driver and a facilitator.[15]

The argument that the United States will retain its innovative edge because it welcomes immigrants, or provides opportunities for education to the world's best students or scientists, becomes meaningless when international intellectual consortia of the highest caliber can combine intelligence across any distance at a keystroke. This changes the dynamic of design and production economics, and favors the developing world at the expense of the developed.[16] It's also not certain that today's division of international labor—high-value-added design and system integration in the United States and low-cost manufacturing and routine software coding in developing countries—will remain a viable model, when many other countries will have sophisticated university engineering and design departments. Of all technological capabilities, systems integration is the easiest to learn and imitate.

The Changing Geopolitical Environment

International telecommunications and the Internet are becoming intertwined with international relations in a way that we don't fully understand yet. We can begin to link telecommunications and international relations in a general framework and conjecture that, like many central arguments in the field of international relations, the development of international telecommunications has its progressive and realist proponents. The arguments have become more intense in the last twenty years with the rise of telecommunications and information technology from low politics to a standard agenda item in international summitry, especially since the early 1990s.

A progressive argument is advanced by cultural historian Robert Wright, whose key point is that history's direction is intellectual advance—scientific, technical, political, and moral. Over time, people build better machines, better governments, better societies, and better moral codes. The international telecommunications system enhances and extends these values. As commerce expands, more and more people have a shared interest in protecting it from disruption.[17]

This argument has its philosophical genesis in the nineteenth-century liberal economic argument that international commerce would eliminate war—an idea that proved short lived in the twentieth century.[18] Yet, the liberal argument, modified to consider war economically unproductive, continues to inform thought about the consequences of war, especially in modifying the destructiveness of its means in relation to its political goals. This was seen recently in Iraq, where targeting was carefully controlled to minimize collateral damage, a function highly dependent on telecommunications and IT. There is a growing moral and political tendency, in Western conceptions of warfare at least, to minimize human losses. If one follows Wright's logic this trend will continue—despite periodic setbacks—and manifest itself in alternative forms of political and military competition, of which information warfare over the telecommunications network is a primary form.

An organic theory of international development as a metaphor of human experience is based on the concept of rise and fall, birth through death. As the Athenian era ended, the Roman empire rose to take its place, and as the United States reaches its zenith, China is waiting to assume the role of the world's leading power. The main thrust of history doesn't change, but telecommunications accelerates the process by facilitating faster and more efficient information dissemination. Historical change that once took centuries now happens in decades. As the acceleration of global knowledge increases, primaril because of the expansion of various networking technologies, the relativities of power change with the complexity. The United States doesn't fall, but other societies become equal in innovation, particularly China and India.

The historicist World System Theory argues that the core changes systematically and inevitably. In the 13th century, China was the core state and Eurasian hegemon. The core shift from East to West has lasted until now, taking centuries. With the development of global telecommunications networks, and the acceleration of information dissemination and the immediacy of global financial markets, the transitions are occurring in decades. Today's core, the United States and to some extent Europe, is being challenged by semiperipheral countries, such as India and China.

Realists start from an historic assumption about international relations: political entities have competitive interests that lead to conflict. Historically, the resolution of critical disputes has been decided by warfare. Societies and nations have always cooperated but have always challenged each other. According to the Realist theory, there is no evidence that this has changed. Telecommunications may facilitate functional integration of customs, postal services, manufacturing, and the dissemination of knowledge, but it also makes opposition to the state or international system easier and more difficult to track. Technology advances and political organizations change, but international relations at their most fundamental—war and peace—are constant. Telecommunications facilitates information warfare and network warfare as much as it facilitates trade.

Whatever theory one chooses, political geography is a marginal concept in a world spanned by a global telecommunications system. Previously understood patterns of production and trade are being replaced by unfamiliar and disruptive ones—for example, international outsourcing on a massive scale. Large corporations are subdivided into networks of dispersed lowest-cost units. All this is made possible by information that rides the global telecommunications network. Telecommunications networks weaken geographically based processes and make possible the rise of distributed and decentralized ones. Political control of corporations and production, including the control of military technologies, becomes increasingly difficult.

There is a fundamental difference between the forthcoming period of international politics and those that preceded it. The international telecommunications system obviates against any single country completely controlling the international financial system and the direction of investment that leads to alternative centers of innovation, at least without destroying the entire edifice. A state-centric, nationalist model of politics is taking a subsidiary role to something new and different. An increasingly complex and sophisticated international telecommunications network is a major facilitator of the process.

Implications

In *The End of History and the Last Man*, Francis Fukuyama implies an ability to understand and even control the underlying forces of history.[19] The book suggests that liberal democracy, as manifested most completely in the United States, is the end game of international politics. This seemed possible during the 1990s, but less so now. It might be difficult in a world of seven billion people where certain technological and telecommunications capabilities approach equilibrium.

We may be at the beginning of a shift in international relations, where U.S. strategy becomes much more constrained than it is now. When technological conditions change fundamentally, the economic, social, and political relationships premised on them change as well. Historical forces drive the system to a new dialectical equilibrium. In this case, a superseding, eco-political influence, based on a global telecommunications system that facilitates an independent financial and market economy, will bring dominant nations into more balanced relationships with regional powers.

A consequence is the closing of the technology gap between the United States and other countries, especially India, China, and a broad Europe. This may result in the closing of the gap between high-speed communications R&D for military applications and development of products for commercial use. This would give regional competitors, criminal networks, and terrorists an improved position in information warfare. At the very least, American technical power, and by extension its military power—especially aspects that are based on international communications networks—may be severely constrained.

One concern is that the United States continues to view the world exclusively through the prism of terrorism. The rest of the world does not, and other economies reflect this fact. If the rest of the world presses on with regional and interregional integration and continues to advance technically along a broad swathe of technologies, will this leave the United States as a massive military power without the leading economic and information infrastructure to support it? And what can be done to prevent this from occurring?

Implications of Outsourcing

One hundred years ago, England was the acknowledged leader in global manufacturing, trade, technological innovation, and finance. It had a prosperous middle class throughout the country and the finest education system in the world. Now it has the City of London and the West End theater district and doesn't make anything. Its universities export technical talent to other countries. For many reasons, America isn't going to replicate England exactly, but it's worth thinking about how the United States might develop in relation to its relative future technical capabilities. As strategy and tactics shift toward information warfare, it's important to emphasize and understand the role of human talent.

The argument about outsourcing breaks into two polarized camps. One argues that outsourcing is detrimental to the American economy and national security, the other that outsourcing is a natural and benevolent feature of a capitalist, democratic, international system in which growth results in non-zero-sum benefits for all participants.[20]

Forrester Research estimates that 3.3 million infotech jobs will move overseas in the next 12 years, taking $136 billion in wages with them. The fiber optics glut and low wages in developing countries make it cheaper to perform back-office functions for telecommunications and information services companies in Manila, Jakarta, or Chongqing than anywhere in the United States. Networks can be managed with equal expertise in Beijing, Shanghai, New York, or Atlanta. More than half of Fortune 500 companies are outsourcing software development or expanding their own development centers outside the United States. Sixty-eight percent of IT executives who responded to a 2003 survey by CIO magazine said their offshore contracts will increase annually. By the end of 2004, 10 percent of all IT jobs at American IT companies and 5 percent at non-IT companies will move offshore, according to Gartner Group, a research and analysis firm that specializes in high-technology trends.[21] This is happening in all business that depend on telecommunications. Of the estimated 13 million jobs in financial services in mature industrial economies (the United States and the European Union, Switzerland, Singapore, Japan, and Hong Kong), around 2 million are forecast to go to India by 2008.[22]

American companies are under intense pressure to cut costs. In 2000, senior American software engineers earned $130,000. The same job now pays $100,000. Experienced Indian software engineers get between $10,.000 and $15,000; top IT professionals might earn $20,000. Bearing Point (formerly KPMG consulting) pays $500 a month for an entry-level, degreed software engineer in China. In India it would be $700, and in the United States $4,000. The key point is that Indian and Chinese companies provide the same quality of work for 15–25 percent of the cost of a western employee.[23]

The migration of outsourced white-collar jobs has moved up the value chain from call center operators to such occupations as equity research, accounting, remote medical radiography analysis, software, chip design, and telecommunications network design. These are not sweatshops. Working conditions at India's IT development companies—whether managed directly by Western companies or by Indian-owned contractors—are considered the best in India, and wages are high by Indian standards.[24]

China is joining India and the Philippines as a destination for outsourced service jobs. Cap Gemini Ernst & Young, Accenture, and Bearing Point are expanding in these countries to take advantage of low wages. By 2007, Gartner, Inc., predicts China will generate $27 billion in IT services, matching India. In the political battles developing over outsourcing, India has been the main target, but China, which many Americans view as a political rival, is likely to be an even bigger target for outsourcing opponents.

According to the beneficial theory of outsourcing, there is no better form of trade for a developing country than to sell services provided by an educated population. Compared to anything else a developing nation can sell—natural resources or hard labor in manufacturing, for example—white collar jobs are more sustainable and eco-friendly.

Therefore, engineers in the developed world should be arguing not for protectionism but for trade agreements that seek to establish rules that result in a real rise in living standards. Proponents of outsourcing argue that this will ensure that outsourcing is a positive force in a developing nation's economy and is not exploitative. The beneficial political argument is that middle-class, white-collar workers often become proponents of the traditional liberal values of freedom of speech, democracy, and transparency. They tend to care most about global issues such as the environment and often have influential political access to their governments.[25]

Proponents also argue that, even if the number of outsourced jobs increases, the overall percentage of high-tech jobs going abroad is likely to remain relatively small. That's because outsourcing increases the probability of loss or theft of intellectual property, as well as of sabotage, cyberterrorism, hacking, and organized crime. Sensitive jobs will remain in the United States.

The corrolary to this argument is that, as smart U.S. companies outsource their more standard high-tech work, they're simultaneously shifting their in-house IT employees to more innovative, higher-value-added functions, such as invention, creation, integration, and key R&D. There is no limit to the number of high-tech jobs around the work, because there's no limit to the ingenuity of the human mind.[26]

Perhaps this true, but isn't it also reasonable to ask, on the evidence of corporate malfeasance in the last two years, whether unregulated transnational profits will trump security when cost is a factor?

Do Export Controls Matter?[27]

Science and technology are the basic tools of modernization and are useful predictors of how economically and militarily advanced a society may become over time. However, although scientific progress requires technology, technological innovation does not necessarily require science. It is possible to adapt and even improve on existing technology without fully understanding it. The Chinese have been doing this for 20 years through a "knowledge ladder" provided by technology transfers and foreign direct investment, while at the same time expanding basic research capabilities. For this reason, it is important when analyzing competence to include both the fundamental scientific capacity of a state (intellectual understanding) and its technological output (high-tech products or materials) to determine how advanced a country is likely to become.

In general, there are three categories of national R&D capability. Basic research pursues knowledge for general human understanding and advancement. Applied research meets a purpose or need by taking basic research and applying it to practical problems, for example, using research in materials science to build a better airplane wing. Technology development leads to a specific application, design, or purpose, for example, a team of Chinese engineers reverse engineering and improving on a fiber optic CATV receiver.

As many American high-tech companies can testify, in India and China it is not essential to follow a linear path from a solid foundation in basic research to technological development. Technological development is opportunistic. However, it probably is true that continued innovation becomes much less likely and limited over time if the fundamentals are lacking, which is why India, China, and other countries spend increasingly significant resources on basic research and see it as a policy goal. Alternatively, a society that is able to develop new products with the aid of external inputs, but that also enjoys a substantial scientific infrastructure, is much more likely to gain the capacity to exploit these technological inputs over the longer term.

A global telecommunications infrastructure accelerates the advancement of basic research by making almost any information available instantly to almost anyone who wants it. Even the poorest nations can access most of the world's most advanced technological know-how, products, and processes. Information needed to build multiprocessor systems from components and subsystems is readily available on the Internet.

Economic and technical development today depend less on where one resides than on how well connected and, ultimately, how intelligent, responsive, innovative, and inventive one can be. It is this increasingly transnational nature of scientific and technological capacity that is the critical distinguishing feature of the current wave of globalization. This is a new global dynamic that will have a substantial and long-term economic impact, as well as political, social, and security implications.[28]

This is not just about selling a router. It is about the ability to produce competitive operating system software improvements, organize after-sales support services, and attend to billing and administrative functions—in short, the entire fabric of a sophisticated information infrastructure.

Multinational corporations, increasingly outside the control of any one state, play a central role in the internationalization of high-tech R&D. This is the result of a widespread change in the source of funding for most R&D activities. By 2000, government-funded R&D as a share of U.S. GDP had dropped to 25 percent, the lowest level since the National Science Foundation began keeping records on R&D spending in 1955. Today, corporate investment outpaces government funding for R&D.

As industry became the primary source of R&D funding, more of this investment began to flow overseas, where production and employment costs are a fraction of American costs. U.S. corporate R&D expenditure abroad increased four-fold between 1986 ($4.6 billion) and 2000 ($19.86 billion), outpacing the average rate of growth for U.S. corporate R&D spending at home. Between 1994 and 2000, the average percentage change in U.S. R&D expenditures abroad (11 percent) outpaced U.S. industry R&D domestic spending (8.6 percent).[29]

In such an environment, would a broad approach to export controls prove too expensive and impossible to manage? The argument for a targeted approach makes some sense as a short- and mid-term policy. In terms of information warfare, such a system would restrict control of a few critical technologies that are used at interdiction and major interconnection points on the international network This is similar to controls recommended by the Defense Science Board for the containment of weapons of mass destruction (WMD), which would shift from a policy of technology protection to one of essential capability preservation. This would involve establishing a continuously evolving list of essential military capabilities and developing strategies for preserving each.[30]

Education

The rebalancing of technical innovation facilitated by the international telecommunications network will enable several countries to achieve sophisticated information warfare capabilities. Judging from their prodigious efforts and achievements in the last twenty years in catching up with most of the world in information technology and telecommunications, China and India will be able to develop offensive information warfare capability.[31]

What is the potential impact on U.S. information warfare capabilities? Many scientists and technologists working for potential adversaries were trained by American universities and companies. They understand the culture of American science and engineering: research methods, intellectual patterns, and entrepreneurial drive. Many have designed critical components of the U.S. information warfare equipment and therefore know both its capabilities and limitations.

Ultimately, the security of the United States, in a strategic environment dominated by information and network warfare, depends more than ever on the education of its population. No human resources can be left to stagnate or fail to reach their optimum capability because of a lack of opportunity or outdated conceptions of leadership and organization. This is especially true in the military.

The problem is that, as the sole superpower, the United States faces numerous competitors, and thus an enormous human resource deficit within ten years. Demographics indicate that the United States will simply be vastly outnumbered by nations with people interested and educated in science, engineering, and technology. At present, there are 8 million postsecondary students in India, and approximately 14 million in China. At least another 5 million are in reasonably good undergraduate institutions in other countries. There are 13 million university and college students in the United States. This will have the effect of depressing wages in the American technology sector, forcing good students into career areas other than engineering and information technology. This poses particular problems for services tasked with information warfare missions.

Certainly, the United States will continue to have exceptional technological capability at the level of elite university education, such as at MIT and Stanford and the more prestigious technical universities and colleges. But the advent of information warfare takes the concept of total warfare to a new level of societal integration and requires a broader-based approach to technical education at the tertiary level.

From a public policy perspective, it will become increasingly important to fund American postgraduates for studentships and postgraduate programs abroad to understand the international telecommunications system in depth. This is exactly the reverse of what has happened since the Second World War, when students around the world came to the United States because it was the leader in innovation and research in theoretical and applied sciences. If only to keep abreast of potential technical developments, Americans will have to follow developments in other countries much more closely. Scholarships are needed to send both civilians and junior officers to technical and management programs in such countries as China, Russia, India, Romania, Brazil, and Indonesia. These programs might be similar to the Olmsted Foundation programs, but on a much larger scale and more specifically related to technology and culture. America's future leaders must be aware of technological trends and of the social and cultural implications of technological innovation.

The human resource and training functions of the military also must change to ensure a very high degree of information warfare capability. The military should send more junior officers abroad on Master's degree and Ph.D. programs—and to civilian universities, not just military academies. They should study in Islamabad, Bucharest, Moscow, and Shanghai, not just Oxford or Bologna, and not in programs set up and run by American universities. More Americans need to get "down and dirty," to learn the languages, lifestyles, and intellectual patterns of other cultures. To paraphrase a particularly apt aphorism, "keep your friends close and your potential adversaries closer."

An information warfare capability that depends on knowledge workers will be far too large to depend only on a degreed officer corps for technical excellence. Much better use of the more intelligent members of the enlisted ranks will be required.

Enlisted recruitment and retention, key factors in maintaining service-level information warfare capabilities, will increasingly depend on educational and promotion opportunities. One way forward is to have a Department of Defense undergraduate college focused on accelerated degree programs for enlisted and junior noncommissioned officer staff. Prototypes of this program could be developed by the National Defense University. The objective would be to produce highly trained cadres of information warfare specialists in the mid- and senior enlisted ranks. Successful completion could lead to early promotion or, perhaps, borrowing from the Army, advancement through joint service warrant officer grades.

Conclusions

The information and network warfare domain that the United States dominates today will be much different in ten years, or even sooner. By early next decade, China, India, and an expanded Europe will match American capabilities in many areas, especially in telecommunications-related technologies essential to effective information and network warfare.

At the same time, the United States is putting increasing emphasis on all aspects of information and network warfare. An information domain that is not dominated by the United States and is constrained by three other powerful regional information powers, may put limits on a number of important strategic and tactical programs. To prepare for this outcome, the United States must constantly reevaluate its rules of engagement with these emerging information powers. Much more research is required, not only in technology, but also in the way the United States prepares its next generation of public policy and military leaders for engagement in a much different world.

Notes

Selected notes appear below. All notes are available online at www.ndu.edu/ctnsp/publications.html/.

[1]FLAG (Fiber Loop Across the Globe) is an undersea cable network comprising over 50,000 kilometers of fiber optic cable that spans four continents and connects the key regions of Asia, Europe, the Middle East, and the United States, providing services to major telecom carriers, internet service providers, and television broadcasters

[3]The argument was presented in "Can India overtake China?," *Foreign Policy*, July-August 2003.

[10]For interesting discussions about the nature of networks and, by extension, how language and terminology influences descriptions of the Internet, see Albert-Lazlo Barabasi, *Linked, the New Science of Networks* (Cambridge, MA: Perseus Publishing, 2003) and Malcolm Gladwell, *The Tipping Point* (Boston, MA: Little, Brown and Co., 2000).

[11]This description of the bifurcation of the Internet and International Telecommunications network is increasingly blurred. It is possible that at some point the Internet will be synonymous with International Telecommunications. Already, the terms are practically interchangeable in much recent writing, but for purposes of strategy and tactics, precision in language is important, and at this time it's important to maintain the distinction.

[12]The Telegeography Report and Database, published by Telegeography, a research division of PriMetrica, Inc., are used by most telecommunications companies in market planning. See www.telegeography.com.

[14]See the work of Dieter Ernst, East West Center, Honolulu, Hawaii, on development of new patterns of technical innovation in the telecommunications and electronic industries. Mr. Ernst's most recent work was not ready for attribution as the time of publication of this document, but his work can be found on the East West Center web site: www.Eastwestcenter.org

[15]Kathleen Walsh, "Foreign High-Tech R&D in China", (Washington, DC: Stimson Center, 2003), 31

[17]Robert Wright, *NonZero: the Logic of Human Destiny* (New York: Pantheon Books, 2000).

[19]Francis Fukuyama, *The End of History and The Last Man* (New York: Free Press, 1999)

[27]This discussion relies heavily on a recent publication by Kathleen Walsh, "Foreign High-Tech R&D in China" (Washington, D.C.; Stimson Center, 2003).

[30]Leslie David Simon, "The Net, Power and Policy in the 21st Century," chapter 23, 630, in Challenges of the Global Century, Washington DC; NDU Press, 2001.

Defense Horizons ***is published by the Center for Technology and National Security Policy . This and other CTNSP publications are available online at http://www.ndu.edu/inss/press/nduphp.html.***

The opinions, conclusions, and recommendations expressed or implied within are those of the contributors and do not necessarily reflect the views of the Department of Defense or any other department or agency of the Federal Government.

Center for Technology and National Security Policy

Hans Binnendijk
Director