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Rational Solutions for Challenges of the New Millennium

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Rational Solutions for Challenges of the New Millennium

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Abstract

We have reviewed ten major public problems challenging our Nation as it enters the new millennium. These are defense, healthcare costs, education, aging population, energy and environment, crime, low productivity growth services, income distribution, regulations, and infrastructure. These problems share several features. First, each is so large, if it were solved; it would have major impact on the U.S. economy. Second, each is resident in a socioeconomic system containing non-linear feedback loops and an adaptive human element. Third, each can only be solved by our political system, yet these problems are not responsive to piecemeal problem solving, the approach traditionally used by policy makers. However, unless each problem is addressed in the context of the system in which it resides, the solution may be worse than the problem. Our political system is immersed in reams of disconnected, unintelligible information skewed by various special interests to suggest policies favoring their particular needs. Help is needed, if rational solutions that serve public interests are to be forged for these ten problems. The simulation and modeling tools of physical scientists, engineers, economists, social scientists, public policy experts, and others, bolstered by the recent explosive growth in massively parallel computing power, must be blended together to synthesize models of the complex systems in which these problems are resident. These models must simulate the seemingly chaotic human element inherent in these systems and support policymakers in making informed decisions about the future. We propose altering the policy development process by incorporating more modeling, simulation and analysis to bring about a revolution in policy making that takes advantage of the revolution in engineering emerging from simulation and modeling. While we recommend major research efforts to address each of these problems, we also observe these to be very complex, highly interdependent, multi-disciplinary problems; it will challenge the U.S. community of individual investigator researchers to make the cultural transformation necessary to address these problems in a team environment. Furthermore, models that simulate future behavior of these complex systems will not be exact; therefore, researchers must be prepared to use the modeling and simulation tools they develop to propose experiments to Congress. We recommend that ten laboratories owned by the American public be selected in an interagency competition to each manage and host a \$1 billion/year National effort, each focused on one of these ten problems. Much of the supporting research and subsystem modeling work will be conducted at U.S. universities and at private firms with relevant expertise. Success of the Manhattan Project at the middle of the 20th century provides evidence this leadership model works.

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I. Executive Summary

A. Introduction

At the beginning of the new millennium, as the world's only superpower, the U.S. is the world's economic, military, and political leader. The Cold War is over, the U.S. economy is sound, unemployment and inflation are at modern lows, and in 1998 the Federal government will spend about \$39 billion less than it receives in tax revenues. Apocalypse connoisseurs are depressed and temporarily silenced by their fruitless search for doom. Many are proposing that these "good times" may last for an additional two decades. If that is the case, we face an unprecedented opportunity to solve an array of complex problems that have been chipping away at U.S. economic growth, National security, and social well-being for several years. At the same time, several of our Nation's leaders are calling on the R&D community to arrive at ideas for science and technology policy that could have a major impact on the future course of events. Others are calling on Congress and the President to think big and develop grand ennobling ideas. Invigorated by recalling the spirit, dedication and success of those that served our Nation by working on the Manhattan Project at the middle of the twentieth century, we recommend that our Nation mobilize major R&D programs to address those problems described in the following sections. Big ideas addressing these public issues will not just magically appear, they will be derived through thoughtful analysis of complex systems using simulation, modeling and research that pushes interdisciplinary knowledge to new heights. Political processes alone have not and will not solve these problems.

B. The Problems

1. Emerging Defense Issues. Today's defense issues lack the clarity of the Cold War, yet the U.S. defense community must prepare for a wide span of security challenges. Threats to U.S. security that are emerging include domestic and international terrorism; international crime cartels; nuclear, chemical, and biological weapons proliferation; regional conflicts arising from multipolar distribution of regional power; the rise of China as an international economic and military power; border control; civil unrest; rising nationalism around the world; proliferation of drugs; religious and cultural conflicts; force readiness issues; assuring access to foreign oil and natural gas, particularly in the Persian Gulf and Caspian Basin regions; overcoming impending shortages of natural resources, especially water; rapid force deployment; and perhaps eventually the resurgence of Russia in a new and unpredictable political state.

As our military investment spirals down to below 3% of GDP, we are particularly concerned that U.S. military capabilities be able to support our foreign policy objectives during a period when, of necessity, our foreign policy is adapting to the U.S. being the world's only superpower. Despite the fact that some polls suggest the public is gradually losing interest in defense issues, this is not the time to cut our investment in defense R&D. We should instead be increasing Federal defense R&D in preparation for unexpected events and be preparing robust military capabilities that position us for threats that could evolve over the next 20 to 50 years. Furthermore, we must prepare for the wide asymptotes of foreign policy responsibilities that could accrue to the world's only superpower.

- ◆ We must, in particular, vigorously support defense research that prepares the U.S. to counter proliferation of weapons of mass destruction (WMDs), limit the expansion of international crime syndicates, and control terrorism throughout the world.

- ◆ We must search for creative ways to assist Russia in developing a liberal democracy subject to the rule of law, and help evolve a Russia that is able to control the criminal element that is destroying entrepreneurship and economic development.
- ◆ We must research the widest potential range of U.S. foreign policy options and identify military systems and defense R&D required to support these policy limits.

2. The Healthcare Cost Problem. The cost of health care in America has risen to over \$1 trillion, or over 14% of GDP. This is between 1.5 and 2 times that of the rest of the industrialized world. In comparison, France spends 9.9%, Germany spends 9.6% and Britain spends 6.9% with little noticeable disadvantage in the quality of healthcare services or quality of life. Despite the fact that Japan's population is older than the U.S. population, Japan only spends 7% of its GDP on healthcare and its citizens live 4 years longer than Americans do. Because the elderly have much higher health care expenditures than other age groups, as America ages, health care costs will soar, perhaps to 25% of GDP by the middle of the next century. Reduced personal savings have financed much of the escalation in health care costs. In our current system, there are few incentives for health care services providers to increase their productivity and reduce charges and there are few opportunities for consumers to negotiate prices with services providers.

The U.S. should initiate a major research program to investigate healthcare system alternatives. Because of the magnitude, complexity, and importance of the healthcare cost problem, it is economically rational to initiate a \$1 billion per year publicly funded research program that would be tasked to arrive at an entirely new design for a healthcare delivery system.

The major components of this program would include:

- ◆ Develop systems models ranging between a state-funded system and an entirely free market system that includes breaking down healthcare systems into subsystems that allow comparison of the cost and effectiveness of various subsystem options. Alternatives to the U.S. model would be synthesized from these systems models.
- ◆ Compare the U.S. healthcare delivery models at the subsystems level and their costs and outcomes to those in other countries.
- ◆ Identify necessary regulatory options.
- ◆ Identify technologies that could lead to substantial reduction in healthcare costs and propose a partnership of private and public funders to develop these technologies.

3. The Education Problem. In 1995 the United States spent \$668 million or 9.2% of GDP on prekindergarten through post-secondary educational services and content. Of this total, \$318 billion was spent on K-12, \$189 billion was spent on post secondary, \$60 billion was spent on workforce training, \$45 billion was spent on the consumer market for education products, \$30 billion was spent on pre K, \$10 billion was spent on training programs, and \$10 billion was spent on child reform. In 1992 U.S. public education expenditure per child was \$11,880 and was only slightly exceeded by that of Switzerland, was almost identical to that of Japan, was approximately two times that of France, Austria, Belgium, and Denmark, and was approximately 50% higher than that spent by Sweden, Norway, and Ireland. We have nearly 60 million

(almost 25% of our population) full- and part-time students enrolled in courses throughout the U.S.

Education employs 55% of local government workers and 45% of state workers. With these levels of employment and their well-organized union, publicly employed educators are able to control both local and state politics.

Despite our massive National investment in education, several concerns surround our education system. These concerns have three primary components:

- ◆ the quality of K-12, particularly 5-12 math and science education is inadequate,
- ◆ college costs are excessive, and
- ◆ the U.S. has failed to design an education system that promotes and offers education from cradle to grave.

Like crime problems, many believe they know, without the benefit of research, just exactly what the U.S. needs to do to address the problems in education. We recommend that the following ideas be examined in research intensive experiments.

To address K-12 math and science education quality, we recommend that pilot research programs be established in the following areas: (1) Start school voucher projects in about two dozen U.S. cities. In those schools attended by students using vouchers introduce a national testing program to monitor progress of these students and benchmark these tests in an equivalent number of other schools not attended by voucher-funded students. (2) Develop and implement a national program to measure what is working and at what economic cost in attempts throughout the nation to improve K-12 education. (3) Develop a national program to **fast track** qualify retired engineers and scientists for teaching K-12 math and science. (4) Initiate a major research program to identify ways to introduce competition into K-12 education and to address the pros and cons of the public giving up ownership and operation of K-12 schools. (5) Select 10 K-12 programs around the nation for a national experiment in technology-intensive education over the Internet. Include in this research ways to increase the productivity and reduce the costs of K-12 education. (6) Develop and field-test a math and science teacher incentive program. (7) Select 10 schools around the nation for a major experiment in which each math and science teacher in grades 5-12 has at least a BS degree in either math or science, rather than an education degree.

To address college costs we recommend that pilot research programs be started in the following areas: (1) Conduct a major study of cost growth in both private and public universities and identify those factors that have driven cost growth. In particular, identify those universities that are shifting the cost of graduate research to undergraduate tuition. (2) Research the roles of universities in other nations and identify those roles that other nations' universities have filled that have had unusually high public return. (3) Fund one state with a strong private and public education system to conduct a massive experiment in education by redirecting their flow of public funds from public universities in their state to students that attend any university, public or private, in any state. (4) Research the overall social costs of peer review and determine how much, if any these costs outweigh the benefits. (5) Initiate a major research program to investigate the pros and cons of shifting the accreditation emphasis in university education from

the educational institution, the educational process and the faculty to accreditation of the graduate. (6) Develop a national scorecard for universities based on the scores of their graduates on the graduate record examination in comparison to their ACT and SAT scores as incoming freshmen that can be used by education consumers for selection of which college they wish to attend. (7) Conduct a major research program that identifies ways to use education technology to deliver the equivalent of university education to our citizens at costs less than one-half current cost.

To promote continuing education, we recommend that pilot research programs be started in the following areas: (1) Conduct a major research program to study the success in China, Turkey, and other nations using continuing education provided through distance learning to identify low cost ways of providing distance learning opportunities throughout the U.S. (2) Task the U.S. Department of Education to develop a distance learning program in information sciences and computer programming that is available to all citizens through the Internet. (3) Develop a national retraining program for mid- and late-career engineers that brings them up to date in software development and information sciences.

4. The Aging Problem. At the beginning of this century, 4% of U.S. citizens were 65 or older. As we approach the end of this century, 13% of the population (33 million U.S. citizens) are over 65 years of age. Since the beginning of the 20th century, the population of the U.S. and the population of those under 65 have both tripled, but the population of those over 65 has increased by a factor of eleven. By 2050, about 80 million Americans or 20% of the U.S. population will be over 65. The leading edge of the baby boomers, those 76 million Americans born between 1946 and 1964, will reach retirement age in 2010. After that the 65-74 population will show dramatic growth over the next 10 years and by the middle of the next century the over 85 age group will have grown to the same size as the 65-74 age group is today.

When one examines the growth rate of various groups in the population, it is the over 85 group that stands out. This population group will grow at a rate of 4.4% over the next 15 years while the overall population is growing at a rate of 1.7%. When the baby boomers reach retirement age in 2010, Social Security and Medicare costs will escalate. However, by the middle of the 21st century when they reach 85 years of age, their impact on Medicare and private savings will be massive. Unless there is a breakthrough in Alzheimer's disease research, 50% of the over 85 population, or 9.5 million will have Alzheimer's disease. If one conservatively adds another 7.5 million Alzheimer's patients from other age groups, we can expect to have 17 million Alzheimer's patients and a minimum of 35 million people will be providing their care at an annual national cost in excess of \$500 billion, or 2.5 times our current annual cost for Medicare. Alzheimer's disease alone is sufficient to break the Medicare bank.

When Social Security was started there were 8 people making Social Security payments for each retired person. We are now down to 3.3 people making Social Security payments for each retiree and we will be down to between 1.6 and 2 wage earners when the baby boomers are well into retirement in the year 2030. By 2020 the imaginary Social Security "trust fund" will peak at \$3.3 trillion. However, that excess will be exhausted by 2030.

In 1996 Medicare provided benefits for 38 million Americans at a total cost of \$200 billion. About 80% of these costs are for inpatient hospital services. Medicare costs are expected to have an annual increase of 8.9% and grow to \$332 billion by 2002. Without changes in

Medicare benefits or a productivity breakthrough in the U.S. healthcare system, Medicare costs will soar when the baby boomers begin to receive benefits.

Medicaid is a means-tested program that provides health care for the poor. The Federal government and states jointly fund it. At this time states are paying about 43% of Medicaid costs and the Federal government pays about 57% of costs. In 1998 the Federal government is expected to spend \$101 billion on Medicaid. By 2008 Federal support for Medicaid is expected to grow to \$210 billion.

The aging population highlights several fundamental problems that the U.S. must address with substantial research programs: (1) The lack of productivity growth in healthcare services. (2) Financial and cultural disincentives to keeping the aging population on the job and working. (3) An inefficient education system that does not offer cradle to grave education opportunities and emphasize workforce retraining that keeps seniors working. (4) Inattention to developing systems that provide care for the elderly at costs they can afford. (5) Under-investment in Alzheimer's research. (6) A political system locked-in to the use of political processes for decision-making that is rapidly falling behind the private sector in using modeling and simulation to forge decisions that are systematically rational.

5. The Energy-Environment Problem. The U.S. makes up less than 5% of the world's population but we produce 25% of the world's goods and services and we consume about 25% of the world's energy at an annual cost of \$525 billion. The most popular international measurement unit for energy is quadrillion units of British Thermal Units or the quad. Our energy supply from domestic sources is coal-21.9 quads, natural gas-19.2 quads, crude oil-13.8 quads, nuclear-7.2 quads, and renewables-6.6 quads. We annually import 22.4 quads; 18.9 quads of this is crude oil and crude oil products. We export only 4.6 quads and 2.3 quads of this are coal. Of our annual energy consumption of 90 quads, 76.5 quads are obtained from fossil fuels. Our annual consumption is distributed as 32.1 quads for residential and commercial use, 34.5 quads for industrial use, and 24.1 quads for transportation. Automobiles idling in traffic jams consume about 3 quads of transportation energy.

Despite a wide array of incremental advancements in energy technology, e.g., solar cells have now been improved to the point where only 7 years of operation are required to recover the electrical energy used in their manufacture, and an over 20 year publicly-funded R&D program in energy, our Nation has been unable to articulate a systems-level National energy strategy that clearly identifies the pros and cons of the issues, differentiates the roles of the private and public sectors, lays out a roadmap for energy technology development with multiple technology options, and rationalizes energy alternatives in terms of their environmental and economic costs. Focus on irrational, dooms-day scenarios has dampened public enthusiasm for funding research on energy and the environment.

The primary issue driving the future of energy consumption is global warming produced by the combustion of oil and coal. While it is widely accepted that global warming is a reality, it is not clear that these claims are real. If they are real, the magnitude of global warming is unclear, what the consequences will be is unclear, what it will cost to reduce global warming is uncertain, and whether it is more cost effective to reduce global warming or learn to live with it is unclear.

The annual U.S. public and private investment in energy R&D is about \$4.7 billion for an industry sector whose annual sales are about \$525 billion. Thus, the total public and private U.S. R&D investment in energy R&D is slightly less than 1% of sales. Furthermore, because the private R&D investment stream is focused on making profits for private firms while the public R&D investment stream is presumably focused on issues of importance to the general public, there should be little overlap in these two investment streams. The U.S. investment in energy R&D is at the level of investment characteristic of a mature industry in which few public issues remain for consideration and there are few economic opportunities for companies. However, because of environmental issues, the energy industry is likely to undergo a great deal of change.

Energy and environment issues are so naturally linked that they must not be separated in systems modeling and analysis of either issue. Neither should their research be separated institutionally. Global warming must be addressed as a research issue rather than a regulatory issue and it must include:

- ◆ Investigation of ways to promote additional carbon dioxide absorption by the ocean.
- ◆ Extension of global climate modeling to include ocean currents and predictions of how global warming will affect various regions of the world and identification of the lowest cost ways to cope with these effects.
- ◆ Modeling of all energy alternatives and their impact on global warming and other environmental effects.

6. The Crime Problem. Those most affected by crime, America's youth, seem least concerned about crime, and those least affected by crime, America's elderly population, seem most concerned about crime.

An absolute upper bound on the cost of America's crime problem has been estimated from direct and indirect annual economic costs to victims (includes quantitative estimates of the cost of pain, suffering, and lost quality of life of victims) to be \$450 billion. Violent crime accounts for \$426 billion in personal costs to victims and property crime victimization costs are \$24 billion per year. Of the \$450 billion figure, 77% is attributed to quality-of-life costs that are based on civil case jury awards. However, very few criminal cases go to civil trials because the typical victim loss is minimal. Most crimes have less than \$200 in victim loss, including medical expenses and lost wages.

There are approximately 48 million crime attempts annually in the U.S. More than 16 million of these are violent crimes and attempted violent crimes (murder, rape, robbery, assault, child abuse, drunk driving, and arson). In 1990, 31,000 deaths, roughly 75 percent of the number of deaths annually attributable to automobile accidents, resulted from crime. Every two years, more U.S. citizens die as a result of criminal activities than died in the Vietnam War. Each year there is about one violent crime for every 130 U.S. citizens. The rate of violent crime in the U.S. is several times that of other industrialized nations.

It is estimated that 5.5 million Americans are in need of treatment for drug abuse. About 3.6 million have a cocaine habit and there are 810,000 users of heroin. Of the total population of those abusing illegal drugs, about 850,000 are in prison for drug offenses. Research conducted

in 1993 suggests that Americans spent between \$49 billion and \$90 billion on illegal drugs. In comparison, the U.S. expenditure on prescription drugs in 1998 was about \$80 billion and for over-the-counter drugs it was about \$20 billion.

In 1994, 45 percent of those arrested in the U.S. were under 25 years of age. Many of those arrested were under age 18. Of particular concern in crime growth in the U.S. is the increased role of juveniles in committing crimes, especially violent crimes. In 1995 law enforcement agencies arrested 2.7 million people under age 18; juveniles were involved in 32% of all robbery arrests, 23% of all weapon arrests, 15% of all murder and aggravated assault arrests, and 13% of all drug arrests. In 1995, the racial composition of the juvenile population was 80% white (includes Hispanics), 15% black, and 5% other. Roughly equal numbers of violent crime arrests were for white juveniles and black juveniles. Over the past 25 years, the arrest rate for murder by juveniles has quadrupled and their arrest rate for rape and robbery has more than doubled. About 70% of juvenile offenders come from single parent families. Putting a child in reform school for one-year costs about \$50,000. This is about 25 percent more than the cost of sending them to a private university.

Despite the seriousness of America's crime problem, most of the money and effort devoted to solving it are restricted to one approach - incarcerating persons who have already committed crimes. The U.S. is currently on an incarceration binge. One-third of all young African-American males is in jail, in prison, or on parole or probation. African-American youth make up only 15% of our nation's young people, yet 49% of all youth arrested for violent crime are African-Americans and they occupy 65% of all bed space in detention facilities. Many in the non African American community interpret these data to mean that African-American males are predisposed to commit crime; the African-American community interprets these data to mean that the criminal justice system is predisposed to arrest, convict, and incarcerate African-American males.

The inability of the U.S. to address the crime problem almost entirely stems from the fact that it is a public problem whose solution falls under the purview of our political system. For reasons that escape our understanding, the crime problem is one that every person in the country, including politicians, seems to believe has a straightforward answer and, therefore, does not need meaningful research. Even though Americans consistently express concern about crime, the nation's investment in crime research is very small. While the National Institutes of Health annually spend \$15 billion searching for cures to diseases, all Federal agencies cumulatively invest about \$50 million researching one of American's most serious diseases, crime. The Federal government annually spends about \$13 billion enforcing drug laws that are not well supported by research. Some are even in conflict with the limited research that exists.

We recommend that the U.S. establish a \$1 billion Federal program on crime research including the establishment of a technology evaluation center recommended in 1993 by a national panel of crime experts. This \$1 billion program should be equally invested in (1) research on the causes and effectiveness of measures to limit crime and (2) technology that prevents crime, increases the risk of being caught when committing crime, and reduces the cost of incarcerating those convicted of crime.

7. Low Productivity Growth Services Industries. As a nation approaches full employment, as the U.S. is currently doing, and its population stabilizes, as many European countries are currently doing, further economic growth must come from increases in the gross labor

productivity of the workforce. During the 1970s and 1980s, the fraction of the U.S. workforce that worked in goods production - manufacturing, construction, and mining - dropped from 26% of the workforce to 19% of the workforce. During the same period, those employed in services industries grew from 62% to 70%. By the mid 1990s, 72% of the U.S. workforce was employed in services industries.

Between 1980 and 1990 the growth rate in gross labor productivity of the U.S. manufacturing sector was 3.3% in comparison to 0.8% for the services sector. Gross labor productivity growth in the services sector was unchanged from that of the 1970s. The productivity revival that took place in the manufacturing sector during the 1980s did not penetrate the services sectors. Productivity growth in many of the services sectors, especially government, health care and education, has stagnated.

There are numerous actions that government might take to improve the productivity of the stagnant services sectors. (1) Recognize that government is a services industry and that it is desirable to increase the productivity of government-provided services. (2) Support R&D that searches for ways to improve the productivity of services, particularly those services in which government makes major investments, e.g., healthcare and education. (3) Improve education, particularly the education of those that might work in the services sector, by introducing the management concepts of total quality management, benchmarking, just-in-time, process reengineering, teaming, continuous improvement, and competitive principles in K-12 education. (4) Maintain a stable macroeconomic environment. (5) Avoid regulations whose public and private costs exceed their public benefits, particularly those that impose great costs on services companies and reduce their productivity.

It is clear that increasing the gross labor productivity of productivity-stagnant services is a subject well worthy of research and well worthy of research funded by the public. The three largest offenders of low productivity growth are all closely affiliated with services owned or heavily subsidized by the public: government, education, and healthcare. Productivity enhancement research should focus on these three areas.

8. The Income Distribution Problem. While the U.S. economy has been growing at an annual rate of 2.4% per year, that growth has not been uniformly distributed throughout our population. The rising tide of national income growth has not lifted all boats. Stagnation or reduction in income of middle and low-income wage earners is a ticking time bomb that will eventually stimulate social instability, economic class conflicts, less education, political instability, growth in crime, and slow economic growth.

In Western Europe, a male worker in the bottom 10% of the earnings distribution earns 68% of the median worker's income; in Japan, that male worker earns 61% of the median. In the United States, he earns 38% of the median. The problem of low pay is not simply a matter of low-skilled immigrants or poorly educated minority youth. It is a problem of the overall distribution of income.

The 20% of households with the highest incomes received 44% of all household income in 1974. By 1994, their share had increased to 49%. During this 20 year period those households whose income was in the bottom 20% slipped from 4.3% of all household income to 3.6% of all household income. During this same 20-year period, the share of household income going to the middle 60% of households dropped from 52% of all household income to 47% of all

household income. In 1974 the income of the top 5% households was 6 times the income of the bottom 20%. By 1994, this ratio had increased to 8 to 1.

The median U.S. family income after inflation was \$36,959 in 1993 in comparison to \$36,893 (1993 dollars) in 1973 in spite of the fact that there was a significant increase in two income wage earners. Although median household wages rose from \$35,082 ('96\$) in 1995 to \$35,492 ('96\$) in 1996, the wage increase was fully accounted for by gain in women's wages which offset a net loss in men's wages. Six years after America's economic boom began; the median worker has experienced a net wage decrease of 5%. Fully 99% of the increase in family income has gone to the top 20% of all wage earners: The top 1% has claimed 62% of the growing pie. The middle two-thirds of the American work force now earns less than the one-fifth at the top. Inequality has become an end-of-century blight on America.

While some have touted professional education as the solution to the income distribution problem, this problem just isn't that simple. For example, engineers' incomes have been stagnant for over two decades.

It is clear that the issue of how the benefits of economic growth are distributed to a society and how that distribution affects future economic growth, unemployment, inflation, and the ability to maintain a liberal democracy are well worthy of systems modeling and simulation. With no redistribution of wealth, workers have little incentive to provide the work necessary to create wealth. At the other extreme, very high wealth redistribution, entrepreneurs have little incentive to create the innovations that drive wealth growth. Somewhere between these extremes there must be an optimum level of wealth redistribution that provides the maximum value to society. We are not comfortable that political processes can find this elusive optimum. Research that addresses this issue and its relationship to globalization of the economy is well worthy of public investment.

9. The Regulatory Problem. Various estimates of the cost of regulations range between \$500 billion and \$800 billion per year. Some conservatively estimate that federal regulations in 1995 cost Americans \$654 billion (47% of the federal budget) or cost the average American family \$7,000. Reviews of those studies of Federal rules and regulations for which compliance cost estimates have been made (these studies do not include the cost of loss of company productivity accruing from compliance) indicate that Federal regulations annually cost \$668 billion. Of course, regulations and rules of local and state governments are often heaped on to Federal regulations. If all of the hidden costs of regulations were included along with the costs of state and local regulations, the annual price tag of regulations would be close to that of health care, or in the \$1 trillion range.

Some review the cost of regulations and argue for wholesale deregulation. Of course, government should only regulate what the public needs regulated. Thus, the issue is less deregulation than how to optimize regulations to reach a compromise between private costs and benefits and public costs and benefits. Because of the economic impact of regulations, it is extremely important that they be optimized for public and private good with great attention focused on economics. Political processes, taken alone, are unlikely to find this elusive optimum.

Weaknesses in the regulatory development process often lead to regulations whose public costs exceed their public benefits. Even though regulations are based on compromise among

those with a stake in the regulations, today's processes rarely lead to win-win solutions that stakeholders support. An improved process that promotes buy-in by all of those affected by regulations is needed. Cost/benefit analyses performed by "honest-brokers" with no particular stake in the regulatory debate can be combined with the war game process to introduce and test major improvements in the regulatory process.

Congress has recognized the need for cost-benefit and risk assessment analysis of regulations. However, it has not yet addressed the organizational issue of regulations. We argue that if regulatory analyses are to be removed from political considerations, an independent group with no vested interest in regulations should provide the cost-benefit and risk assessment analyses and leave agencies to implement regulations and work with Congress on the development of regulations. Furthermore, Congress has not yet considered creating a mechanism to determine whether or not the regulated might identify ways to game regulations and Congress has not yet established a goal for how much the public and private costs of regulations are to be reduced. We recommend investing \$1 billion per year in cost-benefit analysis, risk assessment analysis, and gaming processes with the requirement that within three years these activities must identify ways to reduce regulatory costs by \$200 billion or the analysis groups would lose their funding. Again, Congress is addressing a complex system with piecemeal steps with no real goals in mind other than the appeasement of special interests. Political processes, taken alone, don't always lead to the best solutions.

10. The Infrastructure Problem. The U.S. infrastructure is a complex system of interdependent elements whose combined operation is vital to the security and well being of the U.S. The three primary elements of the U.S. infrastructure include telecommunications, transportation, and the power grid. Additional infrastructure elements include oil and gas delivery and storage, water supplies, emergency services, and government services. The telecommunications and power grid infrastructure elements are privately owned; the public has no responsibility for their operation and maintenance. The transportation element is largely privately owned; exceptions are highways and bridges. Therefore, the public has responsibility for building and maintaining highways and bridges. However, because the U.S. infrastructure is vital to the economic security of our Nation, the public shares responsibility with the private sector for protecting the infrastructure against those that might threaten its existence.

America's transportation infrastructure is congested, it is slowly deteriorating, and it is in need of repair and improvement. Traffic jams are thought to cost Americans \$80 billion a year in lost time. The Federal Highway Administration (FHA) has determined that 28 percent of U.S. roads are in poor to mediocre condition and 32 percent of the Nation's bridges are deficient. One of four bridges on the National Highway System, the backbone of America's road network is obsolete or has structural problems. Over 12,000 of the 42,000 annual highway deaths are believed to result from poorly designed roads, roads whose automobile capacity exceeds design limits, and roads that are inadequately maintained. Highway vehicle accidents are estimated to annually cost \$150 billion with about one-third of this being property damage.

Of the \$31.5 billion the federal government collects in motor fuel taxes, less than \$20 billion is actually spent on maintaining and building roads and bridges. When state, local, and federal taxes on motorists are added, the total transportation tax comes to \$142 billion each year. This includes \$60 billion in motor fuel taxes, \$23 billion in license and registration fees, \$5 billion in tolls, and \$55 billion in motor vehicle sales taxes, vehicle property taxes, and miscellaneous taxes levied on motorists. Of this total collected, expenditures on roads are \$82 billion. These

include \$42 billion on capital outlays, \$24 billion on maintenance and traffic services, \$8.4 billion on administration and research, and \$8 billion on law enforcement and safety. **Because of the lack of incentives for highway and bridge construction companies to invest in construction R&D, there is very little (less than 0.5% of sales) private investment in bridge and highway R&D.**

The American Society of Civil Engineers (ASCE) estimates that we are underinvesting in our roads, bridges, and transit systems by \$18.2 billion annually to maintain current conditions, and by \$42.3 billion to improve conditions and performance. ASCE calculates that driving on roads in need of repair costs American motorists \$23.7 billion a year in extra vehicle repairs and operating costs.

It has become increasingly difficult to set aside funds to support the testing and evaluation of new highway technologies (for example, seismic isolation and dissipation devices, high performance concrete and steel, bonding agents for pothole repairs, a heated pavement system; a high retroreflectivity traffic sign system, and a precast segmental overpass system) that increase the lifetime and reduce the cost of highway maintenance. Regulatory barriers inhibit the introduction of new, proprietary technology into surface transportation systems.

In addition to problems with maintenance of the transportation infrastructure, it is possible for an adversary to mount a structured offensive against the U.S. transportation, power and communications infrastructure, while disguising the attack. The U.S. computer systems network is so vulnerable to malicious assaults that we may one-day face "an electronic Pearl Harbor". Examples of catastrophe include: Wall Street computer screens go blank during an especially busy trading day. Automobile manufacturing lines are brought to a halt due to a programmed power outage. Air traffic control systems bring airliners in to land on a crowded Los Angeles runway where planes are taking off in the opposite direction. All of the bank accounts are emptied throughout a major city. In addition, physical attacks on infrastructure could include regional power disruptions, disruption in 911 calls because of repeat call flooding, bridges carrying automobiles, trains, and telephone cables are destroyed, Internet service providers in a major city are disabled, etc.

This entire area is in need of systemic research that identifies options for the future, estimates the costs and benefits of these various options and lays out research roadmaps for realizing the preferred options.

C. The Solutions

The economic consequences of these problems are immense. A 20% reduction in the costs of healthcare, education, and regulations would allow an additional \$500 billion to be injected into the U.S. economy for wealth-creating purposes. However, because of the economic magnitude of these problems, there are many very influential, financially secure, special interests that will prefer maintenance of the status quo. Every shred of research that contributes in a major way to solving these problems will be challenged and the credibility and competence of the researchers will be impugned. Those researchers and research institutions that prefer political lite should avoid these issues.

Most of these problems have been around for several years. Each is a complex problem whose solution will have to be introduced through and by the U.S. political system. The U.S. political system for a variety of reasons has been unable to address these problems at the

systems level. Rather, it has only been able to introduce piecemeal solutions. If our political system as currently configured and by making use of its current processes, were able to solve these problems, most of them would already have been solved.

The primary output of research on these problems must be models that permit informed decisions to be made by our policymakers. Therefore, the emphasis of researchers addressing these problems must be less on solving them than providing useful, data-based predictions of future events and identifying interrelationships of controllable parameters that can be used to guide the political system in forging policy decisions that address these problems. To accept and adopt research input into the political system, research findings must be made widely available to the public in a language familiar to most of the public, the U.S. policy development process must be adjusted to accept additional informed input, and the U.S. policy development process must develop a meaningful way to prioritize problems and solutions. In the Appendix we offer our suggestions for how the political system should be altered to incorporate research on these problems into the policy development process.

The major components of most of these problems are socio-economic and socio-political. For researchers to make significant contributions to these problems, those with computer-based modeling and simulation skills must team with sociologists, economists, management experts, systems engineers, political scientists, physicists, chemists, public policy experts, lawyers and others. For this to occur, major changes must take place in the culture of U.S. researchers, a community that has often eschewed teamwork and has a tradition of working as independent, individual investigators. Members of the U.S. research community are reminded that unless some of these problems are solved, there will not be any public funds available for pursuit of that favorite research topic they have studied for the last 25 years.

Because of the complexity of these problems, modeling and simulation research will never lead to "clean", indisputable answers; rather, these tools will permit comparisons of alternatives and provide new insight into the interrelationships between parameters and it will offer insight into the root causes of many of these problems. Consequently, the political system must be willing to evolve solutions in an atmosphere of experimentation in which several alternative solutions, each supported by limited simulation and modeling and each well-supported by public outcome metrics, are pursued in parallel.

We recommend that 10 publicly owned laboratories be selected from the Nation's 515 Federal laboratories through a multi-agency competition to lead a National effort to develop models and to simulate these complex systems we have described. Each laboratory would lead and manage a \$1 billion program. Most of these funds would flow-through these lead laboratories and be distributed to universities, companies and non-profit institutes to support specific research activities. The lead laboratories would lead, manage, synthesize others research and provide the advanced computing resources needed to support their problem area. The funds for these activities would be appropriated to each laboratory's agency owner for transfer to the laboratory selected to manage the activity. After 3 years, each lead laboratory would begin to offer policy recommendations, including policy experiments, for pursuit by Congress. Some of these must be long-term continuing activities, e.g., developing cost benefit models for regulations, while others should be completed within five years leaving only a continuing, low-level research effort. With the emergence of massively parallel, high-performance computing at the same time that we are gaining great insight into how to model complex systems that are

seemingly exhibiting chaotic behavior, now is the time to attack a wide array of problems that have long concerned the public.

II. Preface

A. Make a Big Difference.

The Honorable Newt Gingrich made the following observation about our Nation's science and technology policy at The Council on Competitiveness Luncheon, October 1997,

We need to go back to the vision level, and ask a series of very large questions, almost like those asked in '45 and '46, and '47 ...what is our purpose over the next generation or more, how do we organize to that purpose, how do we resource to that purpose, and then how do we measure whether or not we're making progress? And so rather than come to you and say, "Here's your budget," what are we going to do with your share of the money for science--what I'm trying to do is reverse this whole argument. ... You give me a set of strategic investments large enough to be worth doing, and then make it my problem to go out and figure out how to find the money. ... And I'm just here to suggest to you what we need to do is have the moral courage to take a deep step back ... and say, If we had a blank slate tomorrow morning, ... what are the projects, that if we were to have an alumni meeting 20 years from now, we could say, "That was worth doing. That made a big difference."

B. Cathedral Builders.

Pulitzer Prize-winning biographer David McCullough in a speech to Congress at a bipartisan retreat in Hershey, PA, March 1997, offered the following,

There has never been, in any of our lifetimes, a moment of such opportunity as now with the Cold War over. And if we just lift up our eyes a little and begin to see what we might be able to do, we too - we in our time - could be cathedral builders. We can be a great founding generation, like the Founding Fathers. ... as important as balancing the budget may be, as important as restoring civility and law and order in the cities may be, as important as fourth-grade testing may be, or school uniforms, they aren't the grand ennobling ideas that have been at the heart of the American experience and the ideal of the City on the Hill.³

C. Big Ideas.

Daniel Franklin, editorial director of The Economist Intelligence Unit, in The World in 1998, noted,

The United States is at the height of its military and moral power . . . The good times should be the best moment for thinking big, and thinking ahead. America's politicians are squandering a precious interlude of peace and prosperity, which they should be using to tackle issues that will loom large in . . . (the) 21st century. . . From foreign policy to fighting poverty, from the tax system to campaign-finance reform, the market for Big Ideas should be wide open.

³ The Hill, April 9, 1997, p. 27.

D. An Extraordinary Moment in Time.

Peter Schwartz, The Art of the Long View, and Peter Leyden, Wired Magazine, predicted,

We are watching the beginnings of a global economic boom on a scale never experienced before. We have entered a period of sustained growth that could eventually double the world's economy every dozen years. We are riding the early waves of a 25-year run of a greatly expanding economy that will do much to solve seemingly intractable problems like poverty and to ease tensions throughout the world. And we'll do it without blowing the lid off the environment. If this holds true, historians will look back on our era as an extraordinary moment. They will chronicle the 40-year period from 1980 to 2020 as the key years of a remarkable transformation.⁴

E. Interpretation. While it is tempting to bask in America's euphoric glow, Kotkin and Friedman offer a cautious perspective of the future,

Millennial giddiness may well prove tragically shortsighted. To a large extent, it reflects not a widely shared prosperity but a yuppie narcissism that has snared both mainstream liberals and conservatives - a kind of cross-ideological delusion fueled by rising stock values and a robust demand for well-educated white-collar baby boomers. ... it is certainly possible to imagine a second American century in which national challenges are honestly addressed and even successfully resolved. But it is profoundly self-delusional to claim the future by ignoring the present.⁵

As Kotkin and Friedman suggest, the U.S. has not yet solved all of its problems. However, we also believe that the current "good times" (at least for some) provide us with an unprecedented opportunity to address a wide array of problems that have long plagued the public. Most of these are multidisciplinary socioeconomic issues: healthcare costs; education costs, quality, and availability; crime; regulatory costs; distribution of wealth; rationalization of energy and the environment; emerging defense threats; the aging population; low productivity growth services; etc. Despite the optimism of Schwartz and Leyden, we believe that big ideas addressing these public issues will not just magically appear, they will be derived through thoughtful complex systems analysis, simulation and modeling and research that pushes interdisciplinary knowledge to new heights.

Although our political system will play a pivotal role in solving these problems, political processes alone have not and will not lead to solutions for these problems. In fact, our political system is unable to even prioritize these problems. Congressman George Brown recently pointed out,

Congress does have a rational priority-setting system. Unfortunately it is largely zip code-based: anything close to my district or state is better than something farther away.

⁴ Peter Schwartz and Peter Leyden, "The Long Boom: A History of the Future 1980-2020", Wired, July, 1997, p 116.

⁵ Joel Kotkin and David Friedman, "Don't Pop the Champagne Yet", The Washington Post National Weekly Edition, June 1, 1998, p. 17.

But if the science, engineering, and academic community is serious about having a different priority-setting process, the political system will need guidance from it.⁶

To address these problems with Federal R&D seems simple. It is not. Big Ideas that Mr. McCullough and Mr. Franklin would endorse as grand, ennobling, the ideal of the City on the Hill, and thinking ahead do not easily emerge from specialized R&D performers and institutions with narrowly framed missions that are preoccupied with funding inputs.

Mr. Gingrich is absolutely correct, we must develop a new vision for Federal R&D, we must reorganize our Cold War R&D institutions, we must develop new ways for selecting R&D projects, and we must develop metrics that tell us if we are making progress. With the end of the Cold War, our defense R&D investment has been reduced and the arguments for such a large Federal investment in R&D have become fuzzy and non-compelling to a public concerned about crime and the availability and cost of health care. Without a single, focused threat to our security that the Soviet Union posed, arguments for Federal support of R&D have drifted from emphasis on the problem (the Soviet threat) and its solution (military armaments and the space race), to grandiose pronouncements of the wonders and mysteries of science and technology. We expect the public will soon tire of these grand but vague endorsements and lose interest in supporting R&D at its current generous level unless it is redirected to address issues the public is concerned about. The following addresses these concerns.

III. Acknowledgments

We thank the following individuals for their reviews, comments, suggestions, reference materials, challenges, and most of all, their encouragement: Bob Galvin, Gerry Yonas, Bill Knauf, Bob Hermann, Martha Krebs, Alvin Weinberg, Greg Ferrante, Angela Gover, Larry Bertholf, Dan Garber, Bob Feik, Susan Cozzens, George Kozmetsky, Deborah Wince-Smith, Ron Detry, Meg Wilson, Richard Innes, Glen Cheney, Charles Richardson, Glen Kuswa, Charles Eldon, Paul Johnson, Russ Skocypec, Bruce Dale, John Cummings, Al Nauda, Debra van Opstal, Ned Sauthoff, John MacDonald, Carol Thompson, Neil Helms, Paul Hazan, Dick Traeger, Arnie Baker, and officials of the Federal Laboratory Consortium.

IV. Public Problems at the Turn of the Century

A description of public needs that the marketplace has not and will not solve that we believe qualify as big issues worthy of the ideal of the City on the Hill follows.

- ◆ First, we have not attempted to define how much federal R&D is required to solve these; however, we recommend that this assessment be made.
- ◆ Second, this is not a priority list; Congress and the President, not scientists and engineers should establish and implement a credible prioritization process.

⁶ Congressman George E. Brown, Jr., Past and Prologue: Why I am Optimistic About the Future, a speech given on April 29, 1998. Mr. Brown was the William D. Carey lecturer at the AAAS Colloquium on Science and Technology Policy.

- ◆ Third, these are exceedingly complex problems that will likely require partnerships of companies, universities, and federal labs to find solutions.

1. Emerging Defense Issues

A. Defense R&D Supports Foreign Policy

The big news in military security of the last decade is that the Cold War is over. Not wishing to interrupt the celebration party, we nevertheless think it worthwhile to examine what the Cold War was and the impact it had on U.S. investment in R&D. Not only did the Cold War drive the DoD's R&D investment; it drove the R&D investment of NASA and much of the DOE's. The Cold War even provided the justification President Eisenhower needed to launch construction of the 45,000 mile U.S. interstate highway system.

Richard Pipes, Professor of History, Emeritus, at Harvard University offers a clear perspective on why the Cold War existed.

The seven decades of U.S.-Russian hostility that followed the Bolshevik coup d'etat were the result not of a conflict of interests but of the peculiar needs of Russia's conquerors, the Soviet ruling elite. The Bolsheviks seized power in Russia not to reform their country but to secure a base from which to launch a worldwide revolution. ... To remain in power, they needed revolutions to break out in the industrialized countries of the West The Cold War was an artificial conflict initiated and aggressively pursued by a dictatorship that invoked to its people phantom threats to justify its illegitimately acquired and lawlessly enforced authority. No concessions to the communist regime could attenuate its hostility because its very survival depended on it: as in the case of Nazi Germany, belligerency and expansionism were built into the system.⁷

The West's investment in the Cold War countered the expansionist intentions of the Soviet Union. It was because of the Cold War that the U.S. maintained a defense investment in excess of 6% of GDP, and made a public investment in R&D that dwarfed that of other governments.

Unlike the Cold War, today's security threats are diffuse and unfocused, and are, therefore, more complex and difficult to countermeasure than the Soviet threat.

Newtonian mechanistic metaphors have dominated in warfare for years. By applying linear metaphors to conflict, and thus adopting a linear mind-set, the military is inadvertently constraining itself inside a restrictive box. ... The Cold War facilitated and reinforced the mechanical metaphor through a well-defined enemy, traditional tactics designed specifically for that enemy and strict adherence to a traditional operational idea. American military doctrine operated within this framework, and as a result, it was ultimately linear: for every action, there was a calculated step that followed. In the background, there always loomed the "final" step of a nuclear solution.⁸

Hays, Vallance, and Van Tassel echo this theme,

⁷ Richard Pipes, "Is Russia Still an Enemy?", Foreign Affairs, November-December, 1997, p. 66-67.

⁸ Surface Warfare, "The Complexity of War: Engaging the Challenges of Disorder", January/February, 1998, p. 5.

Although the United States still has global interests, the threats are more difficult to identify, are less vital to U.S. security, and may neither demand nor deserve a military response. Thus the other components of U.S. national security have received increased emphasis. In fact, some analysts contend that the most significant threats to U.S. security are economic ones such as the national debt and trade deficits, social problems such as drug abuse and poor education, demographic problems such as overpopulation and migration, environmental concerns such as clear air and global warming, and resource concerns such as "energy security" and "food security." As a result there is no consensus yet on what America's post-Cold War security strategy ought to be. ... There also is no consensus on when and how the military component of U.S. national security should be used.⁹

Today's defense issues lack the clarity of the Cold War, yet the U.S. defense community must prepare for a wide span of security challenges. Threats to U.S. security that are emerging include terrorism (both international and domestic); international crime cartels; nuclear, chemical, and biological weapons proliferation; regional conflicts arising from multipolar distribution of regional power; the rise of China as an international economic and military power; border control; civil unrest; rising nationalism around the world; proliferation of drugs; religious and cultural conflicts; force readiness issues; assuring access to foreign oil and natural gas, particularly in the Persian Gulf and Caspian Basin regions; access to impending shortages of natural resources, particularly water; rapid force deployment; and perhaps eventually the resurgence of Russia in a new and unpredictable political state.

A Rand study identified several emerging new security threats including lethal airborne virus; a fascist coup in a nuclear-armed country; an earthquake in highly populated areas of California; a new Cold War; and revolution and collapse of friendly nations. This study also pointed out that a drop in the cost of placing satellites in earth orbit or a breakthrough in sensor technology that made oceans transparent for submarine detection could also impact U.S. defense strategy.¹⁰

Unless U.S. security is clearly and directly at risk, as would be evidenced by a direct attack on a U.S. city or U.S. physical infrastructure that took Americans' lives, the U.S. military must be prepared to respond to less urgent threats, e.g., Somalia, quickly and with little loss of U.S. lives. That constraint has great impact on U.S. response options and it has profound implications for the types of military systems the U.S. must develop. Newsweek reports,

The only way to achieve a relatively bloodless victory over a well-armed opponent is to deploy so much force, so swiftly, that the enemy is overcome by ... "a regime of shock and awe." It's the technique of the street mugger: sudden, stunning violence that paralyzes the victim's will to fight back.¹¹

Sun Tzu said,

⁹ Peter L. Hays, Brenda J. Vallance, and Alan R. Van Tassel, "What Is American Defense Policy?", in American Defense Policy, edited by Peter Hays, Brenda Vallance, and Alan Van Tassel, Seventh Edition, Johns Hopkins University Press, 1997, p. 11.

¹⁰ Zalmay Khalilzad and Ian Lesser, Sources of Conflict in the 21st Century, Gazelle, 1998.

¹¹ Newsweek Special Issue, "Tomorrow's New Face of Battle", Winter 1997-98, p. 66.

*in military campaigns I have heard of awkward speed but have never seen any skill in lengthy campaigns. No country has ever profited from protracted warfare.*¹²

Of course, the growing reliance of U.S. military systems on commercial technology means that U.S. military strategists must plan their swift and bloodless military response with military technology built from components and piece-parts that are also available to adversaries. Thus, differentiation of military technology among military adversaries is less a product of technological genius than investment. Those countries able and willing to make the investment can have the most advanced military systems in the world.

Just as companies develop a business strategy and develop an R&D program to support that business strategy, as illustrated in Figure 1, nation states develop a foreign policy and develop military systems and military R&D programs to support that foreign policy.

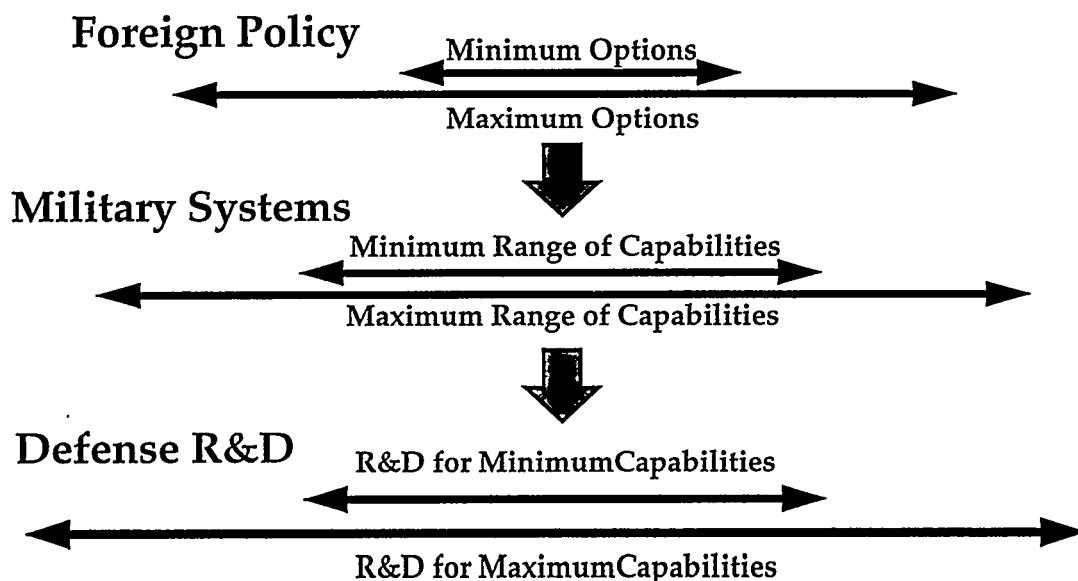


Figure 1: Illustration of how a range of future foreign policy options may be used to define a range of military systems needed for the future and how the range of military systems needed can be used to define a range of defense R&D needs. A nation state that wishes to only invest in R&D that supports a minimum range of military systems capabilities must not then pursue a maximum range of foreign policy options. Vietnam serves as an example of pursuit of a foreign policy option - stopping the further spread of communism - not supported by development of military systems that the U.S. was willing to use in combat.

With the end of the Cold War, U.S. foreign policy has lost clarity and seems to have been overcome by day-to-day tactics. Some argue that U.S. foreign policy has no strategy that defines U.S. vital interests in today's world, defines present and future threats to those interests, and defines what is needed to address these threats. In the absence of strategic clarity that can be understood and supported by the American public, U.S. foreign policy is likely

¹² Sun-Tzu, The Art of War, translated by Ralph D. Sawyer, Westview Press, 1994, p. 173.

to lurch forward in fits and starts while moving from crises to crises.¹³ In Figure 1 we illustrate the range of future foreign policy options as variations in the span of a linear model.

In the absence of clear foreign policy objectives, it is difficult to clearly define what types of military systems are needed and use these definitions to pull military R&D. As we suggest in Figure 1, uncertainty in foreign policy options leads to uncertainty in military systems capabilities and uncertainty in defense R&D needs. Not surprisingly, during this period of uncertainty, it is convenient for military R&D to adopt a technology push perspective rather than military system pull perspective. Of course, if Americans are confused about U.S. foreign policy, the rest of the world must be equally confused. Many think that the uncertainty of U.S. foreign policy led Iraq to believe that the U.S. would not interfere with their occupation of Kuwait.

Hart reminds us of the objectives in war.

In discussing the subject of the objective in war it is essential to be clear about, and to keep clear in our minds, the distinction between the political and the military objective. The two are different but not separate. For nations do not wage war for war's sake, but in pursuance of policy. The military objective is only the means to a political end. Hence the military objective should be governed by the political objective, subject to the basic condition that policy does not demand what is militarily - that, is practically - impossible. ... History shows that gaining military victory is not in itself equivalent to gaining the object of policy. But as most of the thinking about war has been done by men of the military profession there has been a very natural tendency to lose sight of the basic national object, and identify it with the military aim.¹⁴

Clausewitz offered the following observation,

War is not merely an act of policy but a true political instrument, a continuation of political intercourse, carried on with other means. What remains peculiar to war is simply the peculiar nature of its means. ... The political object is the goal, war is the means of reaching it, and means can never be considered in isolation from their purpose.¹⁵

While in the 1800s Clausewitz saw war as a continuation of policy by other means, prior wars were fought almost entirely for religious purposes, often to prove or disprove the supremacy of the gods of the groups at war. Milchemet mitzvah (Holy War) was fought as a war of extermination against those thought to be enemies of God. The Spaniards and Portuguese gave the Indians in Central America and the American southwest the option of Christianity or extermination. In response to Midjanite elders commissioning the prophet Bil'am to curse the people of Israel, Moses ordered the slaughter all Midjanites except female virgins. Until modern times war was regarded as an instrument of religion and the right to declare war rested with religious authorities.¹⁶ As war has generally transitioned from a conflict of religions to an

¹³ James Kitfield, "Strategic Muddle", National Journal, November 22, 1997, p. 2356.

¹⁴ B. H. Liddell Hart, Strategy, Frederick A. Praeger, 1968, p. 351.

¹⁵ Carl Von Clausewitz, On War, edited and translated by Michael Howard and Peter Paret, Alfred A. Knopf, 1993, p. 99.

¹⁶ Martin Van Creveld, The Transformation of War, The Free Press, 1991, p. 135.

instrument of foreign policy, the frequency of conflict has diminished, but complexity has increased.

While the Cold War brought clarity to foreign policy, with its end, complexity and chaos have emerged. In fact, Luttwak argues that coherent policies no longer serve U.S. interests as the world's only superpower.¹⁷ This means that if the U.S. is to develop a military force that is able to support foreign policy objectives, the single most important quality of our military forces must be their flexibility in adapting to unforeseen circumstances. Incoherence in both foreign policy and national defense are the new models and they well may be the dominant models for the next one or two decades.

The Economist explained,

It is one of the puzzles of our time. The range of security threats facing the established industrial democracies seems to be changing with bewildering and often alarming speed. But the debate about how to head off these challenges is mostly stale, bureaucratic and confined, not least by impenetrable jargon, to an introverted elite.¹⁸

Some of the U.S. military services are responding to this period of uncertainty by developing military capabilities, particularly in the command and control area, that are responsive to the uncertainty, chaos and complexity of war.

In a complex, open environment, command and control is fundamentally a process of continuous adaptation. The simple command and control model, the Observation-Orientation-Decision-Action cycle (or OODA loop), essentially describes a process of continuous adaptation to a changing situation. The military organization may be likened to a predatory animal - seeking information, learning and adapting in its desire for continued survival. ... Rather than thinking of command and control both operating from the top of the organization toward the bottom, we should think of command and control as an adaptive process in which "command" is top-down guidance and "control" is bottom-up feedback.¹⁹

During these uncertain times we should expect debate to surround military strategy and it is. The news media have reported that some senior officials in the Air Force believe that U.S. military strategy is on the wrong track.

Far more serious are claims by Air Force officials that U.S. military strategy - and the war fighting models that support it - is fundamentally flawed. Air-power experts say that because the strategy and the models are based on Cold War scenarios involving massive, head-to-head engagements by land armies, with air forces largely in a supporting role, they needlessly risk the lives of tens of thousands of American troops. The Roles & Missions and Deep Attack Weapons Mix studies ... were the most

¹⁷ Edward N. Luttwak, "Why We Need an Incoherent Foreign Policy", The Washington Quarterly, Winter, 1998, pp. 21-31.

¹⁸ The Economist, "Playing Potomac Hold'em", July 11, 1998, p. 3.

¹⁹ Major John F. Schmitt, "Command and (Out of) Control: Military Implications of Complexity Theory, Surface Warfare, January/February, 1998, p. 11.

*exhaustive look at these issues since 1948, and they both show that our models don't work and our warfighting strategy is all screwed up.*²⁰

There are disputes in the Army on the future roles of the Army's National Guard as the Army proceeds to convert the Guard from combat troops to support troops to fill roles more like that filled by the Army Reserve.²¹

Despite criticisms of the lack of certainty of U.S. foreign policy, as we emphasize other places, U.S. foreign policy seems to include uninterrupted access to oil. Execution of this policy requires maintaining a balance of power in the Middle East. Because world consumption of oil is projected to nearly double over the next 35 years (world consumption is growing at a rate of 2% per year), oil reserves in the Caspian Sea region of Central Asia (bordered by Russia, Kazakhstan, Uzbekistan, Turkmenistan, Iran, and Azerbaijan) rival the importance of those of the North Sea and Persian Gulf regions. The U.S., China, Russia, and other countries will compete for a stake in these oil supplies.²² About 70% of Russia's Caspian Sea shoreline are in the republic of Dagestan, a republic in which a fast-growing community of Islamic extremists are calling for secession from Russia and formation of an Islamic state. The pipeline that carries Caspian Sea oil west into Russia passes through Dagestan.²³

Although often denied, another element of U.S. foreign policy sometimes appears to be filling the role of world policeman. (A rule of thumb is that each military unit sent on a peacekeeping mission ties up three other units of the same size - one catching up on lost training and maintenance, a second unit preparing to go on the mission when the first unit returns, and a third unit raided for specialists and specialized equipment to bring the unit on the mission to full strength.²⁴ Thus, peacekeeping roles have significant impact on the readiness of the U.S. military to go to war.) Which beats we are willing to patrol isn't clear - we engaged in Haiti, Bosnia, and Somalia, but declined peacekeeping roles in Cambodia, Algeria, Sri Lanka and Zaire.

Another major element of U.S. foreign policy has been to maintain the ability to simultaneously fight two separate wars of the magnitude of Desert Storm. This might include simultaneously fighting wars in the Persian Gulf region and in Korea. While Desert Storm was a success by most standards; it required a major part of the U.S. military arsenal to achieve this success. The Harvard defense scholar, Huntington, points out that Desert Storm utilized capabilities that are sure to decrease as military spending is reduced,

To defeat Iraq, the United States deployed in the Persian Gulf 75% of its active tactical aircraft, 42% of its modern battle tanks, 46% of its aircraft carriers, 37% of its army personnel, and 46% of its marine personnel. With significantly reduced forces in the

²⁰ James Kitfield, "The Air Force Wants to Spread Its Wings", National Journal, November 18, 1997, p. 2265.

²¹ Congressional Quarterly, "Budget Crunch Has a Service At War With Itself", January 3, 1998, p. 5.

²² Tad Szulc, "Will We Run Out of Gas?", Parade Magazine, July 19, 1998, p. 5.

²³ The Economist, "Losing Control?", July 18, 1998, p. 45.

²⁴ Congressional Quarterly Weekly, "Strain Is Showing as Military Tries to Do More With Less", April 25, 1998, p. 1082.

future, the United States will be hard put to carry out one intervention, much less two, against substantial regional powers outside the Western Hemisphere.²⁵

Eastward expansion of NATO has also been a major element of U.S. foreign policy. Recent events demonstrate that U.S. foreign policy includes preventing the further spread of WMD; however, apparently we have not been successful in preventing the spread of nuclear weapons into India and Pakistan. While not widely discussed, the Cold War strategy of containing the expansion of communism, particularly in the Americas, has been retained as an element of U.S. foreign policy. In exercising this, the U.S. sometimes appears to be attempting to democratize the world, apparently under the assumption that democracies are more civil. Kaplan argues that some of the most uncivil nations in history have been democracies. He notes,

Because both a middle class and civil institutions are required for successful democracy, democratic Russia, which inherited neither from the Soviet regime, remains violent, unstable, and miserably poor despite its 99 percent literacy rate. Under its authoritarian system China has dramatically improved the quality of life for hundreds of millions of its people. ... The lesson to draw is not that dictatorship is good and democracy bad but that democracy emerges successfully only as a capstone to other social and economic achievements. ... Democracy evolved in the West not through the kind of moral fiat we are trying to impose throughout the world but as an organic outgrowth of development. European society had reached a level of complexity and sophistication at which the aristocracy, so as not to overburden itself, had to confer a measure of equality upon other citizens and allocate some responsibility to them: a structured division of the population into peacefully competing interest groups was necessary if both tyranny and anarchy were to be averted.²⁶

Whatever our foreign policy is or evolves to over time, our investment in defense must be sufficient to support that policy. While our nation has the financial resources to support whatever federal budget we need for military security, a defense R&D budget projected to decrease by 17.6% by CY2002 may not support the wide range of U.S. foreign policy objectives that are likely to evolve over the next two decades. Senator Strom Thurmond, Chair of the Senate Armed Services Committee, explained,

Simply put, we have been spending fewer and fewer dollars on our national defense each year for an extended period of time. As a matter of fact, the amount of money we are presently spending on defense represents the lowest percentage of the gross domestic product (2.8 percent) since before World War II. These decreases present some very real and disturbing problems concerning the readiness, effectiveness and combat potential of our men and women in uniform.²⁷

We are particularly concerned that the U.S. defense investment, especially the R&D investment, is inadequate to properly address emerging international and domestic threats. (For comparison, pacifist Japan spends 1.6%, Russia spends 7.4%, France spends 3.1%, Britain spends 3.1%, and China spends 5.7%. In 1997 China increased defense spending by

²⁵Samuel P. Huntington, The Clash of Civilizations and the Remaking of World Order, Simon and Schuster, 1996, p. 90.

²⁶ Robert D. Kaplan, "Was Democracy Just a Moment?", The Atlantic Monthly, December, 1997, pp. 55-80.

²⁷ Senator Strom Thurmond, "We Need a Strong Defense System", The Hill, May 13, 1998, p. 12.

12.7%.²⁸ Absolute comparisons for 1995 defense spending reveal that the U.S. spent \$278 billion, NATO Europe spent \$187 billion, Russia spent \$82 billion, Japan spent \$50 billion, China spent \$32 billion, and non-NATO Europe spent \$31 billion.²⁹)

We close this section with a reminder offered by Alt,

Military power is a necessary ingredient for political and economic success in international relations, but not the sole ingredient. No matter how militarily powerful a nation is, force cannot achieve those things for which only political skill and economic industry are suited. In an anarchic world, it is better to be militarily strong than weak. But such strength alone, especially when there are other strong powers, is not a panacea. ... The efficacy of force endures. It must. For in anarchy, force and politics are connected. By itself, military power guarantees neither survival nor prosperity. But it is almost always the essential ingredient for both.³⁰

B. Post-Cold War Landscape.

With the end of the Cold War, the U.S. has emerged as the superpower of the world (defined in the following) a condition without precedence in modern history. Some argue that U.S. hegemony will remain unchallenged through the early part of the 21st century. The Economist³¹ recently addressed the question of whether new superpowers could emerge in the next 30 years. Four qualities were defined to be characteristic of superpowers.

- ◆ **Long-range military power.** A superpower must have the economic resources to build a nuclear arsenal capable of delivery around the world and this capability must be sufficiently robust to survive surprise attack by another nuclear power. Additionally, a superpower must have an infantry that can be sent to remote parts of the world.
- ◆ **Efficient foreign policy machinery.** A superpower must have a government capable of deciding what it wants to do and the political clout to get these things done.
- ◆ **Public support for vigorous foreign policy.** A superpower must have citizens willing to fight and die for causes supported by the superpower.
- ◆ **Material interests abroad.** A superpower must have practical, meaningful reasons (access to food or energy, open sea-lanes, threatened ally, etc.) for getting involved in issues outside its border.

The Economist used an evaluation system in which each of the above attributes were assigned a high score of 5 and a low score of 0 for each of those nation states, continents, or regional entities thought to have the potential to become a superpower. The scores are shown in Table I.

²⁸The Economist, "The Real Cost of Japanese Defence", October 12, 1996, p. 38.

²⁹The Washington Post, "Pentagon's Plan for Future Draws Heavily from Cold War Past", May 11, 1997, p. A19.

³⁰ Robert J. Alt, "To What Ends Military Power", in American Defense Policy, edited by Peter Hays, Brenda Vallance, and Alan Van Tassel, Seventh Edition, Johns Hopkins University Press, 1997, p. 23.

³¹The Economist, "The Next Balance of Power", January 3, 1998, p.p. 17-19.

Table I: Comparison of the probability that nations, continents, or regional entities can reach or retain superpower status by the year 2030. Islam is an imaginary composite of the approximately 40 mainly Muslim countries.

Attribute	China	Islam	Russia	Japan	US	Europe
Long Range Military Power	4	0	3	1	5	2
Efficient Foreign Policy	3	0	1	3	4	1
Public Support	3	2	1	1	2	2
Material Interests Abroad	3	2	3	4	3	4
Total	13/20	4/20	8/20	9/20	14/20	9/20

According to this analysis model within the next 30 years China will be well positioned to be a superpower of equal stature to the U.S. Note that the lowest score given to the U.S. was for public support for a vigorous foreign policy. The arithmetic scoring system used by The Economist may have under estimated the importance of this criterion, especially for a democratic society. While the other three attributes may be treated arithmetically, it may well be that this attribute should be scored geometrically. If that were the case, the U.S. score would be 24/75 in comparison to a score of 30/75 for China, 4/75 for Islam, 7/75 for Russia, 8/75 for Japan, and 14/75 for Europe.

While many have hoped for a peaceful world and generous spending on R&D for domestic purposes to follow the end of the Cold War, in retrospect, this was naive and a reflection of Americans' unbounded optimism for both world events and domestic issues. First, entitlement increases (see the section on the Aging Population), especially Medicare and Social Security, budget deficit reduction and tax cuts have more than absorbed the post Cold War cuts in U.S. defense spending. Second, peace is not breaking out around the world. Defense scholars seem to agree that the bipolar distribution of power that prevailed during the Cold War was more stable than today's internationally unipolar, regionally multipolar distribution of power. For example, since the end of the Cold War, hostility between India and Pakistan has increased and both have tested nuclear weapons. Should the unipolar power, the U.S., lose its will to retain its international leadership role or the U.S. abuse the privileges of superpower leadership, world military power will be entirely multipolar, it will be regionally distributed, and it will be highly unstable. If the military leadership of the U.S. is slowly diminished the frequency of regional conflicts, such as that between Iraq and Kuwait, are likely to grow. On the other hand, if the U.S. is too aggressive in exercising its leadership role, it can promote instability in the world as other Nations rebel against the perceived dominance of the U.S. Maintaining policies and practices between these asymptotes imposes challenges for which we are unaccustomed.

Huntington argues that for the first time in history, global politics is both multipolar and multicivilizational, with cultural divisions, rather than economic, ideological, or political distinctions, framing the principal post-Cold War identity of civilizations. He argues that the hot spots in world politics are on the "fault lines" between the 7 or 8 major civilizations of the world. Since religion is the principal defining characteristic of civilizations - the most profound difference that can exist between people -- Huntington concludes that fault-line wars are almost always between peoples of different religions.³²

³²Huntington, pp. 20-21, 254-255.

The defense expert, Richard Perle remarked,

For the contingencies the United States is likely to face, a smaller, agile and more technologically advanced military would serve us best, but instead, there's been a tendency to overestimate the risk of some conflicts and exaggerate the amount of military force needed, resulting in inappropriately large heavy forces that lead to greater vulnerability, not less.³³

Newsweek quoted Lt. Col. Ralph Peters, a Pentagon war planner,

There is not one compelling reason to buy a single additional bomber, submarine or tank today, save the preservation of the industrial base. Yet even this is a dubious cause.³⁴

If the U.S. defense budget is to be reduced, personnel reduction is a necessity. Current plans call for cuts that will leave the U.S. with 1.44 million active duty military personnel, the lowest troop level since 1950, just prior to the Korean War. In addition, another round of military base closures is being discussed with implementation sought for around the turn of the century.³⁵ Lacking a clear strategy for the future, these cuts are being uniformly implemented across all services.

The Pentagon houses the world's most massive bureaucracy. Given its internal political dynamics - that is, the need to build a consensus for even incremental change - Defense Department leaders have cut each service by roughly a third since 1989.³⁶

Fighting force reductions increase reliance on information technology. Therefore, budget pressures can force the U.S. to accelerate its pursuit of the information technology defense path or alternatively, increase its reliance on nuclear weapons. Economic considerations are as likely to shape the U.S. and other nation's selections of defense technology as their ideological preferences.

C. Diffusion of Military Technology.

While Desert Storm illustrated the technological advantages of U.S. military systems, as military technology becomes increasingly dependent on commercial technology, especially information technology, it will become easier for advanced military technology to diffuse around the world. Alvin and Heide Toffler have noted,

Even as politicians and the media in various nations extol the blessing of conversion of military technology to civilian uses, a far more extensive counter-process is converting civilian industries to wartime capabilities. This civilianization is the real conversion.

³³ The Washington Post, "Pentagon's Plan for Future Draws Heavily From Cold War Past", May 11, 1997, p. A19.

³⁴ Newsweek Special Issue, "Tomorrow's New Face of Battle", Winter 1997-98, p. 66.

³⁵ The Washington Post, "Pentagon's Plan for Future Draws Heavily from Cold War Past", May 11, 1997, p. 19.

³⁶ James Kitfield, "The Air Force Wants to Spread Its Wings", National Journal, November 8, 1997, p. 2264.

Civilianization will soon give fearsome military capabilities to some of the smallest, poorest, and worst governed nations on earth.³⁷

In looking to the future, some are proposing that the U.S. has the ability to strengthen its position as the unipolar power of the world. It is generally agreed that war fighting is in the early stage of a revolution that is based on the application of information technology - low-cost, ground surveillance microsatellites; satellite-controlled cruise missiles; long-range, precision targeting; digital data compression for transmission and processing intelligence data; encryption and deencryption; and un-manned, supersonic aircraft that can remain undetected while conducting surveillance activities for many hours - and the integration of many of these with stealth technology, including stealth warships. Because of its technological resources and economic strength, the U.S. is better positioned to develop these systems than any other country.

Most scholars of military technology agree that we are perched on the threshold of a new era of military technology that could revolutionize war fighting. The three components of these new technologies include:

- ◆ Intelligence, surveillance and reconnaissance (ISR) technology based on microcircuit sensors.
- ◆ Command, control, communications, and computing systems (C4) based on information technology.
- ◆ Long-range, precision strikes steered by information technology.³⁸

The information technology-based military revolution can greatly expand U.S. military power in the years ahead. However, space-based information technology assets are extremely vulnerable to nuclear weapon blasts that "pump-up" the Van Allen belts.³⁹ While the vulnerability of space-based assets (both commercial and military satellites) to nuclear countermeasures is well known and well understood throughout the world-wide radiation effects community, it is not well understood by policy makers. Webb recently pointed out this vulnerability in a war games exercise at the Naval War College. Within months after detonation of a 50-kiloton nuclear weapon in the outer levels of the earth's atmosphere, the world's communication systems and information-based military systems would be rendered useless.⁴⁰ This extreme vulnerability could encourage a preemptive first strike against emerging nuclear threats that showed any sign of being capable of detonating a nuclear weapon in space.⁴¹

Ironically, nations unable to compete in this high-tech, information-rich, conventional weapons arena may increase their reliance on development of weapons of mass destruction - biological,

³⁷ Alvin and Heidi Toffler, War and Anti-War, Little, Brown and Company (1993) from a digest by Darinne Gordon and Robert Rinne, November, 1995, p. 28.

³⁸ Charles Grant, "America's Ever Mightier Might", The World in 1998, The Economist Publications, January, 1998.

³⁹ James E. Gover and John S. Browning, Radiation-Hardening Systems Considerations: Electrical Systems and Radiation Environments, SAND86-1737. UC-2, March 1987, pp. 45-53.

⁴⁰ R. C. Webb, DASMA, personal communication with James Gover.

⁴¹ The Economist, "The Future of Warfare", March 8, 1997, p. 21.

chemical and nuclear weapons - to support their military operations. However, diffusion of information technology to rogue states and organized crime also creates new threats for U.S. security.

The Santa Fe Institute pulled together a group of 40 military experts, futurists, information technology experts, historians and science fiction writers to create scenarios U.S. security may face in the future. Their goal was to understand how our National security system would need to change to cope with realities of the period 2010-2015 that may result from the diffusion of information technology. In The Santa Fe Institute's **most conservative scenario**, "Rule of Law: The Statist Quo", nation states were assumed to remain the dominant actors. In this scenario it was determined that the dominant nation states face three very different kinds of threats⁴²:

- a. **Threats from other nation states.** Examples include the total collapse of Russia, Saudi Arabia becomes the next Iran, and a Sino-Japanese alliance. Because information technology empowers smaller states and reduces the military advantage of a large population, threats could also arise from countries with advanced capabilities in information technology. Information technology also changes the nature of threats by creating new vulnerabilities and creating new domains for conflict.
- b. **Threats from criminal transnational organizations.** Examples include the Colombian drug cartel, Chinese triads and pirates, and terrorist organizations. It was recently reported⁴³ that Miami, Florida, has become a beachhead for the Russian Mafiosi as well as organized crime gangs from Jamaica, Columbia, and Italy. Russian gangs are located in 24 U.S. cities and are suspected of drug-running, prostitution, extortion, money-laundering, bank frauds, illegal arms sales - including sale of a Russian submarine complete with 62 man crew. Information technology advantages these groups over nation states by increasing their communications while hidden from physical view and by improving the effectiveness of their operations.
- c. **Threats from disordered people, self-organizing in new ways.** Examples include massive movements of refugees, terrorism, and weapons of mass destruction in the wrong hands. Self-organization will occur in response to increasing chaos deriving from demographic, environmental, political, and economic shifts and it will be aided by information technology.

A key objective of warfare is to disable the economy of an opponent. As computers around the world in governments, corporations, and banks become networked, the potential for direct intervention in nations' economies through electronics sabotage will grow. Most of these systems maintain rudimentary security systems and/or "firewalls", but even clever student "hackers" have found ways to circumvent these protection devices. The global information system invites offensive and defensive national teams to threaten or even worse, make subtle changes in critical data the adversary does not recognize. Measure and counter-measure studies demand the U.S. maintain its lead in information/communications technology and recognize that it make provision for unanticipated events by burying software bombs or

⁴² Katherine Fulton and Peter Schwartz, Global Business Network, Emeryville, CA, The Highlands Forum, 1996, Scenarios: Conflict in the Information Age, Santa Fe Institute, New Mexico, August 12-14, 1996.

⁴³ The Economist, "Redfellas: Organized Crime", March 15, 1997, p. 31.

hardware flaws in programs, operating systems, or central processing units to be selectively activated upon command.

D. Weapons of Mass Destruction (WMD)

a. Why Have WMDs? Weapons of mass destruction (WMD) include chemical weapons, biological weapons, and nuclear weapons. There are many reasons that nation states might wish to have a WMD arsenal. Some might desire them in order to use them as an offensive tool in military conflicts. For example, a nation disadvantaged in military information technology, but relatively strong in air power and mechanized infantry, might detonate a nuclear weapon in space to inhibit all space-based communications, especially those of their adversary.

Other nations might see WMDs as a defensive tool to deter others from using WMDs or even conventional forces against them. Of course, WMDs can only deter the deterable and they are only a deterrent for those circumstances in which their owner is willing to use them. Policy analysts generally agree that the nuclear arsenals of the U.S. and/or Israel deterred Saddam Hussein from using chemical or biological weapons during the Persian Gulf war.

For some nation states, particularly those unable to achieve international recognition for their status as an economic, military, or political power, WMDs serve as a symbol of power. Leaders of some Nation states might wish to have this symbol of power for domestic political reasons. For example, recent tests of nuclear weapons by India and Pakistan were likely conducted for domestic political reasons. Nuclear weapons have great symbolic value for Russia.

For rogue nations, WMDs can serve as a tool to promote terrorism.

The Friedmans explain the motivations of other nations that have nuclear weapons,

For the French, the function of nuclear weapons was to preserve the integrity of the nation, to make certain that fundamental issues of war and peace affecting France remained in French hands. In so doing, France could pursue the interests of a normal nation-state, beneath the nuclear level. ...The Franco-Israeli strategy is to employ nuclear weapons as a means of deterring an attack on the nation's very existence. For France, nuclear weapons were a means of limiting a Soviet adventure in Western Europe. For the Israelis, it was also a means for preserving the nation, not only by threatening the Arabs but by threatening their strategic backer, the Soviet Union, in extremis. North Korea's strategy seems to have taken its bearings from this. Isolated from both of its patrons after the end of the Cold War, suffering severe economic problems, the North Korean regime saw nuclear weapons as a guarantor that outside powers would think twice before seeking to undermine communist rule.⁴⁴

The world's only superpower, the U.S., might wish to retain WMDs simply because others have them. Betts points out,

The points to keep in mind about the new world of mass destruction are the following. First, the roles such weapons play in international conflict are changing. They no longer represent the technological frontier of warfare. Increasingly, they will be weapons of the weak - states or groups that militarily are at best second-class. The importance of the

⁴⁴ George and Meredith Friedman, The Future of War, Crown Publishers, 1996, p.p. 87-88.

different types among them has also shifted. Biological weapons should now be the most serious concern, with nuclear weapons second and chemicals a distant third. The mainstays of Cold War security policy - deterrence and arms control - are not what they used to be. Some new threats may not be determable, and the role of arms control in dealing with WMD has been marginalized.⁴⁵

The U.S. maintains a stockpile of nuclear weapons principally as tools to deter war. That is, the risk of destruction by nuclear weapons is so great that nation states opt for a bloodless resolution of conflict. Liddell Hart, regarded as the Clausewitz of the twentieth century, noted,

*The perfection of strategy would be, therefore, to produce a decision without any serious fighting. ... While bloodless victories have been exceptional, their rarity enhances rather than detracts from their value - as an indication of latent potentialities, in strategy and grand strategy. Despite many centuries' experience of war, we have hardly begun to explore the field of psychological warfare. ... (The war strategist's) true aim is not so much to seek battle as to seek a strategic situation so advantageous that if it does not of itself produce the decision, its continuation by a battle is sure to achieve this.*⁴⁶

In addition to the strategic and political reasons that drive nations to develop nuclear weapons, nuclear weapons are **cost effective in comparison to alternative means of producing the same strategic and political objectives**. A recent study⁴⁷ by the Brookings Institution estimated that the U.S. is currently spending \$35 billion per year or 14% of the defense budget on nuclear weapons. Of this total, about \$25 billion is spent on operation and maintenance of the nuclear arsenal, while the remainder is being spent on cleanup, arms control verification, and ballistic missile research. This study estimated that between 1940 and 1996, the U.S. spent \$5.5 trillion on nuclear weapons. When future cleanup, stockpile stewardship, and dismantlement are included, the total cost estimate is \$5.8 trillion.⁴⁸ DOE's annual nuclear weapons budget is currently \$4.5 billion.

b. Proliferation of Nuclear Weapons. The Economist has made the following observation,

*The threat of a Russian-American nuclear Armageddon may have lessened with the ending of the Cold War, but fears about the spread of nuclear weapons have, if anything intensified. "The bomb" remains the power-symbol of choice, coveted by nervous governments around the world.*⁴⁹

There are three countries - Israel, India, and Pakistan - that are thought to have nuclear weapons that have stayed outside of the Nuclear Non-Proliferation Treaty (NPT), the international treaty designed to limit the spread of nuclear weapons. (India and Pakistan have recently removed any uncertainty about their possession of nuclear weapons.) The U.S., Russia, Britain, France and China are NPT signatories. South Korea, Taiwan, South Africa,

⁴⁵ Richard K. Betts, "The New Threat of Mass Destruction", Foreign Affairs, January/February, 1998, p. 27.

⁴⁶ B. H. Liddell Hart, Strategy, Frederick A. Praeger, 1968, p. 339.

⁴⁷ Stephen Schwartz, Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940, The Brookings Institution, 1998.

⁴⁸ David Silverberg, "America's Nuclear Arsenal: \$5.5 trillion Well-Spent", The Hill, July 8, 1998.

⁴⁹ The Economist, "Between the Bomb and a Hard Place", March 25, 1995, p. 23.

Argentina, Brazil, and North Korea have had nuclear weapons programs, but are thought to have closed them down.⁵⁰ The Economist has tracked how nuclear weapons spread to India, Israel, and Pakistan,

Canada sold India a nuclear reactor in 1956 America provided heavy water (D_2O) to operate the reactor. Quite a bit more foreign help later, India used the plutonium produced from the reactor for a supposedly peaceful nuclear test in 1974, and it is now thought to have enough bomb-making material squirreled away for at least 30, and perhaps 60 (some say 100) weapons. Israel got its start in the bomb business in the heat of the 1956 Suez crisis, when France secretly agreed to supply it with a plutonium-producing reactor to be built at Dimona; Norway later provided the heavy water needed to operate it. France also supplied a reprocessing plant for extracting plutonium from Dimona's spent fuel, along with much information on the design and manufacture of nuclear weapons. ... By the early 1990s its stockpile of warheads was being conservatively estimated at between 60 and 100; information leaked in 1986 ... suggested that the total could be as high as 200. Pakistan's secret military program to develop nuclear weapons got under way after the defeat by India in 1971; it accelerated after India's nuclear test (in 1974). Pakistan eventually obtained from firms in Western Europe and North America the technology and equipment to produce highly enriched uranium. It got a lot of catch-up help later - including, it is thought, the complete design for a bomb - from China. Pakistan started producing weapons-grade uranium at its Kahuta enrichment plant in 1986, and is thought to have the makings, including fabricated components, for at least 15 bombs.⁵¹

Scholars generally agree that avoiding nuclear weapon proliferation among major powers in Asia is dependent on a strong U.S. military presence. Should U.S.-Japan relations deteriorate, a domino-like propagation of nuclear weapons in Asia is predicted.

Deprived of America's nuclear shield, Japan would develop its own nuclear weapons to stay even with China. South Korea which has been invaded by both Japan and China in the past would shortly follow. So might the more sophisticated South-East Asian states, whose military budgets are already growing rapidly. Pretty soon, the whole region would be nuclear and nervous.⁵²,

Concern for the proliferation of weapons of mass destruction has grown, not diminished since the end of the Cold War. Even though breakup of the Soviet Union reduced the threat of a deliberate, planned nuclear attack by Russia, the risk of a breakdown in the control of those nuclear weapons has increased.⁵³

It has been reported that it takes about 15 kg of highly enriched uranium or about half that amount of plutonium to make a nuclear bomb. Russia has stockpiled 200 tons of plutonium and 1,200 tons of highly enriched uranium. Each year about 15 tons of plutonium and 45 tons of highly enriched uranium shift from the relatively secure custody of Russia's Ministry of Defense

⁵⁰ *Ibid*, p. 24

⁵¹ *Ibid*, p. 24.

⁵² The Economist, "America and Japan: Friends in Need", April 13, 1996, p. 17.

⁵³ Bruce G. Blair, "Whose Finger Is on The Trigger?", The Washington Post National Weekly Edition, October 7-13, 1996, p. 21.

to the less certain control of Minatom, the civilian ministry that controls Russia's nuclear industry.⁵⁴ There is concern that some of this material could be diverted to a rogue nation that would build and use a nuclear weapon for terrorist purposes. The risk of nuclear terrorism or accidents in Russia's nuclear industry is becoming greater because of the Russian Atomic Energy Ministry's plans to use excess weapons-grade plutonium as fuel at nuclear power stations. Nuclear explosive devices can be made from spent nuclear fuel and such devices can be compact enough to transport in an ordinary truck, making their detection by police or other officials very difficult. Although other Russian military officials dispute this bleak assessment, Russian Defense Minister Igor Rodionov remarked in February of 1997 that Russia might soon approach a threshold beyond which its missiles and nuclear weapons systems become uncontrollable. Mr. Rodionov is now unemployed.⁵⁵

As part of a laboratory-to-laboratory program, scientists from Los Alamos and Livermore have made hundreds of trips to Russia and the newly independent states to offer their expertise. What they found horrified them. "These materials were left embarrassingly vulnerable," recalled (Terry) Hawkins (deputy director for nonproliferation and international security) of Los Alamos. "In one research institute, we found enough weapons-usable material for 15 nuclear weapons setting unaccounted for in boxes."⁵⁶

Grigory Yavlinsky, a Russian economist that leads Yabloko, a democratic, reformist political party that opposes the Yeltsin government, confirms that Russia's WMD control is uncertain and worthy of international concern,

In October 1996, Vladimir Nekhai, the director of a nuclear complex near the Ural city of Chelyabinsk, killed himself because he lacked the money to pay his employees and could no longer ensure the safety of his plant's operations. His suicide underscored the most serious threat to all players in the post-Cold War world: loss of control of the Soviet arsenal of nuclear, biological, and chemical weapons. The increasing risks of chaos in a nuclear power are also evident in the rumors of nuclear smuggling. Russia has thousands of tons of nuclear, chemical, and biological material. Under the rule of a corrupt oligarchy, uranium and anthrax could become black market commodities available to the highest bidder. The control of Russia's weapons of mass destruction is an issue of world safety that cannot be ignored by Russia or the West.⁵⁷

U.S. security experts are reasonably comfortable with Russia's protection of its strategic nuclear weapons; however, there is far less confidence in Russia's ability to protect tactical nuclear weapons from theft and their nuclear materials are widely distributed at facilities throughout Russia with cases reported of unguarded nuclear materials at Russian research facilities.⁵⁸

⁵⁴ The Economist, "Costing a Bomb", January 4, 1997, pp. 30-31.

⁵⁵ Andrew Khalip, "Sacked Russia Minister Draws Gloomy Army Picture", May 29, 1997, Reuter Wire Services.

⁵⁶ National Journal, "What Saddam Has in His Arsenal", January 31, 1998, p. 243.

⁵⁷ Grigory Yavlinsky, "Russia's Phony Capitalism", Foreign Affairs, Volume 77, No. 3, May/June, 1998, p. 75.

⁵⁸ Lecture by Robert Bell, "New Initiatives in Nuclear Weapons Policies, Force Posture, and Arms Control", before the Atlantic Council, January 29, 1998.

As nation states, cultures, and religions around the world rally in opposition to the changing world perceived to be threatening to them, particularly threatening to their entrenched political systems, their old values may be revitalized. We have already seen this in Iran. America, the world's leader in economic, political and military power, will increasingly be identified as the cause of upheaval - the destroyer of the status quo and the marketer of unwelcome values. Perceived as the rich nation, the disrupter of order and the agent for uninvited change, we will become the nation advocates of the status quo love to hate. The seeds of terrorism will have been planted and terrorists may have access through Russia to the fertilizer - weapons of mass destruction - needed to perfect their trade. We are not prepared for the consequences.

Raymond Tanter, professor of political science at the University of Michigan, has identified Iran, Iraq, Libya, Syria, Cuba and North Korea as nation states that practice terrorism, possess large-scale conventional forces, and seek WMDs.⁵⁹ In his examination of the motivation of terrorists, Bruce Hoffman⁶⁰ has concluded that traditional terrorists, violent intellectuals willing to use force to accomplish their goals, have been joined by less cohesive, largely religious individuals embracing mystical, divinely inspired imperatives. The new breed of terrorist is thought to be much more interested in using WMDs than was his more traditional predecessors.⁶¹

c. Importance of Nuclear Weapons to Russia. Russia's withdrawal from Afghanistan and its difficulties in resolving the uprising in Chechnya have prompted news media around the world to speculate on the diminished capabilities of Russia's conventional military forces. Sweden's chief military strategist, Col. Johan Kihl, told Stockholm's Svenska Dagbladet that the threat of an invasion by Russia has disappeared or will vanish within a year, rendering the coastal artillery, lines of mines, and Swedish submarines unnecessary. "The Russian invasion fleet has rusted away, or is on the way to doing so," Kihl said. "The troops Russia has are not being paid, and the tank and fighter factories, which used to pour forth war machines, have come to a halt." Even if a Russian leader wanted to regain his country's military strength, Kihl said it is unlikely that he could do so because of the enormous cost of rebuilding industrial capacity and the lack of leading-edge technology knowledge

Ironically, as its conventional force capabilities are reduced, Russia will increasing rely on their nuclear weapons as a symbol of power and as a deterrent against perceived conventional threats from China, Western Europe, former Soviet republics, and in the eyes of Russia's Cold War elite, the U.S.⁶² Russia's reluctance to ratify the START II treaty and reduce their nuclear weapons cache to 3500 may be evidence of this. Nuclear weapons represent one of the few symbols of power retained by the post Cold War Russia. Pipes reports,

For the ruling elite and much of the intelligentsia (of Russia), accustomed to being regarded as citizens of a great power, the country's decline to Third World status has been traumatic. ... Power and influence for them take the form of imperial splendor and military might second to none. ... There are really two Russias. One is led by the ... population that is eager to break with the past and take the Western route The other

⁵⁹ Raymond Tanter, Rogue Regimes: Terrorism and Proliferation, St. Martin's Press, 1998.

⁶⁰ Bruce Hoffman, Inside Terrorism, Victor Gollancz, 1998.

⁶¹ The Economist, "The Economist Review: Curbing Terrorism", June 13, 1998, p. 3.

⁶² Karinne Gordon and Robert Rinne, Summary of Discussions with Professor Michael Mandelbaum, Director of American Foreign Policy, John Hopkins School of Advanced International Studies, May 1996.

Russia is made up of ... citizens, suspicious of the West and Western ways and nostalgic for the more secure Soviet past.⁶³

The Economist offered the following perspective on Russia,

If the measure of Russia's influence abroad were the number of ways it could foul up the West's policies in general, and America's in particular, then it could fairly claim to be what it wants to be: a great power once more. Yet, for all its recent spanner-tossing - offering diplomatic succor to Iraq in the row over UN inspections, helping an India or an Iran build bigger missiles, refusing to press Serbia to end repression in Kosovo, selling missiles to the Greek part of divided Cyprus - playing spoiler is not as satisfying as being a shaper of world events. Russia is miffed at what it sees as its second-class role in an America-dominated world.⁶⁴ ... Sometimes Russia seems to have several foreign policies, sometimes none at all. What it really has is a weak government and a sense of injustice about its place in the world. ... Since Yevgeny Primakov became foreign minister in 1996, Russia has been reaffirming cordial relations with Soviet-era friends, including such rogue states as Iraq and Iran, and looking at every turn for ways to challenge or outflank American diplomacy.⁶⁵

The first Strategic Arms Reduction Treaty (START I) was signed in 1991. START I, when fully implemented will reduce the number of strategic warheads deployed by the U.S. and Russia to about 8,000 warheads each. START II, if ratified by Russia, would further reduce the number of strategic warheads to the 3,000 to 3,500 range. START III, still in the formulation stage, would reduce the number of warheads to the 2,000 to 2,500 range.⁶⁶ Vladimir Lukin, chairman of the Russian Duma's Committee on International Affairs, has said that the Duma is unlikely to consider the START II strategic arms reduction treaty in the near future. Meanwhile, Viktor Ilyukhin of the Communist faction, chairman of the Duma's Security Committee, says START II is beneficial only for the United States and NATO, but not for Russia, which may lose its last defense shield if START II is ratified. Ilyukhin also said Duma members oppose ratification of the treaty because of the expansion of NATO into Eastern Europe. Knowledge by Russia that they can't afford to pay for START II also serves to inhibit ratification by the Duma. START IV follow-on to START III would require the involvement of other nuclear powers including China.

Israelyan⁶⁷ has examined scenarios for Russia's future.

♦ **Power scenario.** A dictatorship would be revived and it would mobilize the people against enemies outside of Russia. The policy of no first-use of nuclear weapons would be rescinded as would START I and the Biological Weapons Convention. There would be further build-up of ICBMs as well as short and medium range missiles carrying WMD warheads. Russia would act aggressively to protect the rights of Russians living in the former Soviet republics.

⁶³ Richard Pipes, "Is Russia Still an Enemy?", Foreign Affairs, November-December, 1997, p. 68-69.

⁶⁴ The Economist, "Russia's World", May 9, 1998, p. 16.

⁶⁵ The Economist, "Still Most Awkward Partners", May 9, 1998, p. 21.

⁶⁶ The National Academy of Sciences, The Future of U.S. Nuclear Weapons Policy, National Academy Press, 1997.

⁶⁷ Victor Asrelyan, "Russian at the Crossroads: Don't Tease a Wounded Bear", The Washington Quarterly, Winter, 1998, pp. 47-65.

One cannot help but remember that when Weimar Germany was isolated, exhausted, and humiliated as a result of World War I and the Versailles Treaty, Adolph Hitler took it upon himself to “save” his country. It took the former corporal only a few years to plunge the world into a second world war that cost humanity more than 50 million lives.⁶⁸

- ◆ **Cold War II scenario.** Russia would strengthen its ties with anti-Western states such as Iran, Iraq, Libya, and Cuba and it would distance itself from the “Dayton Accords” on the Bosnia crisis by taking a strong pro Serb position. Russia’s armed forces would be fully mobilized, its economy would be militarized, all democratic reforms would be rejected, and it would return to a totalitarian state. It would attempt to reestablish a global alliance with China and would take steps to revive economic relations with Japan. In the extreme, this scenario could lead to a Russia-China-Japan alliance pitted against an U.S.-European Union alliance.
- ◆ **Survival scenario.** Russia would support the eastward expansion of NATO and strengthen its economic and political ties with all European states. Russia would allow for U.S. leadership in world affairs and focus its foreign policy on the development of bilateral relations with Germany, France, and other European countries. Economic might rather than military might would be emphasized in this scenario.

While some speculate about the resurgence of communism in Russia, The Economist offers a nightmare scenario tending toward fascism,

Far more likely, however, if things continue to go sour, is that Russia will swing the other way – not all the way to fascism but towards something nearly as bad, a kind of extreme nationalism: intensely prickly and pan-Slavic, anti-Semitic, hostile to foreigners beyond and within its boundaries, eager to re-absorb the Slav heartlands of Ukraine and Belarus within the Russian fold, eager to make the Baltic trio of countries as weak and jumpy as possible. This quasi-fascism would also, in economic terms, be protectionist, corporatist and loath to privatize any more of Russia’s ailing industry or let people (certainly not foreigners) buy land. It would probably come to an arrangement with the mighty oligarchs, but their crony-capitalism would be tightly dependent on the whims of the political powers that be. The armed forces and the successors to the KGB would be raised again to a position of special eminence within the state. The press and television would be corralled. Russia would become an angry place – neither democratic, nor prosperous, nor kind to its neighbors.⁶⁹

d. Abolishment of Nuclear Weapons? General Butler (retired, USAF) has expressed concern that nuclear weapons might fall into the hands of terrorists.

The first thing that (General Butler) thought when he heard about the February 26, 1993, bombing of the World Trade Center was that the van the terrorists drove into the basement garage “could easily have contained a nuclear device.” He says that realization helped convince him that the longer nuclear bombs and laboratories exist,

⁶⁸ *Ibid*, p.58.

⁶⁹ The Economist, “Russia’s Crisis: Could It Lead to Fascism?”, July 11, 1998, p. 21.

*the more likely it is that their knowledge or equipment will migrate into terrorist camps. "As you move toward the goal of zero, all of that atrophies, it goes away", he argues now.*⁷⁰

We use the above quote of General Butler for two reasons. First, he was correct in speculating that a nuclear device could have done the bombing of the World Trade Center, provided that the terrorists had access to either a nuclear weapon or plutonium-239 or uranium-235 that could be used to construct a crude nuclear weapon. Second, he was wrong to speculate that the knowledge of how to build a nuclear weapon will atrophy as the goal of zero nuclear weapons is approached. If the number of nuclear weapons is reduced, only the knowledge of how to build a safe nuclear weapon that uses the minimum amount of plutonium or uranium per unit yield and is impossible to use, if stolen, can atrophy, and that will not happen unless policymakers among the nuclear-haves allow it to happen.

It wasn't the Manhattan Project or the development of nuclear power that let the nuclear genie out of the bottle; it was the discovery of nuclear fission in 1938 by the German chemists, Otto Hahn and Fritz Strassmann. Furthermore, had Hahn and Strassmann not made the discovery, there were several scientists around the world that had already caused uranium to fission by neutron absorption, but had not yet interpreted their laboratory observations to be fission. Even without the help of the spies, Klaus Fuchs and Theodore Hall, the USSR would have developed a nuclear weapon. We think that it is time to recognize that it was inevitable that the nuclear genie would escape and it is impractical to dream about putting it back in the bottle. Our energies should be focused on how to manage nuclear weapons and how to prevent their proliferation.

The Canberra Commission, General Butler, and others have recommended total nuclear disarmament. As former commander of all U.S. nuclear forces, General Butler has been quoted as being especially strong in his position that nuclear weapons should be abolished,

*today George Lee Butler believes -- and says forthrightly in public -- that nuclear weapons should be abolished. That they do not provide security to Americans or anyone else. That the theory of nuclear deterrence, the bedrock principle of U.S. national security during the Cold War, is costly, wrongheaded and dangerous. ... Butler says that by 1989, he knew that the Cold War was over, communism had failed and the West had won. But many of his military colleagues had yet to grasp this news.*⁷¹

U.S. advocates of zero nuclear weapons cite the dangers of accidental, erroneous, or unauthorized use of nuclear weapons. It is generally believed that deterioration of Russia's military forces increases the risk of their accidental launch of a missile carrying multiple warheads.⁷² Advocates of U.S. retention of nuclear weapons cite their value in deterring threats from nuclear, chemical, and biological weapons; note that Russia has broken its pledges to discontinue its chemical and biological weapons programs; and point out that full verification of treaty conformance is impossible (Undeclared and undetected nuclear stockpiles

⁷⁰ The Washington Post, "The Dissenter", December 7, 1997, p. W18.

⁷¹ Ibid.

⁷² Bruce Blair, Harold A. Feivenson and Frank N. von Hippel, "Taking Nuclear Weapons off Hair-Trigger Alert", Scientific American, November, 1997, pp. 74-81.

and production facilities are possibilities.).⁷³ What few are discussing is the low utility of arms treaties with a nation-state that is under the control of organized crime.

Glaser argues that nuclear disarmament can actually increase the probability of deliberate nuclear war.

Analyses that conclude that nuclear disarmament will reduce the probability of deliberate nuclear war tend to confuse a political problem with a military one. A prerequisite for nuclear disarmament is that the nuclear powers have achieved excellent, robust political relations. If political relations remain sufficiently good, the probability of rearmament and then nuclear war would be very low. However, if relations are this good, the probability of nuclear war could be just as low in a nuclear-armed world. If relations sour following disarmament, then states are far more likely to rearm and nuclear war is more likely during this rearmament phase than in a well-designed nuclear world. Consequently, disarmament would increase the probability of deliberate nuclear war.⁷⁴

Following the end of the Cold War, the University of New Mexico (UNM) Institute for Public Policy in response to a project started by David McVey and Dick Schwoebel of Sandia National Laboratories has conducted public opinion surveys on nuclear weapons. Their surveys show that since 1993 public support for maintaining a stockpile of U.S. nuclear weapons has increased by 10%, but the public does support reducing the size of the stockpile to START III levels. Legislators, understanding nuclear weapons to be political tools, advocate a nuclear stockpile size between two and three times that supported by scientists whose focus is on the technical utility of nuclear weapons. Since 1993, there has been a 31% increase in public support for maintaining the ability of the U.S. to develop and improve nuclear weapons in the future.⁷⁵

e. U.S. Nuclear Weapons Policy. President Clinton has issued a Presidential Decision Directive (PDD-60)⁷⁶ clarifying the role of nuclear weapons in U.S. defense posture. His directive calls for U.S. war planners to retain options for nuclear strikes against the military and civilian leadership and nuclear forces in Russia. The President also expressed the desire to retain a triad of nuclear forces consisting of bombers, land-based missiles and submarine-based missiles. President Clinton's directive emphasizes that nuclear weapons are needed to deter aggression and coercion by threatening a certain and devastating nuclear response to a threat to U.S. national security.

The President's directive demands general planning for potential nuclear strikes against other nations or rogue states that have prospective access to nuclear weapons and that are now or may eventually become hostile to the United States. President Clinton's nuclear targeting directive reflects increasing sensitivity to the threats posed by chemical and biological attacks and reiterates that if any nation uses weapons of mass destruction against the United States, it

⁷³ C. Paul Robinson and Kathleen C. Bailey, "To Zero or Not to Zero: A US Perspective on Nuclear Disarmament", Security Dialogue, 1997, Vol. 28(2): pp. 149-158.

⁷⁴ Charles L. Glaser, "The Flawed Case for Nuclear Disarmament", Survival, vol. 40, no. 1, Spring, 1998, p. 113.

⁷⁵ Hank C. Jenkins-Smith and Kerry G. Herron, Public Perceptions on Nuclear Security and Science, Preliminary Findings, March 2, 1998.

⁷⁶ Washington Post, December 7, 1997, p. A01.

may forfeit its protection from U.S. nuclear attack. The question of what is an appropriate response to attack by a chemical or biological weapon is left open in PDD-60.

The U.S. is still hedging against an uncertain future, with the fundamental principles of deterrence intact and unchanging down through START III numbers. The continuing existence of a triad, a strategic deterrent posture without launch-on-warning, ability to respond to a strategic reversal and ability to survive an attack and function are all preserved under this PDD. Going beyond START III in cuts would require a paradigm shift including such measures as giving up our hedge against strategic reversal. Robert Bell⁷⁷, Special Assistant to the President for National Security Affairs and Senior Director for Arms Control, National Security Council, explained that PPD-60 reiterates that the U.S. will not use nuclear weapons first in response to an attack unless:

- ◆ The attacker is nuclear capable,
- ◆ The attacker is an ally of a nuclear-capable nation,
- ◆ The attacker is not in good standing with the Non Nuclear Proliferation Treaty (NPT).

In order to maintain a safe and credible nuclear deterrent without the benefit of underground testing of nuclear weapons, the U.S. has started the Science-Based Stockpile Stewardship Program. This program emphasizes (1) the development of supercomputer-based analysis methods to simulate aging of the nuclear weapons stockpile and (2) the development of new experimental facilities that can be used to test weapons components and subsystems.⁷⁸

f. Proliferation of Chemical and Biological Weapons. In reviewing the history of WMD proliferation and use, the Office of Technology Assessment reported,

Chemical weapons were heavily used in World War I and have been employed several times since then in regional conflicts. Most recently, Iraq used chemical weapons during the 1980-1988 war with Iran, resulting in some 50,000 Iranian casualties, with Iran belatedly retaliating in kind. Iraq also used chemical weapons against its own Kurdish population.⁷⁹

In 1997, the U.S. Senate ratified the Chemical Weapons Convention, banning the development, production, storage, use, sale or purchase of chemical weapons. Critics of ratification expressed concern about the treaty's far reaching system of international inspections and claimed them to be a threat to U.S. sovereignty and to U.S. companies' competitive secrets. (To inspect an U.S. company without its consent, inspectors must obtain a criminal search warrant from an U.S. judge.) There is evidence, however, that some nations are still developing chemical weapons.

According to an Associated Press account of a Jane's Defense Weekly article that quotes Israeli intelligence, Syria is preparing to produce the VX nerve agent. In a Tel Aviv-dated story

⁷⁷ Lecture by Robert Bell, "New Initiatives in Nuclear Weapons Policies, Force Posture, and Arms Control", before the Atlantic Council, January 29, 1998.

⁷⁸ National Journal, "At Ground Zero", February 21, 1998, p.p. 388-392.

⁷⁹ Office of Technology Assessment, Proliferation of Weapons of Mass Destruction, August, 1993, p. 10.

Wednesday, July 1, Jane's said that Syria is already able to produce other chemical agents "and is set to locally produce quantities of the VX chemical agent." Israeli officials have previously accused Russia of helping Syria acquire chemical weapons, including VX, which is so potent that a single drop can be deadly.

While much has been written about the threat of nuclear WMDs, biological weapons are equally, or perhaps more threatening. Unlike nuclear weapons whose proliferation is driven by the availability of fissile nuclear material, it is generally thought that biological and chemical weapons could be developed in "garage shop" operations no more complex than a microbrewery. Betts reports,

Biological weapons combine maximum destructiveness and easy availability. Nuclear arms have great killing capacity but are hard to get; chemical weapons are easy to get but lack such killing capacity; biological weapons have both qualities. A 1993 study by the Office of Technology Assessment concluded that a single airplane delivering 100 kilograms of anthrax spores - a dormant phase of a bacillus that multiplies rapidly in the body, producing toxins and rapid hemorrhaging - by aerosol on a clear, calm night over the Washington, D.C., area could kill between one million and three million people, 300 times as many fatalities as if the plane had delivered sarin gas in amounts ten times larger.⁸⁰

In a chilling commentary, Jane's said such biological weapons in the hands of a rogue nation with a delivery system could produce a situation whereby the only reliable retribution may well be overwhelming nuclear response.⁸¹ As was pointed out in the Jane's analysis, nuclear weapons are thought to be the most credible deterrent against the use of biological weapons and they may be the most practical way to destroy a biological weapons factory. If a weapon using conventional explosives attacked a cache of biological weapons, the biological agents could be dispersed with some becoming air borne. Attack by a nuclear weapon can change the chemistry of the biological agents through extreme temperatures, ionization and nuclear transmutation and thereby kill all the biological agents.

It has been reported that Russia has developed a variant of the anthrax toxin that is totally resistant to antibiotics. Russian military research laboratories are also thought to have developed three new nerve agents. In fact, in 1979, after signing the Biological Weapons Convention, biological agents, perhaps as small as a "pinch", escaped from a biological laboratory in Siberia and were carried by the wind into the city of Sverdlovsk. Within two days a swath of death was observed for four miles downwind. Los Alamos National Laboratory scientists have examined tissues from some of the victims and found four different types of anthrax strains. They concluded that the Soviet Union was most likely mixing strains to make a more effective type of biological weapon. The Soviets initially claimed that the deaths were caused by contaminated meat.⁸²

UNSCOM arms control inspectors in Iraq have destroyed 38,000 chemical weapons, 480,000 liters of live chemical weapons agents, 48 operational missiles, 6 missile launchers, and 30 warheads that could carry chemical and biological weapons. They discovered the Al Hakam

⁸⁰ Betts, p. 32.

⁸¹ Jane's Land Based Air Defense, 1997-98.

⁸² Albuquerque Journal, "Piece Found in Anthrax Mystery", February 3, 1998, p. A1.

biological weapons factory which is capable of producing 50,000 liters of anthrax and botulism for warhead payloads. They have determined that Iraq has produced 19,000 liters of botulism, 8,400 liters of anthrax, and 2,000 liters of aflatoxin, an agent that causes liver cancer. It is thought that Iraq has facilities that could produce 350 liters of anthrax per week, enough to fill two missile warheads.⁸³ Ten years ago, Iraq demonstrated to the world that they were willing to use WMD when they killed 5,000 of their citizens at Halabja with chemical weapons.⁸⁴

Particularly disconcerting is the observation in a document seized by a U.N. inspection team that Russia agreed in 1995 to provide Iraq with the fermentation equipment that could be used to develop biological weapons. Exercise of these transactions violates a U.N. embargo on sales of biological weapons equipment to Iraq.⁸⁵

A former UN investigator, Raymond Zilinskas, says Iraq could reassemble its germ warfare program with a still-intact scientific team working with freeze-dried organisms. The 200-person workforce of Iraq's biological warfare program is intact and its 80 research and production facilities are "whole and well equipped." Zilinskas was a member of the UN team overseeing the scrapping of Iraq's weapons of mass destruction under terms of the 1991 Gulf War cease-fire.

g. Proliferation of Missiles. In addition to the possibility of international proliferation of nuclear weapon materials, there is concern over the proliferation of ballistic missiles that could carry a nuclear, chemical or biological warhead. Britain's Lancaster University estimates that 35 non-NATO countries have ballistic missiles and that 18 non-NATO countries are capable of installing either nuclear, biological or chemical warheads on these missiles. Iran recently tested a missile that could carry a warhead to Saudi Arabia or Israel. North Korea, with financing from Iran, is thought to be developing a two-stage missile, the Taepo Dong 2, with a range between 2,500 and 4,000 miles.⁸⁶ General John Tilelli, senior U.S. military commander in Korea, told members of the Senate Armed Services Committee his top priority is adequate missile defenses to protect U.S. and South Korean forces from attack by the North. He said defenses right now are inadequate to meet the ballistic missile threat posed by Pyongyang. The U.S. has about 37,000 troops stationed in South Korea.

While Iraq has capitalized on Russia's economic predicament to gain access to biological weapons technology, Iran has gained access to missile technology from Russia. The Washington Post reported,

Although reluctant to discuss details, U.S. officials confirmed reports that Iranian students continue to receive training in Russian technical institutes, and that Russians with ballistic missile expertise continue to take their skills to Iran. They also confirmed a report by Republican Senator Richard G. Lugar of Indiana ... that Russian officials say

⁸³ Robin Cook, British Foreign Secretary, press release, February 4, 1998.

⁸⁴ Robin Cook, British Foreign Secretary, speech to House of Commons, February 10, 1998.

⁸⁵ The Washington Post National Weekly Edition, "Is Russia a Partner in Iraq's Germ Warfare Buildup?", February 16, 1998, p. 17

⁸⁶ The Economist, "Circles of Fear", January 4, 1997, pp. 33-35.

*they lack the legislative authority to investigate and control the activities of private companies and individuals.*⁸⁷

h. Prevention of WMD Proliferation. Senator Lugar⁸⁸ has pointed out that there are three main lines of defense against the proliferation of WMD and the materials used to make them. Individually, each line of defense is inadequate; collectively, they may be sufficient.

- ◆ Prevent proliferation at the sources abroad by developing secure control systems for WMD and the critical materials and components used to make WMDs.
- ◆ Deter and interdict the flow of illicit trade in WMD and WMD materials.
- ◆ Prepare domestically for crises.

The first two of these are non-proliferation activities; the third is a counter-proliferation activity. The basic U.S. approach to non-proliferation is to urge countries to sign treaties in which they promise to not develop, test or use WMDs and not sell materials and components that can be used to manufacture WMDs. John Mearsheimer, a political scientist at the University of Chicago suggests that there are perhaps more that the U.S. can do in the area of nonproliferation.

*Arms control efforts have been conducted, he said, with little regard for the reason that most nations try to acquire nuclear weapons: their value as equalizers against powerful neighbors. ... Instead of pushing international agreements, Mearsheimer said, the United States should concentrate on resolving diplomatic tensions involving undeclared and non-nuclear states.*⁸⁹

E. Russian Organized Crime

The government of Russia is slowly losing its ability to control the expansion of crime. In 1994, Arnaud-de Borchgrave pointed out that Russia has 5,700 Mafia gangs with 100,000 members that are supported by 3 million workers who are responsible for 35% of Russia's GDP.⁹⁰ Russia's Ministry of Internal Affairs estimates that 40% of private business, 60% of state-owned business, and between 50% and 85% of Russia's banks are under the control of Russian organized crime. Roughly two-thirds of Russia's economy is under the influence, if not control, of crime syndicates. Private companies pay organized crime between 10% and 30% of their profits for protection.⁹¹ Grigory Yavlinsky, a Russian economist that leads Yabloko, a democratic, reformist political party that opposes the Yeltsin government, explained,

But while Russia has its economic success stories, many aspects of the economy suggest that it is moving toward a corporatist market in which corruption is rampant.

⁸⁷ The Washington Post National Weekly Edition, "A Dangerous Flow of Information", January 26, 1998, p. 14.

⁸⁸ Senator Lugar, "The Threat of Weapons of Mass Destruction", The Hill, February 25, 1998, p. 39.

⁸⁹ Congressional Quarterly, "As the Dust Settles in India, U.S. Rethinks Nuclear Policy", May 23, 1998, p. 1367.

⁹⁰ Arnaud de Borchgrave comments in Global Organized Crime: The New Empire of Evil, Center for Strategic and International Studies, 1994, p. 106.

⁹¹ CSIS Global Organized Crime Project Report, Russian Organized Crime, 1997, p. 2.

The most important of these trends is the rise of the Russian oligarchs, who have created a form of robber-baron capitalism. Far from creating an open market, Russia has consolidated a semi-criminal oligarchy that was already largely in place under the old Soviet system. After communism's collapse, it merely changed its appearance, just as a snake sheds its skin. The new ruling elite is neither democratic nor communist, neither conservative nor liberal - merely rapaciously greedy.⁹²

Claire Sterling reported on the deterioration of government in Russia,

What we are seeing in Russia is a shared monopoly of power between politicians and crooks, and the system works to their mutual advantage. ... Russian organized crime produces nothing, invests nothing, and is not interested in developing any form of production or any means of furthering the economic welfare of the country... this country is being systematically plundered, ransacked by a criminal class working directly in hand with the political forces running the country, to the total detriment of the society it exploits. ... I think that Western authorities generally, and the United States very much in particular, bear a very grave responsibility for the extraordinary exponential growth of organized crime in Russia and its spread outside of Russia by the shortsightedness and lack of attention that has been paid to this subject.⁹³

Peter Grinenko observed,

In Russia, you have a whole different society. ... You have 70 years of communism; it definitely warped the way people think there. ... Peter the Great imported culture, he did not import ethics. ... there is absolutely no support for law enforcement. ... For it to improve will take decades. ... Pre-coup, the government kind of ran the criminals. After-coup, the criminals are kind of running the government. ... What you have got to be concerned about is that woman that works in there [at a nuclear facility] for her \$12 a month and she has got three kids to feed. ... she is going to take it [nuclear material] and she is going to figure out a way of selling it to feed her kids. That is the danger.⁹⁴

Yonas has explained,

Cold War Russia is being replaced by a Russia slipping into despair, and lawlessness. I neither expected nor hoped for such an outcome from the Cold War. Our Nation's post Cold War goal was to shift the balance of terror that prevailed during the Cold War to a balance of mutual security based on a focus on protection rather than a reliance on threat of destruction. We believed we could prevail in a technology race, and we would persuade the Soviets, even if we had to do that coercively, to join us in a transition away from a military strategy based on the threat of nuclear retaliation. As it turned out, we were wildly successful compared to anything we might have hoped for, but the outcome was not what we expected. ... Now we are so worried about loose nukes and migration of Russian weapons scientists to the rogue nations, that we are expanding our efforts to

⁹² Grigory Yavlinsky, "Russia's Phony Capitalism", Foreign Affairs, Volume 77, No. 3, May/June, 1998, p. 69.

⁹³ Claire Sterling, "Containing the New Criminal Nomenklatura", in Global Organized Crime: The New Empire of Evil, Center for Strategic and International Studies, 1994, pp. 106-128.

⁹⁴ Peter Grinenko comments in Global Organized Crime: The New Empire of Evil, Center for Strategic and International Studies, 1994, p.111-114.

*help Russia with cooperative programs to destroy their nuclear weapons or greatly improve their protection of those weapons, and to work cooperatively with Russian scientists on non weapons programs. This proliferation threat stemming from the collapse of the Soviet Union is the basis of the most serious threat we face, namely the spreading of biological, chemical, and nuclear weapons throughout the world.*⁹⁵

Israelyan⁹⁶ points out,

Early hopes for a warm, broad-based Russian-U.S. partnership that would draw Russia full into the world community of democratic states have been dashed by exaggerated expectations, a lack of vision and political will (especially on the U.S. side), and recurring Cold War symbols of hostility. It is not generally recognized just how close the West is to losing a once-in-a-lifetime opportunity to ensure that Russian reform takes place and to bring Russia definitively into the group of peaceful, prosperous democracies. ... realistic scenarios for outcomes in Russian politics over the next several years no longer include an ideal option. At this point the best we may be able to do is to prevent a new confrontation between the former Cold War adversaries in an arrangement that I call the "survival scenario". ... Continued wishful thinking about the state of relations between Russia and the West will only postpone needed initiatives even further.

F. International Leaders.

Most nations' foreign policies are strongly influenced by whom they select to be their chief executive officer.

*Two nations that have preoccupied American military and diplomatic leaders for the past half century - Russia and China - are likely to face leadership crises during the next presidential term.*⁹⁷

Of course, in 1997 China experienced the loss of its leader, Deng Xiaoping, leaving many to speculate how its foreign policy will be impacted.⁹⁸ There is growing unrest in Belarus over the pro-Russian stance of their President, Alexander Lukashenko. NATO's interparliamentary organization, the North Atlantic Assembly (NAA) is freezing all ties with Belarus. According to NAA president, Sen. William Roth, R-Del., Belarussian President Alexander Lukashenko's policies have undermined the rule of law and the democratic legitimacy of the country's legislature. It is entirely unclear what the foreign policies of a post-Yeltsin Russia led by a rebellious general might emphasize. On the other hand a post Saddam Iraq, or a post-Castro Cuba, like a post Kohemini Iran, might well be less hostile to the U.S.

G. NATO Expansion.

NATO's expansion into Eastern Europe has made many Russian leaders nervous. In fact, opposition to the eastward expansion of NATO is one of the few issues that attain consensus of

⁹⁵ Gerold Yonas, "EMERGING THREATS: International Terrorism and Security Issues", presentation to Alaska World Council, Sept. 5, 1997.

⁹⁶ Victor Israelyan, "Russia at the Crossroads: Don't Tease a Wounded Bear", The Washington Quarterly, Winter, 1998, p. 47.

⁹⁷ David S. Broder, "Echoes of 1936?", The Washington Post National Weekly Edition, October 7-13, p. 4.

⁹⁸ For a review of this and other China issues, see The Economist, A Survey of China, March 8, 1997, pp. 1-22.

both Russia's political left and political right. Mr. Yeltsin has played a major role in negotiating Russia's acceptance of NATO expansion while assuring that Russia's position as a great power is respected. Senator Roth has offered Russia assurance that the eastward expansion of NATO is not a threat.

NATO enlargement will benefit a democratic Russia, particularly as the Alliance extends a hand of friendship and cooperation. Enlargement will provide the regional stability Russia needs to consolidate and direct its energy inward for economic and political growth. We must not allow anachronistic voices to turn NATO enlargement, and the partnership between Russia and the Alliance, into a bargaining process.⁹⁹ ... I have told the Ukrainians that I see them as future members of NATO. I hope that they will continue to implement the reforms necessary for their inclusion in the Alliance. Their eventual membership is in America's vital interest and is a cornerstone of our vision for a post-Cold War Europe.¹⁰⁰

In order to secure Russia's approval of NATO's eastward expansion to countries previously in Russia's sphere of control, NATO has declared that it has no intention, no plan, and no reason to install or deploy nuclear weapons or to station permanently substantial combat forces on the territory of new NATO members. Mr. Yeltsin has played a major role in negotiating Russia's acceptance of NATO expansion while assuring that Russia's position as a great power is respected. In his absence, Russia is likely to be less accommodating.

Schlesinger has described one of perhaps many ironies of the westward expansion of NATO. He points out,

The collapse of the Soviet Union and the Warsaw Pact has ... reduced the dependence of the United States (and its allies) on nuclear weapons. The challenge of holding a nuclear umbrella over our allies in Western Europe and elsewhere has been substantially alleviated. Moreover, the requirement to initiate the use of nuclear weapons in response to an overwhelming conventional attack has been eliminated. Indeed, any need for such a nuclear response to a conventional attack has, at least for this period, happily disappeared. ... Our most senior officials have additionally indicated that NATO membership should be open to any democratic country in Europe. If, for example, NATO is expanded to include the Baltic states, no conventional defense would be possible. Under such circumstances, if we were to fulfill a commitment to provide protection, we would be driven back to threatening a nuclear response to a conventional attack.¹⁰¹

Ted Carpenter¹⁰², Cato Institute, has pointed out that three lethal booby traps await the U.S. if NATO expansion goes forward:

⁹⁹ Senator William V. Roth, Jr., "Toward NATO Enlargement", speech at Center for Strategic and International Studies (CSIS) conference on European security issues, Brussels, February 22, 1997.

¹⁰⁰ Senator William V. Roth, Jr., press release, "U.S. Congressional Delegation Visits Sevastopol, February 20, 1997.

¹⁰¹ James Schlesinger, "Implications of a Zero-Yield Nuclear Nuclear Test Ban", Testimony Before the subcommittee on International Security, Proliferation, and Federal Services of the Senate Committee on Governmental Affairs, October 27, 1997.

¹⁰² The Hill, "NATO: What's the Rush?", March 18, 1998, p. 38.

- ◆ There is potential for conflicts between Poland, Hungary, and the Czech Republic and their neighbors. Poland and Belarus already have a tense relationship and Hungary has conflicts with Romania, Slovakia and Serbia.¹⁰³
- ◆ It will damage the relationship with Russia and strengthen the relationship between Russia and Iran, Iraq, and China and rekindle the Cold War.
- ◆ It will commit the U.S. to pouring money down a financial "black hole". Estimates of the costs of NATO expansion are as high as \$125 billion over 15 years and as low as \$400 million over 10 years.

Grigory Yavlinsky, a Russian economist that leads Yabloko, a democratic, reformist political party that opposes the Yeltsin government, has addressed NATO expansion,

The combination of Chechnya, the collapse of the Russian army, failed economic reforms, a semi-criminal government, and Yeltsin's unpredictability has given the West enough justification to conclude that Russia, for the time being, cannot be a dependable partner and that NATO expansion should therefore continue. Ironically, if the United States explained its push for NATO expansion in these terms to the Russian people, they would at least understand why the alliance is expanding and respect the West for its honesty. But when the West says to Russians: "Russian democracy is fine, Russian markets are fine, Russia's relationship with the West is fine, and therefore NATO is expanding to Russia's borders," the logic does not work, leaving the Russian people and their leaders bewildered and bitter. This resentment will only be exacerbated if the West continues its two-faced policy.¹⁰⁴

In ratifying the admission of Hungary, Poland, and the Czech Republic, all nations captive to the Soviet Union during the Cold War, into NATO, several members of the U.S. Senate have made it clear that they see the first wave of NATO expansion as an experiment. If it works well, they will approve further expansion; if it does not, they will vote to halt NATO expansion.¹⁰⁵ U.S. arms manufacturers see NATO expansion as an opportunity to upgrade the military capabilities of new NATO members.¹⁰⁶

H. Defense R&D Thrusts

As we pointed out at the beginning of this discussion, we are particularly concerned that U.S. military capabilities be able to support our foreign policy objectives during a period when, of necessity, our foreign policy is adapting in seemingly incoherent ways to the U.S. being the world's only superpower. Despite the fact that polls show that the public is gradually losing interest in defense issues, this is not the time to cut our investment in defense R&D. We should instead be increasing Federal defense R&D in preparation for unexpected events and preparing robust military capabilities that position us for events that could evolve over the next 20 to 50

¹⁰³ Ted Galen Carpenter, "The Three Booby Traps of NATO Expansion", The Hill, March 18, 1998, p. 40.

¹⁰⁴ Grigory Yavlinsky, "Russia's Phony Capitalism", Foreign Affairs, Volume 77, No. 3, May/June, 1998, p. 77.

¹⁰⁵ Congressional Quarterly, "Senate Approves Three Nations For Membership in NATO", May 2, 1998, pp. 1164-1166.

¹⁰⁶ National Journal, "Defend Warsaw? Sure, Why Not?", April 4, 1998, p. 782.

years as well as prepare us for the wide asymptotes of foreign policy responsibilities that could accrue to the world's only superpower.

- ◆ We must, in particular, vigorously support defense research that prepares the U.S. to counter proliferation of WMDs and the expansion of international crime syndicates.
- ◆ We must search for creative ways to assist Russia in developing a liberal democracy subject to the rule of law that is able to control the criminal element that is destroying entrepreneurship and economic development in Russia.
- ◆ We must research the widest potential range of U.S. foreign policy options and identify the range of military systems and defense R&D required to support these policy limits.

2. The Healthcare Cost Problem:

A. Cost Comparisons.

The cost of health care in America has risen to 14.5% of GDP, between 1.5 and 2 times (as a fraction of GDP) that of the rest of the industrialized world. In comparison, France spends 9.9%, Germany spends 9.6% and Britain spends 6.9% with little noticeable disadvantage in the quality of healthcare services or quality of life.¹⁰⁷ Despite the fact that Japan's population is older than the U.S. population and spends 30% of its healthcare purchases on drugs in comparison to 8% in the U.S., Japan only spends 7% of its GDP on healthcare and its citizens live 4 years longer than Americans.¹⁰⁸ Until recently the U.S. has been redirecting national resources to health care at the rate of 1 percent of GDP every 20 months.¹⁰⁹ Healthcare costs currently account for 20% of the federal budget and 30% of states' budgets.

Comparisons of the U.S. healthcare system to those of Britain and Germany reveal that even though American hospitals are more productive in the treatment of breast cancer, lung cancer, and gallstones, they lag in treatment of diabetes and their administrative costs are much higher.¹¹⁰ The escalation in U.S. healthcare costs is summarized in Table II. Note the progress that is being made in controlling administrative charges and the progress that is being made in controlling the rate of growth of hospital charges. While much has been made about the cost of medical equipment, the reader may easily see that it is a trivial part of healthcare costs.

In addition to the \$20 billion spent on research shown in Table II, approximately another \$20 billion is spent on research by drugs, pharmaceutical and medical device companies and some of the hospital charges include hidden research costs. If one conservatively estimates that \$50 billion is annually spent on medical research, this is still only 5% of annual medical charges. The amount of money that is being spent on research to investigate innovative new ways of cost-saving healthcare delivery is not even measurable.

Almost 40 million or 15% of Americans do not have medical insurance. Furthermore, while thought to be a necessity, medical insurance actually increases the demand for healthcare

¹⁰⁷ The Economist, "France: A headache", March 8, 1997, p. 57.

¹⁰⁸ The Economist, "Japan's Sickly Drug Firms", October 19, 1996, p. 65.

¹⁰⁹ G. Lawrence Atkins and John L. Bauer, "Taming Health Care Costs Now", Issues in Science and Technology, Winter 1992-93, p 54.

¹¹⁰ The Economist, "Heal Yourselves: The Economics of Health Care", November 9, 1996, p. 92.

services by driving a wedge between the real price and the price actually paid by the insured person. Furthermore, those without health insurance are often forced to resort to the most expensive class of medical services, those provided by the emergency rooms of hospitals.

Table II: Growth of U.S. healthcare costs in the 1990s.¹¹¹ Research costs do not include drug research funded by private companies. These costs are absorbed in the costs of medical products that include drugs. In 1996 state and local taxes paid for 12.7% of healthcare costs, Federal taxes paid for 30.9% of costs, employer paid health insurance paid for 27.3% of costs, and direct individual payments (individual paid health insurance and other out-of-pocket payments) covered 29.1% of costs.¹¹²

Service	1992 Charges	1994 Charges	1996 Charges	1998 Charges	1997-1998 Growth
Hospital	\$305 B	\$335 B	\$363 B	\$395 B	4.6%
Physicians	\$176 B	\$191 B	\$214 B	\$240 B	6.3%
Dentists	\$37 B	\$42 B	\$50 B	\$58 B	8.3%
Other Professional	\$42 B	\$48 B	\$57 B	\$65 B	6.6%
Home Health	\$20 B	\$26 B	\$30 B	\$37 B	8.8%
Medical Products	\$71 B	\$78 B	\$89 B	\$102 B	7.2%
Medical Equipment	\$12 B	\$13 B	\$15 B	\$17 B	8.2%
Nursing Home	\$62 B	\$72 B	\$83 B	\$92 B	5.2%
Personal Healthcare	\$15 B	\$22 B	\$28 B	\$35 B	11.0%
Administration	\$43 B	\$51 B	\$46 B	\$46 B	0.0%
Government Public Health	\$23 B	\$28 B	\$35 B	\$40 B	8.6%
Research	\$14 B	\$16 B	\$17 B	\$20 B	13.7%
Construction	\$13 B	\$15 B	\$14 B	\$16 B	6.8%
Total	\$834 B	\$937 B	\$1,038 B	\$1,160 B	5.7%

Medicare costs now exceed \$200 billion and are growing at an annual rate of 9%. A Washington Post poll showed that 52% of Americans are worried that they and their family will not be able to afford adequate medical care and that the medical benefits they receive will be reduced or eliminated.¹¹³ Current estimates predict 2005 to be the crash date for Medicare. Public polls indicate that the public is aware of the Medicare crises but believes that it can be solved by eliminating Medicare's waste, fraud and abuse or by cutting foreign aid, believed by 64% of those polled to be the largest area of government spending. (Foreign aid actually constitutes about 1% of government spending while Social Security amounts to about 25% of government spending.¹¹⁴ In 1996, Medicare waste, fraud and abuse amounted to \$23 billion or

¹¹¹ DRI/McGraw-Hill, Standard & Poors, and U.S. Department of Commerce International Trade Association, U.S. Industry & Trade Outlook '98, 1998, p. 45-2.

¹¹² The Concord Coalition, Financing Retirement Security for an Aging America, 1998, p. 29.

¹¹³ The Washington Post National Weekly Edition, "What About Us?", September 23-29, 1996, p. 9.

¹¹⁴ The Washington Post National Weekly Edition, "Hands Off Social Security and Medicare", April 7, 1997, p. 35.

14% of Medicare's total costs.) The public's share of healthcare costs, paid through tax revenues, has been rapidly increasing and now accounts for over 46% of healthcare charges. So, want it or not, we are already almost one-half way to a government-funded healthcare system.

B. Impact of Aging Population.

It is well known that the U.S. population is aging and that the aging population is just beginning to place great stress on Medicare, Social Security, and Medicaid. In 1987 the overall per capita expenditure for healthcare in the U.S. was \$1,776 (1987 dollars.) However, the distribution of expenditures varied widely with age. For example, those under 19 years of age spent \$745, those between 19 and 64 spent \$1,535, those over 65 spent \$5,360 and those over 85 spent \$9,178.¹¹⁵

There is a continuum of care that can help provide for the residential and medical needs of the elderly. These range from home health care, congregate care, assisted living facilities, skilled nursing home facilities, and acute care hospitals. As the elderly move through this hierarchy of services, costs grow rapidly. For example, the total monthly cost of assisted living facilities ranges between \$1,500 and \$3,000 depending on the range of services needed; skilled nursing care averages about \$5,000 per month, subacute care costs about \$15,000 per month, and acute care in a hospital costs about \$38,000 per month.¹¹⁶ Because government supported programs are skewed toward the high cost end of the care spectrum, many of the elderly whose needs could be adequately met by a lower cost option are encouraged to utilize the highest cost options of skilled nursing homes and hospital care.

The Council on Competitiveness estimates U.S. health care costs will increase to 16% of GDP by the year 2000 and grow to 18% of GDP by 2005.¹¹⁷ Some suggest that when the baby boomers reach their late 70s and 80s in the middle of the 21st century, U.S. health care costs may soar to 25% of U.S. GDP.¹¹⁸ By this time U.S. personal savings will have evaporated and investment will be entirely financed by foreign borrowing. Presumably, by this time Japan and other Asian countries will have transitioned from their Keynesian underconsumption practices and be saving less. Hence, the cost of borrowing foreign capital will be higher than today's costs. Growth of a single consumption-intensive area of the economy does not inhibit economic progress when offset by reductions in other consumption-intensive categories. However, Kennedy's review of 500 years of international history suggests that when consumption-intensive defense spending grew to between 10% and 15% of GDP, its growth was often not offset by reductions in other consumption-intensive categories. Rather, it was accompanied by reduction in savings and investment. Damage to nations' economies was the inevitable outcome.¹¹⁹ Similar responses and consequences will eventually accompany the escalation in health care costs.

C. Impact on Savings.

¹¹⁵ The Concord Coalition, Financing Retirement Security for an Aging Population, 1998, p. 35.

¹¹⁶ Data provided by Lois Jean Gover, assisted living business consultant.

¹¹⁷ Council on Competitiveness, Highway to Health, March 1996.

¹¹⁸ Edith Weiner and Arnold Brown, Insiders's Guide to the Future, The Boardroom, Inc., 1997.

¹¹⁹ Paul Kennedy, The Rise and Fall of the Great Powers, Random House, 1987, p.539.

Health care consumption is slowly eroding National savings and, as the population ages, this problem will continue to escalate. The net National savings rate has dropped from 9.1% in the 1950s to 2.7% in the early 1990s.¹²⁰ This drop is driven by the trend for the elderly to have more money and to spend more of it.¹²¹ It is healthcare that the elderly are increasingly purchasing. The personal consumption expenditures of Americans is summarized in Table III.

Table III: Personal consumption expenditures of Americans in 1994.¹²²

Expenditure	% of Personal Income
Household Electricity	2.4%
Gasoline, Oil, Fuel, and Coal	2.6%
Other Durable Goods	2.4%
Household Operation	3.3%
Transportation	3.9%
Furniture, Household Equipment	5.0%
Motor Vehicles and Parts	5.4%
Other Nondurable Goods	7.5%
Clothing and Shoes	5.3%
Housing	14.3%
Food	14.7%
Health Care	15.7%
Miscellaneous Services	17.5%

Between 1984 and 1994 medical care absorbed 20% of the growth of consumption expenditures.¹²³ Since 1975, outlays for housing and transportation services have risen by 1.5% of personal income while outlays for religious, social welfare, educational, and recreational activities have increased by 1.8% of personal income. Outlays for personal business services, including banking and brokerage fees, have increased by 2.1% of personal income. Outlays for goods - food, clothing, and gasoline - have decreased by almost 8% of personal income. Since 1975 personal savings have decreased from 8% of personal income to 4% of personal income. The consumption area driving the decrease in savings is medical services. **Since 1975 an additional 5.8% of personal income has gone to medical services.**¹²⁴ Thus, were it not for major increases in the productivity of goods, rapidly escalating health care costs would have dropped savings to only 2.2% of personal income.

Speaker of the House Newt Gingrich has pointed out that Americans need to save more,

The state of savings in America today is bleak. More than 50 million workers - about half of the workforce - have no retirement coverage at all, whether through an employer provided plan or individual accounts like IRAs or 401(k) plans. Among

¹²⁰ The Economist, "Growing Old Expensively", September 7, 1996, p. 76.

¹²¹ Lawrence Kotlikoff, John Sabelhaus, and Jagadeesh Gokhale, Understanding the Postwar Decline in US Savings: A Cohort Analysis, Brookings Papers on Economic Activity, 1996, and Steven Pearlstein (The Washington Post), "Study Pins Savings Lapse On Elderly", The Albuquerque Journal, October 5, 1996, p. C6.

¹²² U.S. Department of Commerce, Bureau of Economic Analysis, 1994.

¹²³ Competitiveness Policy Council, Running In Place: Recent Trends in US Living Standards, September, 1996, p. 18.

¹²⁴ Business Week, "Solving the Savings Riddle", November 11, 1996, p. 26.

*small businesses, the numbers are even more alarming: only about 25 percent of workers in these enterprises are covered by some kind of retirement plan.*¹²⁵

D. Causes of Cost Escalation.

a. Lack of Productivity Growth. Simply reducing the rate at which Medicare costs grow does not address the root cause of the healthcare cost problem. Neither does forcing small businesses to purchase health insurance for their employees. Indeed, the productivity of the entire U.S. health care system must be increased. This means that more services must be provided by fewer people. Regulations, both government-imposed and professionally imposed, and government interference with the free market, have removed the economic incentives that drive productivity growth. Many physicians imposed regulations, e.g., withholding information on physicians' records of patients, are in conflict with a free market. Oxford Health Plans is attempting to circumvent the long-standing physicians' practice of withholding medical information from patients by surveying patients to determine their interpretation of the quality of care they received at hospitals and from physicians.¹²⁶ Of course, hospital administrators and physicians are quick to point out that patients are not qualified to judge the quality of the services they receive. Furthermore, in a monopoly environment, in which patients have few choices, they need not worry themselves with quality issues.

b. Piecemeal Regulations. The healthcare cost issue highlights the failure of non-systemic, piecemeal approaches that rely on political processes to address problems in complex systems. While Congress has been heavily engaged in the details of healthcare services, the "big picture" has received little attention. Every healthcare regulation that is added aggravates the root cause of all healthcare cost problems - cost escalation driven by zero or even negative productivity growth. The solution to the U.S. healthcare problem will require a combination of skills in economics, business, political science, systems modeling, and technology, particularly information technology, integrated preventive diagnostics, minimally invasive therapies, imaging technology, preventive medicine and incentives programs, and rehabilitation science and assistive technologies¹²⁷, that forces major changes in the healthcare delivery process.

The federal government has been unable to make an overall investigation of the U.S. healthcare system and propose a systems-level solution that increases competition, reduces costs, and offers incentives to improve productivity.¹²⁸ Instead, it is pursuing a piecemeal¹²⁹, incremental, microscopic approach in which Congress is even beginning to specify the number of days of hospitalization each surgical procedure requires.¹³⁰

¹²⁵ The Honorable Newt Gingrich, "50 Million American Workers Have No Retirement Coverage", An Advertising Supplement to The Washington Post National Weekly Edition, June 1, 1998, p. S1.

¹²⁶ Washington Post National Weekly Edition, "Light on Medical Care", April 14, 1997, p. 25.

¹²⁷ Samuel Varnado, Bryon Cloer, and Donald Wesenberg, The Role of Technology in Reducing Health Care Costs, Sandia National Laboratories Report, SAND 60-2469, November, 1996.

¹²⁸ James Gover, "Systems Modeling: the first step in a process for solving the health care cost problem", presented at IEEE Conference, The Role of Technology in the Cost of Health Care, April 27-29, 1994, paper included in SPIE Proceedings, pp. 388-398.

¹²⁹ Elizabeth Teisberg, Michael Porter, and Gregory Brown, Innovation, Information, and Competition: A Lasting Cure for American Health Care, Working paper of the Harvard Business School, February, 1994.

¹³⁰ Joan Beck(Chicago Tribune), "Washington Taking Over Health Care Piece by Piece", The Albuquerque Journal, October 2, 1996, p. A10.

Bills introduced in 1997 include: regulations on health care plans, provisions guaranteeing health care to the estimated 10 million uninsured children, expansion of preventive care including immunizations and routine check-ups, assurance of emergency room care for those that need it, limitations on health care intervention in doctor-patient discussions, and elimination of "drive through" mastectomies.¹³¹ One needed bill, although still piecemeal legislation, a bill to curb gag clauses that prevent doctors from informing patients about their treatment options, has been introduced by Representative Greg Ganske.¹³² As Professor Herzlinger points out,

Consumers can find out much more about the quality of a Toyota than about the physician who will perform their open-heart surgery. An industry that calls its customer a "patient" clearly fails to appreciate how many people work and how little free time they have. Most nations run health care systems that are inconvenient and arrogant. ... In 1997, Americans provoked legislators to require the vastly disliked managed-care organizations to provide information they once denied, such as whether their doctors earn more money as a reward for providing less care. ... To fulfill consumer demands for information, many providers will publish "report cards" that compare their performance to a peer group.¹³³

c. Managed Care. Over 56% of Americans now receive their healthcare through managed care. Temporary lulls in health care spending, as we are currently experiencing, stem from HMO imposed substitution of primary care physicians, statistically-based diagnostic opinions, and chemical therapeutics for medical specialists, technology-based diagnostics, and medical laboratory technology-based therapeutics. Cost savings are resulting from reduced income of medical specialists and withholding of services not increases in delivery efficiency. It is now clear; at best HMOs are no more than a partial answer to the health care cost problem. Between 1994 and 1995 because of HMOs physicians' annual net income before taxes dropped \$8,700 to \$186,600 with the reduction being due to diminished income for the highest paid specialists.¹³⁴ However, as we saw in Table II, physician's charges amount to only 20% of total healthcare costs.

While HMOs have been hailed as the solution to America's health care cost problem, reduction in specialists' income is largely being offset by hidden administrative costs including the amount of time that patients spend negotiating with their HMO and primary care physicians for referrals. Incredibly, primary care physicians are being rewarded by HMOs for withholding referrals to specialists. Americans are experiencing lower quality services than they had five years ago with HMOs magnifying rather than attenuating the inefficiencies of America's mom and pop healthcare delivery system.

The syndicated columnist, David Broder, reports that after consulting with numerous health policy gurus, he has concluded that U.S. health care costs are poised to again accelerate with annual health care costs perhaps rising to \$1.5 trillion in five years while the share of uninsured elderly increases from one in six to one in five. He notes that each year those without health

¹³¹ The Hill, "Congress to the Rescue", April 9, 1997, p. 15.

¹³² Peter H. Stone, "Ready for Round Two", National Journal, p. 15, January 3, 1998.

¹³³ Regina Herzlinger, "Shopping for Your Doctor", The World in 1998, The Economist Publications, January, 1998, p. 60.

¹³⁴ Washington Post National Weekly Edition, "Getting Into the Doctor's Pockets", September 9-15, 1996, p. 34.

insurance increases by about 1 million. Broder explains that many, if not most, of the piece-meal, partial remedies to the health care problem that have been pursued by Congress will actually increase, rather than decrease health care costs.¹³⁵

Scholars at Harvard University have partnered with the Kaiser Foundation to develop a survey of 1,000 randomly selected Americans on HMO services. This survey revealed a startling difference in response when the respondent bears responsibility for the cost of the extra service. When respondents are insulated from paying for a service, most want the service. When respondents must bear some of the responsibility for the cost of a service, the fraction wanting the services is reduced by about 50%. For example¹³⁶,

- ◆ Support for a law allowing patients to sue for malpractice dropped from 64% to 36% when respondents were asked if they would still favor the law if it would cause some employers to drop health insurance coverage.
- ◆ Support for a law requiring HMOs to provide more access to specialists dropped from 81% to 59% when respondents were asked if they would still favor the law if it caused an increase in insurance premiums. Support dropped below 50% when it was proposed that this law would mean government might get "too involved" or employers might drop health insurance.
- ◆ Support for a law allowing a woman to see a gynecologist without HMO approval dropped from 82% to 58% if it meant an increase in premiums and it fell to 48% if it caused some employers to drop health insurance.

The Economist reports,

*Survey after survey shows that most Americans fear that managed care firms care more about money than medicine. The popular view is that HMOs make their money by denying potentially life-saving surgery to sick children, and then award their manager seven-figure bonuses. ... Yet most of this opprobrium is misplaced. Managed-care firms have their faults, to be sure, but the fact remains that thanks to HMOs America's health care system works better than it used to. The advantages of managed care outweigh the drawbacks.*¹³⁷

F. New Concepts.

a. Specialty Hospitals. Hospitals are in a golden age of profitability. The combined profit margins of hospitals were 6.8% in 1996, the highest they have been in the previous 16 years. At the nation's 400 major teaching hospitals, the median profit margin was 4.5%. Columbia's Reston Hospital Center had a pretax profit margin of 31% in 1997. Much of the profit gain has derived from shutting-down services units that are non-profitable.¹³⁸

¹³⁵ David S. Broder, "Health-Care Costs Poised to Resume Daunting Increases", Albuquerque Journal, October 26, 1997, p. B2.

¹³⁶ The Washington Post National Weekly Edition, "Turning the Question", January 26, 1998, p. 35.

¹³⁷ The Economist, "Your Money or Your Life", March 7, 1998, p. 23.

¹³⁸ The Washington Post National Weekly Edition, "Hospitals Are the Picture of Health", February 19, 1998, p. 19.

Although physicians like to remind their patients of the high costs of medical school education, the public through Federal subsidies pays many of these costs to teaching hospitals.

So-called direct medical subsidies, for instance, help pay for the salaries and benefits of residents (of teaching hospitals), program administration costs, faculty supervisory costs, and hospital overhead. Medicare pays out \$2.4 billion per year for these subsidies. Medicare shells out another \$5.2 billion per year in "indirect" medical education subsidies, which help teaching hospitals defray the costs of training residents and providing specialized services to severely ill patients. UCSF and Stanford last year received \$100 million in subsidies from Medicare because of their status as teaching hospitals. ... The government also gives hospitals that care for the non-paying poor a total of \$5.2 billion a year in so-called disproportionate-share payments. Major teaching hospitals account for only 6 percent of nonfederal hospitals in the country, ... yet they supply half of the uncompensated care.¹³⁹

Because of these subsidies, teaching hospitals are insulated from market pressures that drive them to search for ways to improve their efficiency and effectiveness. Professor Regina Herzlinger¹⁴⁰, Harvard Business School, has concluded that U.S. hospitals have much to learn from the management practices of McDonalds. This progressive company has concentrated on speed, consistent product and service, and value for money spent. To do this it has standardized food products and preparation processes. Professor Herzlinger points out that, like McDonalds, hospitals that have been the most successful have limited the range of services they provide to customers and they have excelled at those specific services they have chosen as their specialty. By specializing, these hospitals have much higher success rates and their costs are often between one-half to two-thirds of the rate at typical general-purpose hospitals that are not expert in any particular area of healthcare. Treatment of chronic diseases such as cancer, diabetes, heart disease, and emphysema accounts for 75% of U.S. health care costs. All of these are amenable to standardized treatment by specialist hospitals.

In no country are hospitals even close to such standards of efficiency (as those of fast food companies). This (hospital) is an industry that rarely bothers to measure its own performance, learn from others, or put patients' interests above those of doctors. As the recent troubles of Columbia/HCA suggest, groups that have tried to apply business practices to medicine are not always widely admired. Americans rank hospital services lower value for money than anything else they buy, including legal advice. It is odd, as Peter Drucker has noted that it has taken management theory so long to sink its teeth into an industry that accounts for between 7% and 15% of GDP in most developed countries.¹⁴¹

Rochester General Hospital cardiac care team serves as an example of how a hospital can reduce inefficiencies and improve patient care. In winning the 1998 RIT/USA TODAY Quality Cup award¹⁴² for healthcare this team has reduced:

¹³⁹ National Journal, "Intensive Care", April 11, 1998, p. 803.

¹⁴⁰ Regina Herzlinger, Market Driven Health Care: Who Wins, Who Loses in the Transformation of America's Largest Service Industry, Addison-Wesley, 1997.

¹⁴¹ The Economist, "Hamburgers and Hernias", August 9, 1997, p. 55.

¹⁴² USA TODAY, "Streamlined Surgery Is Win-Win Situation", May 1, 1998, p. 5B.

- ◆ patient time in the operating room from a range of three to five hours to a range of two to three hours,
- ◆ patient time in the hospital from 7 days to 4 days,
- ◆ patient charges for coronary artery bypass surgery by 6.5%,
- ◆ patient readmission rate from 18% to 9%,
- ◆ patient costs for blood from \$481 to \$347,
- ◆ mortality rate from 2.2% to 0.68%, and
- ◆ number of surgeons required to perform 1500 bypass surgeries per year from 10 to 5.

b. Competition and Technology. Productivity growth can only be driven by increased competition among service providers that leads to replacement of many of those working in the health care field with low-cost technology.¹⁴³ Some have sought to blame technology for the growth in health care costs. As Teisberg¹⁴⁴ has pointed out to Congress, medical technologies remain costly even when widely diffused because **reimbursement to service providers for the use of technology has been based on customary charges that are largely unrelated to the cost of the technology.** Furthermore, recent studies have shown that the database is so poor on treatment outcomes, health care providers are clueless on the cost effectiveness of alternative treatments and technologies.

*The new economics of medicine has put the heat on providers to find the most cost-effective forms of care. But the research that doctors and managed-care companies use to weigh which treatments work best and cost least suffers from something approaching financial illiteracy.*¹⁴⁵

In today's healthcare system, technology may reduce the cost of providing the healthcare service, but may not reduce the charges that are passed on to the recipient of the services. Furthermore, the demand for certain health care services can increase when there is a major decrease in the cost of this service to the consumer. In highly competitive systems, technology innovation increases productivity, increases quality and reduces both costs and charges. In weakly competitive systems such as healthcare and education, technology innovation often reduces productivity, increases quality, decreases costs and increases charges. The path to productivity growth is first competition, then technology innovation. The latter occurs only because it is a necessity for surviving market competition. Productivity growth and quality of service are the result.

¹⁴³ Joseph Bronzino and James Gover, "Medical Technology: A Solution to the Health Care Cost Problem", IEEE Engineering in Medicine and Science Magazine, June 1994.

¹⁴⁴ Elizabeth Olmstead Teisberg, "INNOVATION: The Key to Reducing Costs of High Quality Health Care", testimony for the U.S. House of Representatives Committee on Science, Space, and Technology Subcommittee on Technology, Environment, and Aviation, March 17, 1994.

¹⁴⁵ Business Week, "Fuzzy Figures on Health Costs", January 26, 1998, p. 22.

Information technology has the potential to revolutionize medicine by reducing the actual costs while increasing the quality of services.

Only 5% of American doctors use electronic medical records. ... A typical visit (to a physician's office) costs about \$90 in America. This can be cut to \$15-\$25 if the check-up is done remotely using equipment that costs about \$1,000. Since televisits cost less, they can be made more often, cutting hospitalization rates by a third and the length of an average hospital stay by a day. ... Virtual home visits by community nurses in Wales were only a fifth as expensive as conventional ones, and most patients were more satisfied because they were visited more often. ... A survey ... found that less than one visit in 2,000 is made electronically. ... McKinsey, a consultancy, estimated that America's health-care bill could be cut by \$270 billion a year - 25% of total expenditure - if medical organizations made an annual investment of \$50 billion in information systems.¹⁴⁶

After visiting their physician's office, patients are often required to either travel to a hospital and have x-rays made and read at the hospital or have them made at a clinic that is part of their physician's work complex. In the latter case either a radiologist must travel to the clinic to read the x-rays or they must be hand-transported to a radiologist for reading. Research in Norway found that radiologists saved between 5 and 6 hours per week when the radiograms were sent to them electronically.¹⁴⁷

In 1997 the U.S. health care industry spent \$15 billion on information technology (IT). By 2001 it is predicted that the annual IT investment will double to \$30 billion. Kaiser-Permanente, the largest HMO, plans to invest over the next 5 years, \$1 billion in a national clinical-information system that links its 10,000 doctors that are spread out over 19 states. This system will keep medical records for the nine million members of Kaiser-Permanente.¹⁴⁸

c. Automated Testing. Coates, Mahaffie, and Hines project that by the year 2025,

The health care debate of the late 1990s gave unexpected impetus to the automated medical center. Based on the work of Project Caduceus, there was the now-popular proliferation of shopping mall and work-site health centers. These are expert systems tied to physical equipment. Typically, the way the earliest versions worked, a person walked into the center, was greeted electronically, asked to urinate into a bottle, spit into a test tube, puncture the skin to get a blood droplet for the slide, and place each of the containers into the appropriate receptacles. While the samples were being processed, the person sat at the Caduceus and engaged in a medical dialogue. Effectively Caduceus did everything that a physician at that time did on the first two visits, including presenting alternative diagnoses, the need for further tests, and the subsequent diagnosis on the completion of the tests.¹⁴⁹

¹⁴⁶ The Economist, "IT and Health Care", February 28, 1998, p.p. 66-67.

¹⁴⁷ The Economist, "IT and Health Care", February 28, 1998, p. 66.

¹⁴⁸ Fortune, "Can Computers Cure Health Care?", March 30, 1998, p. 112.

¹⁴⁹ Joseph F. Coates, John B. Mahaffie, and Andy Hines, 2025: Scenarios of U.S. and Global Security Reshaped by Science and Technology, Oakhill Press, 1997, p. 54.

d. Patient Self-Help. While the politicians, regulators, physicians, and healthcare administrators fiddle, patients themselves have begun a minor revolution in healthcare services by establishing self-help communities over the Internet. Most of these on-line networks are devoted to a single health-related topic. They provide medical information, coping tips and emotional support, and in some cases, second opinions.¹⁵⁰ Professor Herzlinger expects this revolution to continue.

As this revolution takes hold the government will primarily fulfill a regulatory role. As in other markets, it will ensure the integrity of the providers, insurers and consumers, and protect against restraint of trade. It will also police the validity of the information that fuels market transactions, just as the Securities and Exchange Commission helps to insure the validity of the financial data that are key to the efficiency of the capital markets. The cost-containment that accompanies this new system may at last persuade the American public to broaden the safety net for those who cannot afford to buy adequate health cover - a revolution indeed.¹⁵¹

e. Employer Partnerships. Some areas, e.g., Minneapolis - St. Paul, are rebelling against HMOs. In Minnesota's twin cities, 26 of the areas major employers have bypassed HMOs and contracted directly with medical facilities to provide health care for their employees. Employers have banded together to contract directly with doctors, and inject marketplace economics into the health care industry.¹⁵²

f. New Agency. Politicians are having great difficulty addressing what should be done with this massive \$1 trillion dollar enterprise. One false step and a budding political career can instantly be "washed-up". Most political analysts agree that President Clinton's attempt to guarantee healthcare for every American played a major role in the Republican takeover of Congress in 1994. A "politically safe" option is to address a microscopic piece of healthcare and make constituents think that something significant has been done. An option that is being considered is to create an independent healthcare regulatory agency, modeled after the Securities and Exchange Commission, and dump the healthcare regulatory issue squarely in its lap. This body would oversee healthcare quality.¹⁵³

G. The Role of R&D

One may think of the U.S. healthcare system, illustrated in Figure 2, as a complex system in which charges and technology are the primary inputs and the health of the population is the primary output.

An ideal health care system would simultaneously maximize the health output and minimize the charges input in such a way as to maximize the ratio of health to charges. In Figure 2 we consider three different configurations of the U.S. healthcare system. We claim that today's system is moderately regulated and operates for a variety of reasons, principally regulatory reasons, as an oligopoly with minimum competition among healthcare providers. Most

¹⁵⁰ Tom Ferguson, "Health Care in Cyberspace: Patients Lead a Revolution", The Futurist, November-December, 1997, p. 29.

¹⁵¹ Regina Herzlinger, "Shopping for Your Doctor", The World in 1998, The Economist Publications, January, 1998, p. 61.

¹⁵² Fortune, "Taking on the HMOs", February 16, 1998, p.p. 96-104.

¹⁵³ Marilyn Werber Serafini, "Micromanaged Care?", National Journal, December 13, 1997, p. 2506.

researchers claim that technology innovation has driven up healthcare costs in today's system with little perceptible gain in health output, so we show the productivity of the system as a decreasing function of technology. Today's system may well have lower productivity than the two extreme alternative systems we consider in the following.

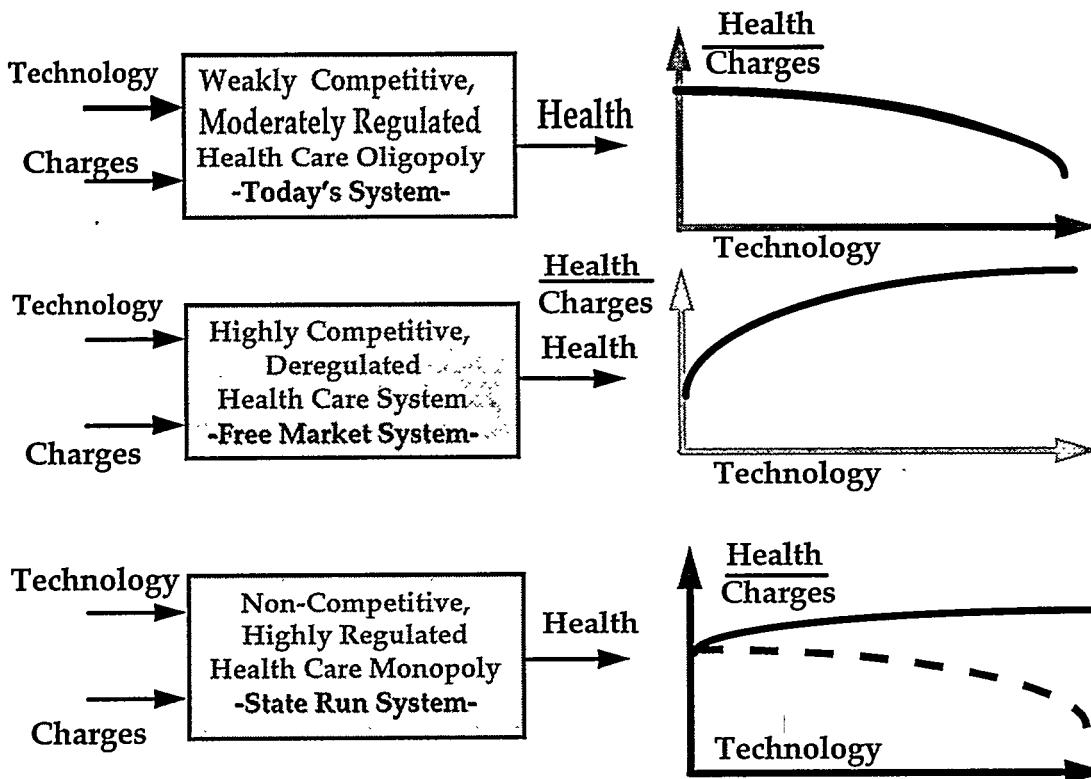


Figure 2: Dependency of healthcare system productivity (ratio of health output to charges input) as a function of technology input for three configurations of the U.S. healthcare system.

In the second system, we illustrate a system entirely driven by the free market. In this system service providers are engaged in intensive competition for patients. There is great pressure for service providers to find innovative ways to reduce healthcare costs because their survival is at stake. Regulations that inhibit competition are discarded. Employers will no longer provide health insurance and health insurance will only cover medical catastrophes. Nurses provide over 80% of patients' healthcare needs and nurse practitioners and physicians services are used only when needed. In this system services providers will find innovative ways to use technology to reduce the costs of services so we show productivity growth increasing as the technology input is increased. The role of the public in this system is to protect the public against anti-trust practices and to provide information to the public so that it can make informed decisions. Although healthcare costs would drop in this system, there will still be those in the lowest income groups that would not be able to afford medical services.

The third system, a state-run system, represents the opposite extreme. In this system the public provides the funds for all healthcare services through tax revenues. Like The Netherlands, the Federal government determines what fraction of the GDP is to be spent on healthcare and it determines exactly how much it is willing to pay service providers to provide for a service. Technology can lead to significant improvements in the productivity of the

healthcare system when regulators require that cost reductions resulting from technology innovation be passed on to the public. In this system there will be no incentives for services providers to innovate so the public would of necessity absorb all research costs and the public would absorb all the costs of educating healthcare providers.

While these extreme systems are interesting to think about, the U.S. should initiate a major research program to investigate healthcare system alternatives. Because of the magnitude, complexity, and importance of the healthcare cost problem, it is economically rational to initiate a \$1 billion per year publicly funded research program that would be tasked to arrive at an entirely new design for a healthcare delivery system.

The major components of this program would include:

- ◆ Develop systems models ranging between the extremes described here that includes breaking down healthcare systems into subsystems that allow comparison of the cost and effectiveness of alternative models. Alternatives to the U.S. model would be synthesized from these systems models.
- ◆ Compare the U.S. healthcare delivery models at the subsystems level and their costs and outcomes to those in other countries.
- ◆ Identify necessary regulatory options.
- ◆ Identification of technologies that could lead to substantial reduction in healthcare costs and propose a partnership of private and public funders to develop these technologies.

3. The Education Problem:

A. Introduction.

In 1995 the United States spent \$668 million or 9.2% of GDP on pre kindergarten through post secondary educational services and content. Of this total, \$318 billion was spent on K-12, \$189 billion was spent on post secondary, \$60 billion¹⁵⁴ was spent on workforce training, \$45 billion was spent on the consumer market for education products, \$30 billion was spent on pre K, \$10 billion was spent on training programs, and \$10 billion was spent on child reform. In 1992 U.S. public education expenditure per child was \$11,880 and was only slightly exceeded by that of Switzerland, was almost identical to that of Japan, was approximately two times that of France, Austria, Belgium, and Denmark, and was approximately 50% higher than that spent by Sweden, Norway, and Ireland.¹⁵⁵ We have nearly 60 million (almost 25% of our population) full- and part-time students enrolled in courses throughout the U.S. Education employs 55% of local government workers and 45% of state workers.¹⁵⁶ Despite our massive National investment in education, several concerns surround our education system. These concerns have three primary components: (a) the quality of K-12 math and science education is inadequate, (b)

¹⁵⁴ Most reports of U.S. companies annual investment in training quote figures in the \$50 billion to \$60 billion range for formal training. Informal training costs, those training efforts not reported by companies, are estimated to range between \$180 billion and \$200 billion per year. See, for example, Information Technology Association of America, Help Wanted: The IT Workforce Gap at the Dawn of a New Century, February, 1997, p.35.

¹⁵⁵Lehman Brothers, Second Annual Education Industry Conference, February 11, 1997, New York, NY.

¹⁵⁶ *Ibid.*

college costs are excessive, and (c) the U.S. has failed to design an education system that promotes and offers education from cradle to grave.

B. K-12 Math and Science.

In 1996 international exams¹⁵⁷, U.S. students performed at almost exactly the international averages in both mathematics and science but were behind the scores of students from Japan, South Korea, Singapore, the Czech Republic and Hungary and roughly the same as students from England and Germany.¹⁵⁸ Comparisons of K-12 scores around the world demonstrate that countries with one-half the per student investment of the U.S. are matching or exceeding the examination performance of U.S. students. Although U.S. fourth-graders were second only to South Korea in science, by the eighth grade their scores were only slightly above average. Singapore, the leader in both math and science scores by a considerable margin, expects children to be able to read and write in two languages and do simple arithmetic prior to entering the first year of formal schooling. In addition, parents invest in private tutoring outside of the formal classroom to ensure the success of their children in the classroom.¹⁵⁹ From a very early age Japanese children are taught that learning is an enjoyable part of life and that the motivation for learning is resident in the student, not the teacher.¹⁶⁰ Our considerable investment in education is not producing the performances many Americans expect particularly companies that are seeking manufacturing employees.

There are three schools of thought regarding the K-12 math and science education issue. One group argues that the root cause of poor math and science scores is poor reading skills. Some argue that these stem from replacing phonics with word recognition as the fundamental way of teaching reading in the early grades.¹⁶¹ Others argue that teachers know how to teach reading, but development of reading skills is hampered by non-literary environments, reduced conversation and reduced auditory-only input during the early ages of children.¹⁶² A second group argues that the issue is strictly an inner city issue whose root cause is socioeconomic and regardless of the effort invested in education, poor math and science scores are only the symptom of a much more severe social problem. A third group argues that the K-12 problem is not just limited to inner city schools, it is also widespread in suburban and rural schools. This group believes that poor math and science scores are not necessarily a consequence of poor reading skills, rather they argue that poor teaching skills, illogical and ill sequenced curriculum, and poor textbooks are the likely culprits. All three groups have important points to make. (Polls show that 62% of Americans believe that our educational system will get worse instead of better.¹⁶³)

Given the fact that high school science is taught in such an illogical sequence, it is remarkable that any students suffer through the agony. As Aldermen points out, students first study

¹⁵⁷Third International Maths and Science Study, TIMSS.

¹⁵⁸For a comparative tabulation of TIMSS math and science scores by nation, see, for example, The Economist, "Who's top", March 29, 1997, p. 21.

¹⁵⁹ Alan Lim, Letters to the Editor, The Economist, April 19-25, 1997, p. 8.

¹⁶⁰ Gail Benjamin, Japanese Lessons: A Year in a Japanese School Through the Eyes of an American Anthropologist and Her Children, New York University Press, 1997.

¹⁶¹ Personal communication, Mr. Charley Richardson, IEEE senior member.

¹⁶² Personal Communication, Mrs. Carol Thompson, Educator, Flushing, Michigan.

¹⁶³ The Washington Post National Weekly Edition, "What About Us?", September 23-29, 1996, p. 9.

biology, then chemistry, then physics, leaving biology to be learned by memorization and without logic.

*biology, without a chemistry prerequisite, can only be descriptive - heavy on memorization and dense classification schemes to which are patched, often incomprehensibly, some of the many molecular aspects of modern biology. ... Survivors go on to chemistry. But since they have not yet studied physics, they have little idea of the fundamental forces that govern atomic and molecular interactions in chemistry. About 20 percent of U.S. high-school students then proceed to physics, study that all too often fails to convey to students a solid understanding of concepts, hidden as they are behind the math.*¹⁶⁴

Marshall explains that schools are not structured to take advantage of the way we learn.

It is my belief that the espoused crisis in public education is predominantly a crisis about learning and that it is fundamentally grounded in the dynamic integration of two new domains of inquiry:

- 1. The paradigm shift from a machine-based “clockwork” conception of the universe to a complex adaptive perspective.*
- 2. The paradigm shift from understanding the brain as a computer to be programmed and learning as a linear process of information accumulation to understanding the brain as a dynamic, self-organizing neural network and learning as a natural, active, and messy process of pattern formulation and constructed meaning. ...*

*The insights of complex adaptive system theory and learning theory have fundamentally altered these (schooling and learning) metaphors and have radically reframed the discourse on learning and schooling; in place of machine-based metaphors are fluid, organic, and biological metaphors that place schooling structures in dynamic opposition to our new knowledge.*¹⁶⁵

Throwing money at the K-12 education problem has not proven to be an effective strategy. Fifteen elementary schools in Austin, Texas, that principally served black and Hispanic children from low-income families were the site of an interesting experiment. At thirteen of the schools the class size was reduced without any change in curriculum, at the other two schools the class size was reduced by the same amount, but the curriculum and teaching style was also overhauled.

After four years, attendance rates and test scores had skyrocketed at the two schools that overhauled their curriculum and teaching style to stress high expectations for the students and techniques such as small-group learning to

¹⁶⁴ Leon M. Lederman, “Getting High School Science in Order”, Technology Review, April, 1996, p. 62.

¹⁶⁵ Stephanie Pace Marshall, “Creating Sustainable Learning Communities for the Twenty-First Century”, in The Organization of the Future, edited by Frances Hesselbein, Marshall Goldsmith, and Richard Beckhard, The Drucker Foundation, 1997, pp. 177-188.

*encourage greater classroom participation. At the other 13 schools, absenteeism remained high and achievement low, despite the smaller class sizes.*¹⁶⁶

C. College Costs.

Although an informal survey of Harvard graduates revealed that less than 10% could explain the phases of the moon¹⁶⁷, at the college level the quality of education is generally of less concern than it's cost. Lack of productivity growth, in combination with stagnation or reduction in income has resulted in education costs that an increasing fraction of America's population can no longer afford. Just as the shifting of wealth has made a college education a near necessity for personal income growth, the cost of college has made college less accessible to those in the low and middle-income groups. The June 1997, graduating undergraduate class of 1.2 million spent, on average, \$150,000 of private and public (government) funds for their education.¹⁶⁸ Of course, funds provided to public colleges and universities by taxpayers create the illusion that public schools cost less than private schools. Most analyses indicate that private schools actually cost less when the tax bite is included in the calculus and most of the "great universities" are private schools.

The average debt for those graduating from college is \$11,000 with some carrying debts of \$30,000 to \$40,000.¹⁶⁹ During the 1980s health care prices grew 117%; the price of attending public and private colleges increased 109% and 146% respectively.¹⁷⁰ In 1996 the price of tuition at state-assisted colleges and universities averaged 8.9% of annual family income in comparison to 4.5% in 1980. Of course, these figures do not include the subsidy paid through state taxes, the federal subsidies, funds drawn from endowments, and the many contributions made to universities by alumni and others. In 14 states the cost of tuition at a state-assisted college exceeds 10% of annual family income in that state. A Washington Post poll showed that 58% of Americans believe that a good college education is becoming too expensive.¹⁷¹

Bowen proposes that there are 5 laws of higher education costs.

- ♦ The dominant goals of institutions are educational excellence, prestige, and influence.
- ♦ In quest of excellence, prestige, and influence, there is virtually no limit to the amount of money an institution could spend for seemingly fruitful educational ends.
- ♦ Each institution raises all the money it can.
- ♦ Each institution spends all it raises.

¹⁶⁶ Rochelle Stanfield, "Making Money Matter", National Journal, May 23, 1998, p. 1176.

¹⁶⁷ Parade Magazine, "Have Our Schools Heard the Wake-Up Call?", January 19, 1997.

¹⁶⁸ USA Today, "College Costs Too Much, Fails Kids", July 17, 1997, p.15A.

¹⁶⁹ The Washington Post National Weekly Edition, "You've Made the Grades, Now It's Payback Time", July 8-14, 1996, p. 20.

¹⁷⁰ George Will, "Education Today: Pay More, Learn Less", The Washington Post, March 24, 1996.

¹⁷¹ The Washington Post National Weekly Edition, "What About Us?", September 23-29, 1996, p. 9.

- ◆ The cumulative effect of the proceeding four laws is toward ever-increasing expenditures.¹⁷²

In June of 1997 Congress created an 11 member National Commission on the Cost of Higher Education, composed primarily of college educators, and tasked it to design strategies to limit increases in tuition and other college costs. This group has not yet brought any new recommendations to Congress on how costs might be controlled; instead, it angered several members of Congress by defending cost growth.¹⁷³ We site this failure, not to criticize the Commission, rather, we wish to illustrate that part-time commissions are not the best way to conduct complex, multi-dimensional systems studies. Congress can be guaranteed that the traditional political process of polling experts and synthesizing their opinions into a set of recommended policies will not solve the college cost problem.

Marshall offers a model of education that suggests the old model of education, the Newtonian model, has outlived its utility and must be replaced with new educational models that recognize learning as a property of a complex, adaptive system.

*By design, we constructed and operated our Newtonian schools as we understood our world, and this produced iatrogenic and learning-disabled institutions that have suppressed reflective thought, creativity, and the innate and inexhaustible human capacity for lifelong growth. ... We must transform the mechanistic paradigm of schooling into an integrated, holistic, and systemic vision of a sustainable learning community.*¹⁷⁴

We note the recent interest shown by investors in the business opportunities presented by the \$668 billion annual market for education. Such interest is bound to result in private competition for all sectors of education and especially for those opportunities being ignored by colleges and universities (such as continuing education). The competition from outside the traditional education community is likely to self-correct accelerating costs and might well initiate intercollegiate competition for students based on costs.

The news media are reporting with increasing frequency that universities have been sacrificing both the cost and quality of undergraduate education to support research. Other reports suggest that those concerned about the cost and quality of college and university education is growing. In the following we offer a sample of quotes given in the news.

¹⁷² Howard R. Bowen, "What Determines the Costs of Higher Education?", in Finance in Higher Education, edited by David Breneman, Larry Leslie, and Richard Anderson, ASHE Reader Series, 1996, p. 123.

¹⁷³ Congressional Quarterly, "Commission on College Costs Back to the Drawing Board", December 20, 1997, p. 3129.

¹⁷⁴ Stephanie Pace Marshall, "Creating Sustainable Learning Communities for the Twenty-First Century", in The Organization of the Future, edited by Frances Hesselbein, Marshall Goldsmith, and Richard Beckhard, The Drucker Foundation, 1997, pp. 177-188.

Media Criticism of Education

*Much academic research is dross, churned out merely to advance an academic's career. Worse, the publish or perish syndrome which dominates academia has devalued the original purpose of higher education—that is, education itself. At too many institutions, including many of the most famous, teaching is an after-thought and done poorly. The pursuit of research has gone too far. It is time to tilt the balance back towards education.*¹⁷⁵

*In most cases, schooling does not develop originality, delight in ambiguity, or self-expression. Rather, the thinking skill that's rewarded is figuring out the "right answer" — that is the answer held by the person in authority, the teacher. This pattern holds through university and postgraduate education, especially in a class where the professor wrote the text. ... Our way of testing and grading reinforces a pernicious pattern of short-term, superficial thinking. ... The fear-based, authority-pleasing, rule-following approach to education may have served to provide society with assembly-line workers and bureaucrats, but it does not do much to prepare people for the world as it is today.*¹⁷⁶

*You're smart people and so you figured out many years ago that most of your courses were entirely irrelevant information. ... What you learned wasn't how-to-learn, but to recite, to get by, to work the system. School is to learning what "Cliff's Notes" is to literature. You learned to lip-sync knowledge. ... A university was once thought of as a place for freethinkers. Not now. The thinking is never free; it is both expensive and shackled. In the absence of freethinking, college has become vo-tech for bureaucrats. A diploma proves that you are already a card-carrying bureaucrat, that you are willing to do what you are told for years at a time.*¹⁷⁷

*Reform in higher education has been hampered by a near absence of strategic management, as well as by institutional traditions such as tenure that actually act as disincentives to productivity. And so the process of meaningful reform in the ivory tower grinds along at a snail's pace. Higher education will pay a price for resisting society's demands. Highly selective colleges and research universities probably can afford to ignore society's reform call. But most enrollment-dependent institutions face major revenue shortfalls and increased competition from proprietary institutions. ... The only realistic answer is growth in learning and teaching productivity, which will bring down costs and produce better-prepared students. ... The time is right to challenge the worn-out and ineffectual paradigms of the ivory tower and to embrace the sometimes painful but essential process of reform.*¹⁷⁸

D. Continuing Education.

The ability of the U.S. to continue to attract high-value-added industries from around the world depends upon having a high quality workforce, especially a high quality engineering and engineering management workforce. Except for some progressive private engineering schools,

¹⁷⁵ The Economist, "Teaching Spires", August 24, 1996, p. 14.

¹⁷⁶ Michael J. Gelb, Thinking for a Change, Harmony Books, 1995, p. 8.

¹⁷⁷ Dale Dauten in graduation speech, "Conformity Class Is Over", Albuquerque Journal, May 7, 1997, p. D8.

¹⁷⁸ USA Today, "College Costs Too Much, Fails Kids", July 17, 1997, p.15A.

e.g., Kettering University (formerly The General Motors Institute) employs a cooperative engineering education model which interweaves education and work, the U.S. education system is designed to accommodate a linear model of learning. During early years one studies then eventually receives a diploma or degree which certifies the state of learning reached. This simplistic, linear model of learning is incompatible with the realities of globalization, yet most public universities continue to resist change. (Publicly funded oligopolies and monopolies can do this and still survive.)

The ability of the educational institution to provide this learning experience has itself been certified by an accreditation board. After "getting the degree", the graduate then marches off to the learning application phase. In many fields, engineering in particular, learning must be viewed to be a cradle-to-grave experience and must be thoroughly integrated with work throughout the work experience. However, educational institutions are organized to provide courses according to this linear model with the delivery schedule drawn out over a several month period. Consequently, continuing education does not serve the needs of the U.S. workforce. The National Academy of Science observed,

The United States has one of the most diversified, but poorly coordinated training enterprises in the world. ... Work-related training and continuing education are provided by a broad spectrum of private and public institutions. ... Across this vast and diverse training enterprise, there are few common standards, the quality of training is uneven, and important subsets of the nation's current and potential workforce are poorly served, particularly with regard to job-related training and continuing education within industry.¹⁷⁹

Because of the short half-life of engineers' education, continuing education for engineers has been particularly difficult to accommodate. The Competitiveness Policy Council pointed out that the mobility of engineers means that their professional education has become a **public good** which individual companies are increasingly unwilling to finance.¹⁸⁰

Many states, however, have recognized the need to continuously re-certify professional engineers and have recently begun to require annual continuing education units for the maintenance of their certification. To date 3 of the 50 states have passed these regulations. Companies will likely respond by outsourcing the continuing education of their engineers to private or public organizations. An entrepreneurial group of educators has sensed growing opportunity for new sources of income.

E. Future of Education.

Universities have not yet taken full advantage of the productivity gains promised by information technology.

Governments need to raise the standards of education and skills to let their economies take full advantage of IT (information technology) and the expansion of knowledge

¹⁷⁹ National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and the National Research Council, Preparing for the 21st Century: Technology and the Nation's Future.

¹⁸⁰ Robert M. White, US Technology Policy: The Federal Government's Role, September, 1995, A paper commissioned by the Competitiveness Policy Council, p. 15.

*industries. Education is one of the few sectors which has so far remained largely outside the technological revolution.*¹⁸¹

While computers and the Internet offer many opportunities for distance learning, Blinder and Quandt suggest that they have not improved learning in the traditional classroom environment.

*Since students started to submit term papers written with word processors, the appearance of the papers has greatly improved. Lines of text are justified, spell-checkers catch most spelling errors, footnotes fit neatly on the page, and so on. But the thinking has not improved, and the quality of the research has sometimes deteriorated.*¹⁸²

We must learn how to use technology to improve college and university education while reducing its price to the consumer. As with health care, government has been unable to address the root cause of the college cost problem. For example, it has been noted that tax breaks for families paying college tuition is bad tax policy and worse education policy and it fails to address the fundamental problem, stationary or even reduced productivity.¹⁸³ Further federal subsidies (either research grants or tuition subsidies) are likely to increase the demand for college and, therefore, increase the cost.¹⁸⁴ We can expect states to increasingly look for piecemeal, non-systemic, silver-bullet solutions (tenure modification, more federal R&D funds, increased student loans, increased solicitation of contributions from alumni, tax credits for education, etc.) to the education cost escalation problem. These efforts are not systemic and only delay addressing the issue as a system.

We are living in wrenching times with one foot in the past characterized by hierarchies and bureaucracies, and one in the future characterized by teaming and collaboration. Because we're in an evolutionary period of change, old types of organizations, e.g., educational institutions, are not disappearing, but instead becoming smaller parts of an adapting organizational structure. The new organization consists of small internal units that have buying customers. Hewlett Packard, for example, consists of numerous small independent business units each performing a niche function. The HP structure showcases the advantages of self governing teams (small, entrepreneurial, adaptive), in contrast to the weaknesses of hierarchies exemplified by the current university system where decision-making is often paralyzed. Higher education is on the edge of a revolution as distance learning begins to take off. The inefficient bureaucracies at some of the more forward looking universities are slowly being replaced by self generating departments that allocate resources in proportion to value gained, i.e., the inefficiencies of having a \$100K professor teach 5 or fewer students can no longer be tolerated.¹⁸⁵ Congressman George Brown recently offered the following observation to the science and technology community,

¹⁸¹ The Economist, "A Survey of the World Economy", September 28, 1996, p. 45.

¹⁸² Alan S. Blinder and Richard E. Quandt, "The Computer and the Economy", The Atlantic Monthly, December, 1997, p.31.

¹⁸³ Lawrence E. Gladieux and Robert D. Reischauer, "Higher Tuition, More Grade Inflation", Washington Post National Weekly Edition, September 9-15, 1996, p. 26.

¹⁸⁴ Virginia I. Postrel, "Clinton's Education Inflation", The Washington Post National Weekly Edition, April 7, 1997, p. 21.

¹⁸⁵ Robert Floran, Sandia National Laboratories, personal communication to James Gover, summary of observations made at World Futures Society Meeting, July, 1997.

*We are on the cusp of a number of changes in the way that we conduct our research and education activities. As exciting and challenging as it is to be in the midst of all of this change, however, our research and academic enterprise is anticipating little of it, provides little leadership in setting goals for change, and thus may even project a public attitude of being resistant to it. We shy away from the difficult work of developing qualitative measures for our efforts.... An individual researcher is measured by numbers of publications or citations, research dollars obtained, or numbers of graduate students. Universities are similarly ranked by quantity.... All of this leaves us with a clumsy and unsophisticated set of tools for evaluating the best of human innovation and thinking.*¹⁸⁶

Lifelong education systems for home use are needed.

Coates, Mahaffie, and Hines predict the following for education in the year 2025,

Educational tools and apparatus are everywhere. Although nearly all children (96.3%) go to a public institution for schooling, the experience is hardly like what was provided in the schools of the 20th century. The in-classroom learning time has shrunk greatly, and the schools are directed at physical, social/interpersonal, and artistic development. The educational components of traditional reading, writing, and arithmetic are split 60/40 between school and home. For high school students, the shift has been even more striking to a 40/60 split. High school is primarily for interpersonal development, hands-on activities, and group activities such as teams, theater, and song.

The typical student now enters college with one year of advanced placement, and it is not unusual for extremely bright students to earn two-and-a-half years of advanced placement. The college is primarily a social acculturation institution for youth and young adults. It has also become a site for continuing education by people of all ages.

*The sea change in education in the United States has been the shift from primary, secondary, and tertiary (college) education to quaternary education, that is, lifelong, individualized education. The sites of quaternary education are 50% at home, 15% at work, and 35% elsewhere.*¹⁸⁷

The vacuum in leadership that exists within the current university structure and universities resistance to change has greatly accelerated a trend in recent years toward company owned universities; there are now over 1,000 of these in the US with two-thirds being accredited. These, along with distance learning centers represent new competitors for the traditional university. The continued rapid growth of this educational model attests to the failure of the current education system to provide the private sector with graduates who can function and add value in the corporate world. We can see these trends occurring all over the United States,

¹⁸⁶ Congressman George E. Brown, Jr., Past and Prologue: Why I am Optimistic About the Future, a speech given on April 29, 1998. Mr. Brown was the William D. Carey lecturer at the 1998 AAAS Colloquium on Science and Technology Policy.

¹⁸⁷Joseph F. Coates, John B. Mahaffie, and Andy Hines, 2025: Scenarios of U.S. and Global Security Reshaped by Science and Technology, Oakhill Press, 1997, p. 54-55.

where the traditional large, bureaucratic, generally publicly-owned and operated university continues to be plagued by declining enrollment, while the smaller, agile and more responsive technical vocational institute struggles to keep up with growth, as it attempts to serve the rapidly growing needs of local employers.

Outside of the U.S. the emerging model of education is the megauniversity. These institutions rely on remote teaching methods to reach hundreds of thousands of students. Around the world eleven megauniversities annually teach up to 500,000 students each (Anadolu University in Turkey has 578,000 students and China TV University has 530,000 students.) while maintaining per student education costs ranging between 5 percent and 50 percent of the costs of universities that employ traditional methods.¹⁸⁸ Many universities are reluctant to join the Internet revolution in teaching. Last year faculty at Toronto's York University went on strike in order to keep their extension courses off the Internet. Recently, nearly 900 professors at the University of Washington have signed a letter written to Governor Gary Locke complaining about education services offered over the Internet. In their letter they pointed out,

While costly fantasies of this kind present a mouthwatering bonanza to software manufacturers and other corporate sponsors, what they bode for education is nothing short of disaster. Education is not reducible to the downloading of information.¹⁸⁹

In looking to the future it is clear that education systems must emphasize lifelong learning and they must permit the learner to gain access to knowledge in a wide variety of environments including the home environment and the work environment. Rather than argue for an exclusively on-campus education program or an all-Internet education program, we propose that future education systems are likely to include elements of each.

F. Government's Response to the K-12 Education Problem.

The Washington Post has summarized both the administration's plans for addressing the K-12 education problem and the plan of the Congressional majority¹⁹⁰. Neither exhibit great imagination, neither is based on authoritative research, both reflect many tacit assumptions about the "root cause" of K-12 education problems, neither is systemic, and both are piecemeal responses designed to win the approval of special interests. Government's response to the education problem is not a reflection on the capabilities of policymakers; rather it illustrates the shortcomings of political processes.

The President's plan emphasizes brick and mortar and has the following features:

- ◆ Spend \$22 billion over the next two years repairing and modernizing schools. These funds would come from federally authorized bonds issued by the states.
- ◆ Spend \$12 billion over the next seven years to hire 100,000 new teachers and reduce class size in elementary school classes to 18 students per teacher. Funds would come from the tobacco settlement.

¹⁸⁸ Science, "Schools Ponder New Global Landscape", July 18, 1997, p. 311.

¹⁸⁹ Todd Woody, "Academics Rebel Against an Online Future", Industry Standard, an IDG.net Site, June 12, 1998.

¹⁹⁰ The Washington Post Weekly Edition, "Dueling School Plans", March 23, 1998, p. 31.

- ◆ Offer \$1.5 billion in grants over the next five years to urban school districts that adopt tougher classroom standards.
- ◆ Designate \$200 million to create or expand after-school programs.
- ◆ Increase funding for classroom technology by \$3.2 billion.

The plan of the congressional majority is as follows:

- ◆ Convert \$10 billion in targeted Federal education spending into block grants for states to use for classroom instruction.
- ◆ Allow parents to have \$2,000 per year tax-free savings accounts for their children's education.
- ◆ Spend \$75 million to start school voucher projects in about two dozen cities.
- ◆ Redirect Federal education money for teacher testing and merit pay programs.
- ◆ Spend \$210 million improving teacher training in reading.

G. R&D Needs in Education.

a. Introduction. Like crime problems, many believe they know, without the benefit of research, just exactly what the U.S. needs to do to address the problems in education. We recommend that the following ideas be examined in research intensive experiments.

b. K-12 Math and Science Education Quality. We recommend that pilot research programs be established in the following areas:

- ◆ Start school voucher projects in about two dozen U.S. cities.
- ◆ In those schools attended by students using vouchers introduce a national testing program to monitor progress of these students and benchmark these tests in an equivalent number of other schools not attended by voucher-funded students.
- ◆ Develop and implement a national program to measure what is working and at what economic cost in attempts throughout the nation to improve K-12 education.
- ◆ Develop a national program to **fast track** qualify retired engineers and scientists for teaching K-12 math and science.
- ◆ Initiate a major research program to identify ways to introduce competition into K-12 education.
- ◆ Select 10 K-12 programs around the nation for a national experiment in technology-intensive education over the Internet. Include in this research ways to increase the productivity and reduce the costs of K-12 education.
- ◆ Develop and field-test a math and science teacher incentive program.

- ◆ Select 10 schools around the nation for a major experiment in which each math and science teacher in grades 5-12 has at least a BS degree in the subject they are teaching, rather than an education degree.

c. College Costs. We recommend that pilot research programs be started in the following areas:

- ◆ Conduct a major study of cost growth in both private and public universities and identify those factors that have driven cost growth. In particular, identify those universities that are shifting the cost of graduate research to undergraduate tuition.
- ◆ Research the roles of universities in other nations and identify those roles that other nations' universities have filled that have had unusually high public return.
- ◆ Fund one state with a strong private and public education system to conduct a massive experiment in education by redirecting their flow of public funds from public universities in their state to students that attend any university, public or private, in any state.
- ◆ Research the overall social costs of peer review and determine how much, if any these costs outweigh the benefits.
- ◆ Initiate a major research program to investigate the pros and cons of shifting the accreditation emphasis in university education from the educational institution, the educational process and the faculty to accreditation of the graduate.
- ◆ Develop a national scorecard for universities based on the scores of their graduates on the graduate record examination in comparison to their ACT and SAT scores as incoming freshmen that can be used by education consumers for selection of which college they wish to attend.
- ◆ Conduct a major research program that identifies ways to use education technology to deliver the equivalent of university education to our citizens at costs less than one-half current costs.

d. Continuing Education. We recommend that pilot research programs be started in the following areas:

- ◆ Conduct a major research program to study the success in China, Turkey, and other nations using continuing education provided through distance learning to identify low cost ways of providing distance learning opportunities throughout the U.S.
- ◆ Task the U.S. Department of Education to develop a distance learning program in information sciences and computer programming that is available to all citizens through the Internet.
- ◆ Develop a national retraining program for mid- and late-career engineers that brings them up to date in software development and information sciences.

Bertholf has offered an innovative proposal for creating a new Federal role in education. He proposes that the Federal government stop funding university research and laboratory equipment through agency grants and instead use the funds to (1) establish a "Internet University" that would provide graduate education and continuing education to all Americans and (2) support designated user facilities around the country that would be used by university professors and graduate students as research facilities.¹⁹¹ Clearly, with the evolution of the Internet and its great potential for reaching millions of Americans as a research tool, it is time for the Federal government to rethink its role in education.

4. The Aging Problem.

A. Introduction.

There are three primary changes taking place in our society that are likely to have profound impact on the future of the U.S. These changes are due to (1) major differences in the fertility rate of women representing different ethnic backgrounds; (2) a new wave of immigrants from regions of the world not traditional sources of immigrants to the U.S. and (3) the aging of our population. Here we briefly summarize the source of immigrants to the U.S. because it is linked to the aging of our population and the ways our Nation may respond to population aging. In Table IV we compare the source of immigrants to the U.S. in 1996 to the source of U.S. immigrants in 1960.

Table IV: Cumulative sources of immigrants to the U.S. in 1996 and 1960.¹⁹²

Country	1996	1960
Mexico	6,679,000	576,000
Poland	-	748,000
Soviet Union	-	691,000
England	-	528,000
Ireland	-	339,000
Austria	-	305,000
Hungary	-	245,000
Czechoslovakia	-	228,000
Philippines	1,164,000	-
China	801,000	-
Cuba	772,000	-
India	757,000	-
Vietnam	740,000	-
El Salvador	701,000	-
Canada	660,000	963,000
Korea	550,000	-
Germany	523,000	990,000

In 1960 most immigrants to the U.S. came from Europe; today's immigrants come from Asia and Latin America. Descendants of European immigrants currently account for 74% of today's U.S. population; African immigrants and descendants of African immigrants and slaves account for 12% of the U.S. population; immigrants and descendants of Latin American immigrants

¹⁹¹ Dr. Larry Bertholf, personal communication to James Gover.

¹⁹² Ibid, p. 7.

account for 10% of the U.S. population; and immigrants and descendants of Asian immigrants account for 3% of the U.S. population. By the year 2050 demographers predict that 53% of the U.S. population will be white, 25% of the U.S. population will be Hispanic, 14% of the U.S. population will be black, and 8% of the U.S. population will be Asian. Some predict that this condition could lead to polarization within the U.S. political system.

William Frey, the University of Michigan demographer, sees in this pattern, the emergence of separate Americas, one white and middle-aged, less urban and another intensely urban, young, multicultural and multiethnic. One America will care deeply about English as the official language and about preserving Social Security. The other will care about things like retaining affirmative action and bilingual education. ... Many immigrant parents say that although they want their children to advance economically in their new country, they do not want them to become too American. ... Asked by researchers ... how they identified themselves, most (immigrants) chose categories of hyphenated Americans. Few chose "American" as their identity. ... asked if they believe the United States is the best country in the world, most of the youngsters answered: no.¹⁹³

The Economist offers an optimistic long-term perspective on the impact of Hispanic immigration trends on the U.S.

It is 400 years since Spanish conquistadors first claimed the land to the north of the Rio Grande. Spanish-speakers from the rest of the American continent have never ceased to follow their example. ... About 30m of them are now fully fledged Americans. They have become the most important minority in the United States. ... in a country still divided along lines of race and class, many Latinos consider that they have an essential role to play ... Latinos have no racial ax to grind; they themselves are not only brown but also black and white. Although they often meet discrimination, they have little taste for the politics of quotas or compensation. And although they have always supported "affirmative action" programs, they now loathe bilingual education, the program most specifically devised to give them a leg-up into American life. Even poor Latinos retain a sturdy distrust of government, preferring to rely on their families. Relatively few Latinos are on welfare; most believe that a man ought to help himself first by his own efforts.¹⁹⁴

In the 1990 census about 30 million of the counted U.S. population were of Latin descent. An additional 2 million to 3 million were not counted because they are illegal immigrants principally from Mexico. By 2050 the U.S. Latino population is expected to reach 96 million. Of the current Latino population, approximately 63% are of Mexican decent, 12% are of Puerto Rican decent, 8% are of Cuban decent, 12% are of Central American decent, and 5% are from the Dominican Republic. By 2020 Latinos are expected to become the majority population in both California and Texas.

Spanish-speaking America is already the world's fifth-largest Hispanic nation. Within ten years, only Mexico will have more Spanish-speakers. ... If their education does not improve, most Latinos will be servicing rather than running 21st century America. Even so, their eagerness for betterment, their readiness to do lowly jobs and, above all, their

¹⁹³ The Washington Post Weekly Edition, "Diversity and Division", March 2, 1998, p. 2.

¹⁹⁴ The Economist, "A Minority Worth Cultivating", April 25, 1998, p. 21.

*refusal to choose between the white bus and the black will make them perhaps the most vital group in the whole American experiment.*¹⁹⁵

In most of the nations that are the current source of immigrants to the U.S., women's rights lag those of the U.S. by several decades. We can increasingly expect conflicts in the workplace between professional women and male immigrants.

B. Maintaining Population.

For a nation to exactly maintain its population without immigration, its total fertility rate (TFR) must be 2.1 (each woman must average having 2.1 children.) The U.S. TFR peaked in 1960 when U.S. women averaged 3.65 children each. By 1976 the U.S. TFR had troughed at 1.74 children per woman. Unlike most of the world's industrial powers, the U.S. fertility rate is slightly above 2.0. In comparison, France and the United Kingdom have fertility rates of about 1.8 and Germany's is about 1.4. By the end of 1998, Italy, Germany, Greece and Spain will have more people over the age of 60 than are under the age of 20. Japan, a nation that does not welcome immigrants, has a TFR of 1.39. Sweden, a nation that has offered incentives to women to give birth, has a TFR of 1.4. Bologna, Spain has a TFR of 0.8. In comparison, the TFR of Palestinians in the Gaza Strip is 8.8 and the 45 nations of East, West and Middle Africa have TFRs in excess of 6.0. The New York Times recently pointed out,

*Driven largely by prosperity and freedom, millions of women – here and throughout the developed world – are having fewer children than ever before. They stay in school longer, put more emphasis on work and marry later. As a result, birth rates in many countries are now in a rapid, sustained decline. Never before – except in times of plague, war and deep economic depression – have birth rates fallen so low for so long.*¹⁹⁶

This low TFR in the developed world is driven by many factors including increased employment opportunities for women, the necessity for women to work to maintain family income (see the section on the shifting of wealth), the necessity for and the high cost of education (see the section on education), the abortion option, the perception that future generations will inherit a world less desirable than the present version, and a growing unwillingness to sacrifice today's pleasures for tomorrow.

The U.S. TFR is not evenly distributed among various ethnic groups. The TFR for Hispanics is 3.0, for African-Americans it is 2.4, for American Indians it is 2.1, for Asian Americans it is 1.9 and for non-Hispanic whites it is 1.8.¹⁹⁷ The fraction of these births by unmarried mothers has been rising for five decades. Currently, 14% of Asian American births, 21% of non-Hispanic white births, 40% of Hispanic births, and 67% of African-American births are to unmarried mothers. The trends are - births to unmarried, non-Hispanic white mothers are growing while births to unmarried African-American mothers are decreasing. The fraction of out-of-wedlock births has increased over the last two decades, a period in which welfare benefits have steadily

¹⁹⁵ The Economist, "The Keenest Recruits to the Dream", April 25, 1998, p. 27.

¹⁹⁶ The New York Times, "Population Implosion Worries a Graying Europe", July 10, 1998, p. A1.

¹⁹⁷ Carol J. De Vita, "The United States at Mid-Decade", Population Bulletin, Vol. 50, No. 4, March 1996, p. 14.

declined.¹⁹⁸ While a popular opinion, there is no evidence that welfare payments have served as significant incentive to promote births by unmarried mothers.

Even without further immigration, the U.S. population would continue to increase until 2035 when it would peak at 311 million. With immigration at current levels, the U.S. population will continue to grow until 2050 when it will peak. Between 1946 and 1964, 76 million babies were born in the U.S. This generation is called the baby boomer generation.

The term "youth deficit" is used by demographers to describe the condition when a country's population in the 15-24 year old range falls below the 15% to 20% of total population range that is thought to exist in stable societies. Between 1990 and 2010, 29 countries are expected to experience youth deficits. Most all industrialized countries are included in these 29 countries. By 2010, approximately 10% of Japan's population will be between 15 and 24 years of age. China will have a youth deficit by the turn of the century. Although most of the industrial competitors of the U.S. are expected to experience youth deficits, the U.S. is not.¹⁹⁹ The U.S. working age population continues to grow. However, youth deficits in Japan and Europe will demand that more of these nations' income and saving assets be spent on their aging population. Therefore, less foreign capital will be available from foreign creditors for investment in the U.S.

The life expectancy for those born in the U.S. in 1995 is 72.6 years for men and 79.0 years for women. The future growth in life expectancy is projected to be about one-half the rate it has grown in recent years. Forecasts by the U.S. Social Security Administration put life expectancy in 2050 at 77.5 years for men and 82.9 years for women. Extrapolation of life expectancy from past data suggest an average of 84.3 years for both sexes combined by 2050.²⁰⁰ By 2040 the number of Americans over age 85 will be equal to the number of preschool children. Peterson points out,

*the economic implications of America's aging population over the next several decades will dwarf, in sheer dollars, any other big issue one might name. Indeed, how we deal with the entitlement and savings crises may determine how the other issues we face will ultimately play out.*²⁰¹

C. Aging Data.

At the beginning of this century, 4% of U.S. citizens were 65 or older. As we approach the end of this century, there are 33 million U.S. citizens (13% of the population) over 65 years of age. In Table V we show how the over 65 population in the U.S. has changed and how it is projected to change over the 20th and 21st centuries. These data illustrate that after a rather steady period of growth since World War II, the U.S. has entered a period 1990-2010 where the growth rate of the over 65 population is only 50% of what it has been since World War II. This is a direct result of the low fertility rate of the 1930s. That period will then be followed by a period in which the rate of growth of the over 65 population again doubles as the baby boomers retire.

¹⁹⁸ Ibid, p. 35.

¹⁹⁹ NTIS Directorate of Intelligence, Youth Deficits: An Emerging Population Problem, August 1990.

²⁰⁰ John R. Wilmoth, "The Future of Human Longevity: A Demographer's Perspective", Science, April 17, 1998, p. 395.

²⁰¹ Peter G. Peterson, "Will America Grow Up Before It Grows Old?", The Atlantic Monthly, May, 1996, p. 75.

That period will then again be followed by the lowest growth rate period of the over 65 population since World War II. Since the beginning of the 20th century, the population of the U.S. and the population of those under 65 have both tripled, but the population of those over 65 has increased by a factor of eleven.

Table V: Percentage growth rate in the over 65 population in the U.S. between 1910 and 2050.

Year Range	Percentage Growth Rate of Over 65 Population
1910-1930	2.6%
1930-1950	3.1%
1950-1970	2.4%
1970-1990	2.2%
1990-2010	1.3%
2010-2030	2.8%
2030-2050	0.7%

By 2050, about 80 million Americans or 20% of the U.S. population will be over 65.²⁰² By 2005, U.S. workers over age 55 will account for 15% of the labor force. The median age of the workforce in the year 2000 will be 45 years. In Table VI we show the age distribution expected for the U.S. population. The leading edge of the baby boomers will reach retirement age in 2010. Note after that how the 65-74 population shows dramatic growth over the next 10 years and by the middle of the next century the over 85 age group will have grown to the same size as the 65-74 age group is today.

Table VI: Age distribution of U.S. population from 1995 to 2020²⁰³.

Year	Total Pop.	0-14 Years	15-24 Years	25-34 Years	35-44 Years	45-54 Years	55-64 Years	65-74 Years	75-84 Years	>85 Years
1990	-	-	-	-	-	-	-	18.0 M	10.0 M	3 M
1995	263 M	58.2 M	36.3 M	41.7 M	42.2 M	30.2 M	21.1 M	19.0 M	11.1 M	3.6 M
2000	276 M	59.9 M	37.8 M	38.2 M	45.1 M	36.2 M	23.4 M	18.6 M	12.4 M	4.3 M
2005	288 M	60.6 M	40.8 M	36.8 M	43.1 M	41.2 M	28.9 M	18.7 M	13.3 M	5.1 M
2010	300 M	-	-	-	-	-	-	21 M	13.2 M	6 M
2020	-	-	-	-	-	-	-	30.1 M	15.5 M	7 M
2050	-	-	-	-	-	-	-	34.6 M	26.6 M	19 M

When one examines the growth rate of various groups in the population, it is the over 85 group that stands out. This population group will grow at a rate of 4.4% over the next 15 years while the overall population is growing at a rate of 1.7%. While the impact of the baby boomers reaching retirement age will impact Social Security and Medicare costs by 2010, when they reach 85 years of age, the impact on Medicare and private savings will be massive. Unless there is a breakthrough in Alzheimer's disease research, 50% of the over 85 population, or 9.5 million will have Alzheimer's disease. If one conservatively adds another 7.5 million Alzheimer's patients from other age groups, we can expect to have 17 million Alzheimer's patients and a minimum of 35 million people will be providing their care at an annual national cost in excess of

²⁰² *The Economist*, "The Gerontocrats", May 13, 1995, p. 32.

²⁰³ U.S. Census Bureau, Projections of the Population, by Age and Sex, for Regions, Divisions, and States: 1993 to 2020 - Series A (Preferred Series).

\$500 billion, or 2.5 times our current annual cost for Medicare. Alzheimer's disease alone is sufficient to break the Medicare bank.

In Table VII we show those states with the largest and smallest change in the populations of those over 65 and those over 85 between 1993 and 2020. While many observe that Florida has a population that is noticeably older (16% of Florida's current population is over age 65), by 2020 over 32 states will have an over 65 population that is 16% or higher and the U.S. average will be about 16%. By 2020, Florida's over 65 population is projected to be 26% of its population.

Table VII: States with the largest and smallest changes in elderly population between 1993 and 2020.²⁰⁴ Those states with the largest increases in their over 65 and over 85 populations are located in the southwestern U.S.

State	>65 Population in 1993	>65 Population in 2020	Percent Increase	>85 Population in 1993	>85 Population in 2020	Percent Increase
Nevada	155,000	333,000	116%	10,000	34,000	245%
Arizona	529,000	1,121,000	112%	46,000	148,000	221%
Colorado	462,000	743,000	108%	37,000	89,000	144%
Georgia	695,000	1,419,000	104%	65,000	156,000	138%
Washington	612,000	1,245,000	104%	62,000	146,000	136%
Utah	165,000	334,000	102%	16,000	42,000	161%
California	3,303,000	6,622,000	101%	323,000	809,000	151%
Texas	1,835,000	3,640,000	98%	186,000	428,000	130%
New Mexico	178,000	350,000	97%	16,000	44,000	167%
Iowa	436,000	546,000	25%	58,000	85,000	47%
N. Dakota	94,000	117,000	24%	13,000	20,000	56%
West VA	278,000	342,000	23%	28,000	46,000	67%
Pennsylv.	1,908,000	2,303,000	21%	187,000	320,000	71%

The oldest of the baby boomers are now eligible to join the American Association of Retired Persons, AARP, an association that already has 32 million members or one-half of all Americans age 50 and older. When the peak of the baby boomers are eligible for membership in AARP, its membership is expected to grow to about 50 million. AARP's annual income is about \$80 million so it has the money and the membership to play a major role in influencing national policy.

Lester Thurow has remarked,

for the first time in human history, we're going to build up a very large group of people who don't work, are very affluent, and get most of their money from the government. That group is the elderly. This is a revolution the world has never seen. In 1963, 23% of Federal spending went to people over the age of 65. In 1993, the number was 47%; in 2003, it will be 58%; in 2013, it will be 75%; and in 2040, it will be 100%. Of course, that can't happen. How does a democracy cut the paychecks of a majority of its voters? Forty percent of the elderly get all of their money from government; the rest of the population gets 40% of their money from the government. This situation is called the "double 40 whammy," and it will test our democracy. ... From the point of view of a

²⁰⁴ USA Today, "Study: 2020 Begins Age of the Elderly", May 21, 1996, p. 4A.

politician, it's easier to cut investment activities that won't affect anything for the next 15 years than to deny the elderly their health care and pensions.²⁰⁵

Of importance is the economic impact of the aging population. Peterson points out,

sustained productivity growth requires investment, and no country can sustain high rates of investment without saving. ... capital accumulation is essential to productivity growth - and is, moreover, the one condition over which society can exercise direct control. ... Yet we now face public budgets strained to the breaking point by the costs of demographic aging, which will crowd out all forms of capital accumulation - private and public, material and human. Without fundamental policy reform a graying America cannot be a saving America.²⁰⁶

D. Major Public Policy Issues of the Aging

a. Social Security Costs. Each month the Federal government issues Social Security checks to almost 44 million Americans. An aged couple, both Social Security beneficiaries, may receive up to \$15,456 per year. People may claim reduced Social Security benefits as early as age 62. In 1998, over 140 million workers and their employers will pay 12.4% of their earnings (6.2% each) up to \$68,400 to Social Security. Those receiving Social Security payments whose annual income exceeds \$34,000 for an individual or \$44,000 for a couple pay income taxes on up to 85% of their Social Security benefits. Until recently, a typical retiree could expect to receive far more in Social Security benefits than he or she paid in Social Security taxes. However, today's system is no longer a good deal for participants. For example, those retiring at age 65 in 1980 required only 2.8 years to recover their investment plus interest. For those that retired at age 65 in 1995, it will take 13.1 years. For those retiring at age 65 in 2025, it will take 21.8 years to recover their investment.²⁰⁷

The U.S. spends the smallest fraction of GDP on public pensions of any of the major industrial powers, yet public sources currently provide over 40% of the total retirement income for Americans. Nevertheless, the two major threats to the financial solvency of the Federal government are Social Security and Medicare. Social Security alone accounts for 40% of all Federal entitlement spending. Congressman Kasich argues that the U.S. has not only a \$5.5 trillion national debt, but we have about \$14 trillion in unfunded liabilities related to Medicare and Social Security that we will incur over the next 75 years.²⁰⁸ By 2030 all of the baby boomers will be age 65 or older. Under current conditions, Social Security will run a \$766 billion deficit by then. Peterson points out,

On our current path, entitlements will eventually consume all federal revenue, leaving nothing to pay for interest on the national debt, much less defense, education, and other discretionary expenditures (including research).²⁰⁹

²⁰⁵ Lester C. Thurow, "Surviving in a Turbulent Environment", Planning Review, v23n5, September/October, 1995, pp. 24-29.

²⁰⁶ Peter G. Peterson, "Will America Grow Up Before It Grows Old?", The Atlantic Monthly, May, 1996, p. 64.

²⁰⁷ David Koitz, Geoffrey Kollmann, and Jim Cornelius, "Current Social Security Issues", CRS Report to Congress, January 4, 1996, p. 4.

²⁰⁸ National Journal, "Looming Liabilities", January 17, 1998, p. 104.

²⁰⁹ Peter G. Peterson, Will America Grow Up Before It Grows Old?, Random House, 1996, p. 66.

On March 16, 1998, on the 71st anniversary of his birth, Senator Daniel Patrick Moynihan unveiled his new Social Security rescue plan at Harvard University. His plan provides for the establishment of individual retirement accounts, increases the retirement age to 70, reduces the percentage of payroll deduction but increases the upper limit for payroll deduction to \$97,500, and places Medicare on a pay-as-you-go structure. The Senate has approved 51-49 a non-binding resolution sponsored by Senator William V. Roth, Jr., also over 70 years of age, that called for devoting the Federal budget surplus to establishing personal retirement accounts.²¹⁰

When Social Security was started, the life expectancy of Americans was 62 years of age and most Americans didn't think about retiring until they were 65 years of age. Consequently, there were 8 people making Social Security payments for each retired person. Because people now retire sooner and live longer, we are now down to 3.3 people making Social Security payments for each retiree and we will be down to between 1.6 and 2 wage earners when the baby boomers are well into retirement in the year 2030. By 2020 the imaginary Social Security "trust fund" will peak at \$3.3 trillion. However, by 2030 that excess will be exhausted. Over the next 75 years from now it is projected that Social Security payments to retirees will exceed income on average by 16%. In response to this concern, Congress has raised the age for receipt of full Social Security benefits to age 67.²¹¹

Using the most conservative or highest-cost projection for the growth in Social Security benefits we would need to immediately raise the payroll Social Security tax rate by 50% (from 12.4% to 18.4%) to meet future obligations at current benefit rates. Thus, the conservative projection suggests an increase of 6% of salary in payroll deductions. The intermediate projection, traditionally an underestimate, requires an increase of 2.5% of salary in payroll deductions.²¹² The Center for Strategic and International Studies has recommended that the Social Security payroll tax remain fixed at 12.4%, but that 2% of payroll be set aside to fund individual-directed savings accounts that could include stockmarket indexed funds. Projected Federal budget surpluses would be used to pay for the transition to this new system.²¹³

There are four major options to restore solvency to Social Security - cut benefits, increase contribution rates, raise the retirement age, and advance fund Social Security. Political processes are likely to lead to policies that are a combination of these options. Bosworth and Burtless explain,

To restore long-term solvency to public pensions, policymakers confront a choice among four reform alternatives. Three - cutting benefits, increasing contribution rates, or raising the age of retirement - can be implemented within the present pay as you go framework. The fourth moves away from pay-as-you-go toward advance funding of retirement obligations - either within the public system or in privately owned and managed pension funds. ... Declining labor force growth and the dramatic slowdown in labor productivity growth have eliminated ... advantages of a pay-as-you-go system.

²¹⁰ National Journal, "The Two Per Cent Solution", April 11, 1998, p. 795.

²¹¹ David Loitz, Geoffrey Kollmann, and Jim Cornelius, Current Social Security Issues, CRS Report to Congress, January 4, 1996.

²¹² Laurence J. Kotlikoff and Jeffrey Sachs, "Privatizing Social Security", The Brookings Review, Summer, 1997, p. 20.

²¹³ The Economist, "And the Work Goes On", May 23, 1998, p. 26.

The rate of return has fallen below 2 percent a year in most countries and may soon become negative.²¹⁴

Krauthammer has pointed out the perceived 1998 budget surplus predicted to range between \$40 billion and \$60 billion isn't really a budget surplus if excess Social Security payments aren't included in the calculation. He proposes that a separate Federal account should be established for Social Security and excess payments for Social Security not be included in Federal budget considerations.²¹⁵ A national poll conducted by CBS News and the New York Times asked the question, "If there was a budget surplus and you had to choose between the following things, how would you like the money to be used?" Of those polled, 59% replied preserve Medicare and Social Security, 18% replied pay down the national debt, 13% replied cut income taxes, 9% preferred other options and 1% didn't have a suggestion.²¹⁶ R&D performers that interpret the 1998 budget surplus as evidence that Federal R&D will be substantially increased should recognize that their preference is some fraction of the 9% group.

b. Baby Boomer Savings. The Social Security system has served to reduce the poverty rate among elderly households from 35% in 1959 to 11% in 1995.²¹⁷ However, when the baby boomers are well into enjoying their Social Security benefits in about 30 years, the system will be bankrupt. This observation invites the question, what fraction of the baby boomers will need Social Security benefits? Dr. B. Douglas Bernheim, a Stanford University economics professor did a study on baby boomer savings patterns. He concluded,

Baby boomers are saving only one-third of what they should to maintain a pre-retirement standard of living. Boomers will want to collect federal benefits supported by the smaller generations that follow, leading to intense conflict between generations, a fight led by the resourceless elderly. The elderly are a politically potent group, which will be 50 percent larger and really concerned about Social Security because they don't have any money. ... In fact, 57 percent of the baby boomers believe they will receive "some, but not all" of the Social Security benefits, while 33 percent think they will receive none at all, according to a Gallup poll.²¹⁸

However, when Gale includes housing equity in the calculation, he concludes that over two-thirds of baby boomer households appear to have more than the minimum needed. He explains,

Roughly speaking, a third of the sample is doing well by any measure, a third is doing poorly by any measure, and a third is just hanging in there. ... Up to two-thirds of the households are now saving at least as much as they should be. And two-thirds are "at

²¹⁴ Barry Bosworth and Gary Burtless, "Budget Crunch: Population Aging in Rich Countries", The Brookings Review, Summer 1997, p. 12.

²¹⁵ Charles Krauthammer, "Take Social Security Out of Budget", Albuquerque Journal, May 31, 1998, p. B2.

²¹⁶ National Journal, "The Politics of Surpluses", April 25, 1998, p. 922.

²¹⁷ William G. Gale, "Will the Baby Boom Be Ready for Retirement?", The Brookings Review, Summer, 1997, p. 5.

²¹⁸ The Hill, "AARP Shifts Its Gears, Aims for Baby Boomers", January 21, 1998, p. 8.

risk", in that any deterioration in their situation could make it impossible for them to maintain their living standards in retirement.²¹⁹

It should be noted, however, that estimates of the financial security of the baby boomers fail to take into account the economic impact of Alzheimer's disease. At today's institutional costs of \$47,000 for an Alzheimer's resident, many of the baby boomers thought to have financial security might find they were not prepared to fund institutional care.

c. Medicare. Medicare is a Federal program that partially pays for healthcare for Americans over 65 years of age. It also includes benefits for certain disabled Americans and for kidney dialysis treatments. This program has two major components: (1) Medicare A funds hospital insurance which covers some of the costs of hospital stays and postacute care and (2) Medicare B supplemental insurance for outpatient care. Medicare participants pay \$42.50 per month for Medicare B: This has been adequate to cover outpatient costs for the last three years. Medicare does not cover any of the costs of prescription drugs. In 1998 U.S. workers and their employers paid 2.9% of their wage and salary income for Medicare Hospital insurance for those eligible for Medicare benefits. Roughly one out of seven Americans receives Medicare benefits in comparison to one out of six that receives Social Security benefits.

Medicare does not cover all of the healthcare costs of the elderly. In 1994, the non-institutionalized elderly spent on average \$2,500 per-person out-of-pocket on healthcare. This amounted to 21% of family income. Almost one-half of these out-of-pocket costs were for health insurance. In 1994 the over 85 population spent \$3,800 per person for out-of-pocket healthcare. The fastest growing category of out-of-pocket spending is on home healthcare, as the elderly delay entering nursing homes. Medicare pays for short-term nursing home care, but it does not cover lower-cost custodial care, the type of care needed by those with Alzheimer's disease.

In 1996 Medicare provided benefits for 38 million Americans at a total cost of \$200 billion. About 80% of these costs are for inpatient hospital services. Medicare costs are expected to have an annual increase of 8.9% and grow to \$332 billion by 2002. Congress has debated limiting Medicare charges to the range between \$150 billion and \$270 billion by 2002 and has attempted to cloak cuts in Medicare payment growth in evasive language.

Without changes in Medicare benefits or a productivity breakthrough in the U.S. healthcare system, Medicare costs will soar when the baby boomers begin to receive benefits. There are two primary options to reduce the cost growth of Medicare: (1) increase the overall productivity of healthcare services or (2) reduce the benefits funded by Medicare. The attention of policymakers is concentrated on the second of these.

d. Medicaid. Medicaid is a means-tested program that supports the poor. The Federal government and states jointly fund it. At this time states are paying about 43% of Medicaid costs and the Federal government pays about 57% of costs. In 1998 the Federal government is expected to spend \$101 billion on Medicaid. By 2008 Federal support for Medicaid is expected to increase to \$210 billion. In 1998, Medicaid amounted to 48% of the Federal budget

²¹⁹ William G. Gale, "Will the Baby Boom Be Ready for Retirement?", The Brookings Review, Summer, 1997, p. 8.

for means-tested entitlement programs; by 2008, Medicaid will have increased to 55% of the Federal budget for means-tested entitlement programs. Medicaid supports four groups.²²⁰

- ◆ Medicaid is the primary source of health insurance for low-income families with children.
- ◆ Medicaid pays for acute and long-term nursing home and community-based care for poor elderly individuals whose incomes and assets are low enough to qualify.
- ◆ Medicaid covers acute and long-term institutional and community-based care for physically and mentally disabled children and adults.
- ◆ Medicaid covers the Medicare premiums and cost-sharing requirements for low-income elderly and disabled individuals who are eligible for both programs.

Medicaid spends 70% of its resources on elderly and disabled beneficiaries. About 7 million children have no health insurance; 3 million of these are eligible for Medicaid, but are not enrolled.

Many are critical of public programs such as welfare and Medicaid that support the poor. As The Economist recently pointed out, in times past many of these needs were provided through philanthropy.

*The parallels between "the gilded age" at the turn of the century, when people like Rockefeller, Carnegie and Morgan made their money, and today are uncanny. There is the same onrush of innovation; the same straining at the social fabric as immigration surges, industries restructure and inequalities widen; and the same pell-mell creation of new wealth. ... But when it comes to philanthropy the parallel ends. The gilded age's "malefactors of great wealth" were also benefactors of extraordinary generosity. Andrew Carnegie put philanthropy at the heart of his "gospel of wealth". John D. Rockefeller, who gave away a tenth of his income even when he was a clerk in Cleveland, declared that "anybody who dies rich dies disgraced" and transformed Standard Oil from the greatest wealth-creating machine in the world into the greatest charity-dispensing machine in history. ... Today's new rich have the opportunity to shape America - and the world - just as profoundly as Carnegie and Rockefeller did. But so far most have failed to take it. George Soros, the financier, is one notable exception: he has given a fortune in creative and unusual ways, taking great care over how the money is spent. Ted Turner, the media mogul, is another: earlier this year, he gave \$1 billion to the UN.*²²¹

e. Alzheimer's Disease. Alzheimer's is a progressive, degenerative disease characterized by amyloid plaques and neurofibrillary tangles of the cortex region of the brain. It is the most common form of dementia. Alzheimer's disease is not caused by a single factor, but probably by a number of genetic and environmental factors that interact differently in different people. It is estimated that 4 million Americans have Alzheimer's disease. The number of Americans with Alzheimer's is projected to exceed 14 million by 2050. Although Alzheimer's disease sometimes affects younger people, it is generally a disease of the elderly - 3.0% of those between 65 and 74, 18.7% of those between 75 and 84, and 47.2% of those over 85 have

²²⁰ The Concord Coalition, Financing Retirement Security for an Aging America, 1998, p. 39.

²²¹ The Economist, "Philanthropy in America", May 30, 1998, p. 19.

Alzheimer's disease²²². As we have previously pointed out, the over 85 age group is the fastest growing age group in the U.S.

This dreaded disease is thought to appear in the brain as many as 20 years in advance of any identifiable behavioral symptoms. Once the symptoms appear, life may continue for anywhere from 8 to 20 years. Research suggests that as Hispanics and African Americans age, the frequency of Alzheimer's disease in these populations is likely to increase disproportional, perhaps as much two to four times that of the white population, the basis for current statistics and projections.²²³

The total annual cost of Alzheimer's disease is \$100 billion, ranking it just behind heart disease and cancer in economic costs. By the middle of the next century the annual cost of Alzheimer's disease will exceed \$500 billion. These costs do not include the opportunity costs of family members that leave the job market to provide care for Alzheimer's patients or the quality of life costs of family members.

Most people with Alzheimer's disease are receiving Medicare payments for health services. The annual per capita expenditures for Medicare beneficiaries with Alzheimer's disease in 1995 were \$7,682 in comparison to the Medicare average benefit of \$4,524. Almost one-half of Medicare beneficiaries with Alzheimer's disease also receive Medicaid payments because Alzheimer's has bankrupted them. Of the total population eligible for both Medicare and Medicaid, 22% have Alzheimer's disease.

About 70% of Alzheimer's patients live at home. Although 75% of the care for these is provided by family and friends, the average annual cost of paid in-home care is \$12,500. Nursing home care for Alzheimer's patients averages \$47,000. Medicaid pays for over half of the total nursing home costs in the U.S. Federal Medicaid policies encourage families with Alzheimer's patients to seek nursing home care, because of Medicaid eligibility, rather than lower cost assisted living facilities with specially designed Alzheimer's care facilities that are not Medicaid eligible. The usual practice of caring for Alzheimer's disease is keep patients at home until the family is physically and mentally exhausted, then place them in a private-pay assisted living facility until all financial resources are exhausted, and finally place them in a Medicaid eligible nursing home where they stay until death. Despite the emotional and economic costs of Alzheimer's disease, in 1998, the Federal government will only spend \$350 million on Alzheimer's research. This represents a \$1 investment in research for every \$287 of social cost.

Comparison of the Federal government's research investment in AIDS to that made for Alzheimer's research provides further evidence that the Federal government is under-investing in Alzheimer's research. In 1996, government spent \$1.5 billion on AIDS research in comparison to \$309 million on research for Alzheimer's disease. This obvious disparity in spending results from the following widely held attitudes.

- ◆ Alzheimer's is primarily a disease of older people; spending money on the elderly is futile.

²²² Testimony of Dr. Steven T. DeKosky, University of Pittsburgh, before the Senate Appropriations Committee, Labor/HHS/Education Subcommittee, March 24, 1998.

²²³ Ming-Xin Tang, et.al., "The APOE-ε4 Allele and the Risk of Alzheimer's Disease Among African Americans, Whites, and Hispanics," JAMA, March 11, 1998, pp. 751-755.

- ◆ Alzheimer's patients cannot lobby on their behalf and professional entertainers have concentrated their lobbying on AIDS, a disease widespread in their profession, rather than Alzheimer's disease, a disease rarely found among entertainers because of their relative youth.
- ◆ Alzheimer's disease, because it affects the brain, is not a visually striking disease.²²⁴

Unlike cancer, especially lung cancer, heart disease, and AIDS, where lifestyle can influence the probability of disease onset, any relationship to life style or other factors that can be influenced by individuals, and the onset of Alzheimer's disease is unknown.

To persuade Congress and the President to increase spending for Alzheimer's research by \$100 million during a period when the NIH research budget is growing roughly \$1 billion per year, the National Alzheimer's Association has found it necessary to initiate a massive grass-roots lobbying program bringing the effects of Alzheimer's disease to the attention of Congress. Rosemary Cronin, wife of Bob Cronin, an age 54 victim of Alzheimer's disease, testified before the U.S. Senate.

*when we read statistics reporting the NIH's 1997 budget for cancer research was \$3.1 billion and the budget for Alzheimer's was \$323 million we want to scream and say, hey, wait a minute ... we're out here, too. And our families are out here. We need help and we need the research not only to continue but also to increase.*²²⁵

At least one member of the entertainment world, Piper Laurie, is speaking out on behalf of Alzheimer's victims.

*My father, who died two years ago, developed Alzheimer's disease. ... For my father, the disease brought horrible indignities to a very dignified man. ... when he was in a small nursing home in Arizona, he had grown so weary of the confusion and anxiety that he walked into the backyard one day, removed all of his clothes and lay down on the earth. When someone came to help him he whispered, "I just want to go to sleep."*²²⁶

Orien Reid pointed out to Congress that Alzheimer's is a disease that affects families, not just individuals, and many of those family members are young.

My mother had Alzheimer's disease. It devastated me to watch the disease destroy the mind of a woman who had counseled imminent leaders like the late Dr. Martin Luther King, and former Atlanta Mayor, Maynard Jackson. ... My mother's Alzheimer's disease forced a major disruption in my personal and professional life. Those were sacrifices I was willing to make. But it also robbed my son and daughter of their childhood, took the

²²⁴ Jennifer Monath, "Alzheimer's Disease, Long-Term Care, and Health Policy: Who's Going to Pay the Bill?", Reference Services Review, Spring, 1997.

²²⁵ Testimony of Rosemary and Bob Cronin, Dubuque, Iowa, before the Senate Appropriations Committee, Labor/HHS/Education Subcommittee, March 24, 1998.

²²⁶ Testimony of Piper Laurie, Los Angeles, CA, before the Senate Appropriations Committee, Labor/HHS/Education Subcommittee, March 24, 1998.

*money I had saved for their college education, and left an indelible mark on them that continues to affect their lives.*²²⁷

The clock is ticking on Alzheimer's disease. Unless this disease is conquered in the very near future, it will bankrupt Medicare and Medicaid and destroy the lives of millions of American families, particularly Hispanic and African-American families that are finally beginning to experience the American dream.

E. Public Response to Aging Issues

a. Extended Working Age. By the year 2005, 15% of the U.S. workforce will be over age 55. By the turn of the century, workers median age will be 45, roughly the median age for the baby boomers. By 2030, 20% of Americans will be over age 65. Today, just 16% of men over age 65 are still working. In 1940, one-half of 69 year old men were still working; in 1997 only 46% of 62 year old men were still working.

An option for reducing Social Security costs is to keep the workforce employed well past today's retirement age. Peter Drucker proposes that people work until age 75. If this is to happen, our society must overcome many myths and incorrect perceptions of older people and it must incentivize older workers to continue to work.

*In our worship of youth, we have adopted a number of misconceptions about older people's ability to work. "The association between age and work performance dominates our thinking," says Harold Sheppard, a professor in the department of gerontology at the University of South Florida in Tampa who served as former President Jimmy Carter's counselor on aging. "Many of our attitudes toward aging are a product of physicians' perspectives, and they only see the sick. There is a general mind-set that old means incapacity."*²²⁸

Alan Reynolds²²⁹ a researcher at the Hudson Institute has been investigating the effect of early retirement on economic growth in the U.S. Reynolds argues that currently 79% of eligible workers begin collecting retirement benefits at age 62. He suggests that this contributes to a labor shortage that will cramp U.S. economic growth in the 21st century.

*Social Security and Medicaid earnings limits and tax penalties subject our most experienced workers to marginal tax rates as high as 67%. Social Security formulas - based on 35 years of work that an employee usually completes before age 60 - encourage early retirement. Although incomes usually rise with additional years of work, any pay increases after the 34-year mark result in higher Social Security taxes but only small increases in benefits.*²³⁰

Numerous mythical concerns about older workers handicap their ability to find employment. These myths include,²³¹

²²⁷ Statement of Orien Reid, Laverock, Pennsylvania, before the Senate Appropriations Committee, Labor/HHS/Education Subcommittee, March 24, 1998.

²²⁸ Margaret Kaeter, "Age Old Myths", Managing Diversity, Vol. 7, No. 5, February, 1998, p. 3.

²²⁹ Alan Reynolds, "Restoring Work Incentives for Older Americans", Outlook, October, 1997.

²³⁰ The Futurist, "Early Retirement Slows Economic Growth", April, 1998, p. 15.

²³¹ Margaret Kaeter, "Age Old Myths", Managing Diversity, Vol. 7, No. 5, February, 1998, p. 3

- ◆ **Older workers cost more.** In fact a retired worker that has earned retirement from a previous employment can cost far less than a younger worker that needs health insurance and other fringe benefits. Besides that the older worker can bring wisdom of experience to the job.
- ◆ **Older workers are sick more.** In fact, older workers actually take fewer sick days than those do under 40 years of age.
- ◆ **Older workers can't learn new skills.** While it often takes longer to train older workers, older workers change jobs less frequently; therefore, it can be overall more cost effective to train older workers than to train younger workers.
- ◆ **Older workers are less productive.** Older workers tend to work smarter, have a better sense of human behavior, and a better sense of when to intervene. When Grumman Corporation made lay-off decisions based strictly on worker performance, they found out after the downsizing that the average age of their employees had increased by 10 years.

If we are to overcome the culture and tradition of discriminating against older workers, it will be necessary to develop labor laws that have some teeth. As a general rule, the courts have not been particularly sensitive to the plight of older workers. The National Journal recently reported,

it appears to be getting tougher to prove age discrimination in court. ... a July ruling by a California state appeals court - in a case brought under the state's age discrimination law - said that employers could give younger workers preference over older ones if they had an economic justification for doing so.²³²

While age discrimination is a despicable practice under any conditions, it is particularly important that the U.S. tradition of discriminating against older workers, a tradition developed when there was an excess of young workers and unemployment was high, be wiped out before the baby boomers begin to reach retirement age. With unemployment below 5%, now is the time for the U.S. to experiment with (1) older worker retraining programs; (2) policy options such as offering tax credits for hiring and retraining older workers, particularly the low skilled; (3) extending the Earned Income Tax Credit as an incentive for older workers to continue to work; and (4) stopping age discrimination in firms, agencies, federal laboratories, and universities that spend public funds. To get the attention of employers that have embedded age discrimination into their culture, the penalty for age discrimination must be swift and very painful.

b. Research on Aging Population Issues. Issues surrounding the aging population highlight several fundamental problems that the U.S. must address: (1) The lack of productivity growth in healthcare services. (2) Financial and cultural disincentives to keeping the aging population on the job and working. (3) An inefficient education system that does not offer cradle to grave education opportunities and emphasize workforce retraining. (4) Inattention to developing systems that provide care for the elderly at costs they can afford. (5) A political system locked-in to the use of political processes for decision-making that is rapidly falling behind the private

²³² National Journal, "When We're 64", September 27, 1997, p. 1885.

sector in using modeling and simulation to forge decisions that are systematically rational. Each of these issues is worthy of substantive research programs.

5. The Energy-Environment Problem

A. Introduction.

The U.S. makes up less than 5% of the world's population but it produces 25% of the world's goods and services and it consumes about 25% of the world's energy. The most popular measurement unit for energy at the international level is quadrillion units of British Thermal Units or the quad. Our energy supply from domestic sources is obtained from the following sources: coal-21.9 quads, natural gas-19.2 quads, crude oil-13.8 quads, nuclear-7.2 quads, and renewables-6.6 quads. We annually import 22.4 quads, with 18.9 quads as crude oil and crude oil products. We export only 4.6 quads with 2.3 quads as coal. Of our annual energy consumption of 90 quads, 76.5 quads are obtained from fossil fuels. Our annual consumption is distributed as 32.1 quads for residential and commercial use, 34.5 quads for industrial use, and 24.1 quads for transportation.²³³

Americans annually spend about \$525 billion on energy. This is about one-half of their expenditure on health care and roughly two times their expenditure on national defense. To meet energy needs, America has slowly increased dependence on foreign sources of oil and domestic coal. The first of these sources may not be dependable, and both are more polluting than other energy alternatives. If long-range alternatives such as renewable energy sources, e.g., solar and biomass, hydrogen fuel, and nuclear fission and fusion are needed to combat global warming, it is unlikely that the marketplace will make the investment required to develop these technologies until the cost of energy dramatically increases or environmental concerns lead to consumer coal and oil prices that include their environmental costs.

Energy use is closely linked to nations' economic development and it is a primary driver of nations' foreign policy. Although the U.S. is less dependent on Middle East oil than Europe and Japan, protection of U.S. access to oil was a, if not the, primary reason for U.S. participation in Desert Storm and it was the principal reason for Germany and Japan helping compensate for the economic costs of this war. The Economist predicts that access to oil will also be a major driver of China's, Russia's and Europe's foreign policy in the future.

As China's economy expands, the Chinese will be looking to this area (the rectangular region between Saudi Arabia and Kazakhstan) for much of the extra energy they will badly need; they may, for instance, offer military assistance to the rectangle's countries (as they already have to Iran) in the hope of thereby getting favorable treatment in oil and gas supplies. As Russia's fear of China increases, the Russians will want to make sure that the countries of at least the eastern part of the area, the ex-Soviet states, remain within Russia's sphere of influence. And meanwhile Europe stands at the door, asking for its share of the rectangle's energy.²³⁴

Despite heavy public investment in energy R&D, principally for electricity generation, progress in reducing the U.S. dependence on foreign oil is invisible to the public. The public has largely forgotten the gasoline lines many thought to be caused by U.S. oil companies response to the

²³³ David Beck, Kevin Boyack, and Marshall Berman, Industrial Ecology Prosperity Game, Sandia Report, SAND98-0643, March 1998, p. 123.

²³⁴ The Economist, "The Next Balance of Power", January 3, 1997, p. 19.

Carter administration's consideration of an import oil tax. The public shows a propensity to continue to purchase fuel-inefficient vehicles and even pay what many thinks to be large gas-guzzler taxes imposed by the U.S. Congress. (By comparison Europe pays between \$2 and \$4 dollars per gallon of gasoline and 18 to 20 cents per kilowatt hour for electricity and Japan pays over 24 cents per kilowatt hour for electricity²³⁵). The consequences of this apparent shortsightedness remain as a pending threat to our economic security. Note, however, the public need not rush out and fund R&D to produce a 100-mile per gallon automobile. The big three auto companies have the financial resources to do this and will when it is to their economic advantage to do so. It is the responsibility of the public to create that economic advantage, not subsidize R&D for the auto manufacturers. (U.S. auto manufacturers have the financial resources to develop major R&D programs in any area they wish. At the end of 1997 Ford had \$21 billion in cash and marketable securities, General Motors had \$15 billion, and Chrysler had \$7 billion. Much of these cash reserves are being used to buy back stock.²³⁶)

Petroleum imports and trade imbalance with Japan are the two major factors driving the U.S. trade deficit. These accounted for \$100 billion of the \$175 billion 1995 trade deficit.²³⁷ As petroleum prices increase in response to petroleum demand increasing faster than petroleum supply early in the 21st century, the U.S. trade deficit will also grow. A GAO study²³⁸, however, noted that as long as the Nation's heavy dependence on oil continues, reducing imports would only force the Nation to shift to more expensive domestically produced oil. Reducing the growth in imported oil to 80% of its expected growth level would annually cost the U.S. between \$50 billion and \$100 billion in GDP.²³⁹

MacKenzie has pointed out²⁴⁰,

In 1973 the United States imported 35% of its oil, 5% of which was from the politically volatile Middle East. In 1995, it imported 44% of its oil, with 9% coming from the Middle East. ... DOE projects that OECD countries will increase their demand for oil by 20% by 2010 ... Non-OECD nations will increase their demand for oil by more than 50% by 2010. ... International Energy Agency projects that by the year 2010, world petroleum demand will be 35% to 39% greater than in 1994 - reflecting growth of about 2% per year. ... If the upper level of ultimate reserves (2,400 billion barrels) proves to be the case, and the Middle East countries are prepared to increase their production threefold, then a 1.5% growth in oil supply could be maintained until 2010.

Environmental issues are especially complex with major economic, political, technical and cultural dimensions and many are closely linked to energy production and consumption. Major environmental issues include population growth, natural disasters, loss of tropical rain forests,

²³⁵ Data provided by Dr. Dan Arvizu, Director, Sandia National Laboratories.

²³⁶ Fortune, "The Big Three's Dilemma", March 16, 1998.

²³⁷ Philip H. Abelson, "The Changing Frontiers of Science and Technology", Science, Vol. 273, July 26, 1996.

²³⁸ Government Accounting Office, Evaluating U.S. Vulnerability to Oil Supply Disruptions and Options for Mitigating Their Effects, December, 1996.

²³⁹ George Lobsenz, "GAO Challenges U.S. Policy On Reducing Oil Imports As Costly, Counterproductive", The Energy Daily, vol. 24, no. 238, December 16, 1996.

²⁴⁰ James J. MacKenzie, "Heading Off the Permanent Oil Crisis", Issues in Science and Technology, Summer 1996, p. 50.

loss of wetlands, species extinction, acid rain, water shortages, loss of habitat, military nuclear waste, local air pollution, global climate change, loss of high-altitude ozone, commercial nuclear power, toxic wastes, and garbage.²⁴¹ Carlson and Goldman point out,

The biggest environmental impact of the future may be political. The growing battle over environmental issues will prove to be one of the most disruptive and politically explosive controversies of the next few decades not only in the U.S., but in the world. It will redefine political parties and political allegiances as a variety of groups fight for the commitment (along with the contributions) of the environmentally concerned public. ... Marxism's widely admitted failure to outproduce capitalism has been followed by a seamless shift in leftists' attention to the environment as the new excuse for centralized government control of the economy.²⁴²

While political processes are a necessary component of addressing complex, non-linear, multidimensional issues with multiple feedback loops, such as the environmental issue, we have concluded that political processes are not sufficient to solve these problems. Therefore, as we argue in the discussion of regulations, the U.S. must alter its regulatory development processes, particularly the processes used to develop environmental regulations, to incorporate additional modeling, simulation, and analysis.

B. Apocalyptic Scenarios

a. Too Many People and too Few Everything Else? The environmental movement has sparked support for the argument that we are running out of resources and causing the collapse of critical ecosystems. Some argue that economic growth promotes consumption of our resource base. Sagoff²⁴³ contradicts this point of view.

The idea that increasing consumption will inevitably lead to depletion and scarcity, as plausible as it may seem, is mistaken both in principle and in fact. It is based on four misconceptions:

- ◆ *We are running out of raw materials.*
- ◆ *We are running out of food and timber.*
- ◆ *We are running out of energy.*
- ◆ *The North exploits the South.*

Without economic growth, which also correlates with lower fertility, the environmental and population problems of the South will only get worse. For impoverished countries facing environmental disaster, economic growth may be the only thing that is sustainable.

²⁴¹ Richard Carlson and Bruce Goldman, Fast Forward: Where Technology, Demographics, and History Will Take America and the World in the Next 30 Years, Harper Business, 1994, p. 145.

²⁴² Ibid, p.p. 143-144.

²⁴³ Mark Sagoff, "Do We Consume Too Much?", The Atlantic Monthly, June, 1997, pp. 80-96.

The U.S. political system has tended to lurch from one projected catastrophe to the next. In recent years predictions of imminent catastrophes have included: population explosion, food production shortage, energy shortage, destruction of the environment, nuclear power accidents, nuclear winter, mineral depletion, deforestation, industrial competitiveness, mad cow disease, etc. The Economist argues that these phenomena follow a seven-year cycle.

- ◆ Year 1: Scientist discovers a potential threat.
- ◆ Year 2: Journalists oversimplify and exaggerate the threat.
- ◆ Year 3: Environmentalists get on the bandwagon, polarize the issue, and paint skeptics as lackeys of big business or some other special interest group.
- ◆ Year 4: Bureaucrats and legislators get involved and divert the issue from science to regulation.
- ◆ Year 5: A villain is picked and blamed for the problem.
- ◆ Year 6: Skeptics question the validity of the threat driving greens into paroxysms of pious rage.
- ◆ Year 7: Quiet backing off from the issue without any fanfare or admission that the threat was a phantom.²⁴⁴

Of course, the regulations and the large government infrastructure established to address the phantom threat can be left in place even when the threat is determined to be relatively unimportant. The agency with this infrastructure can continue to spin their threat scenarios. For example, the Department of Commerce Technology Administration was still proclaiming the competitiveness issue to be a threat, even after most regarded the threat to be much more limited than first thought and well under control by the private sector.

The Economist has challenged the basic assumption of many environmentalists.

*The environmentalists' underlying assumption is that nature, free of man's interference, is generally benign and stable; yet much of the scientific evidence suggests otherwise.*²⁴⁵

In 1972 the Club of Rome published the report, Limits to Growth, that predicted rapid depletion of oil reserves, natural gas, silver, tin, uranium, aluminum, copper, lead and zinc.

*In every case except tin, known reserves have actually grown since the Club's report; in some cases they have quadrupled. ... of 35 minerals, 33 fell in price during the 1980s. Only manganese and zinc were exceptions.*²⁴⁶

²⁴⁴ The Economist, "Environmental Scares", December 20, 1997, p. 21.

²⁴⁵ The Economist, "A Survey of Development and the Environment", March 21, 1998, p. 16.

²⁴⁶ The Economist, "Environmental Scares", December 20, 1997, p. 19.

In 1798 the Reverend Thomas Malthus proposed that the growth of world population would soon outstrip the food supply. His name has become a byword for alarmism and alarmists are often labeled "Malthusians". Nevertheless, apocalyptic prophecy remains a staple of our culture. For example, linear extrapolations of the world's population from its current level of 6 billion lead many to make absurd predictions of a world population near 300 billion by the middle of the 22nd century. Taking into consideration the drop in birth rates that accompany economic growth leads to predictions that the world's population will nearly double by the middle of the next century and then begin to slowly decline. While absorption of that growth will not be trivial, it pales in comparison to absorption of a hundred billion or so.²⁴⁷

The U.S. is currently the third most populated nation behind China and India. Among the industrialized nations, the U.S. is one of the fastest growing. During the first half of the 1990s U.S. population grew by 1% per year so that each year about 2.7 million people were added. In contrast, the average population growth rate for Western Europe over this period was 0.4% per year and for Japan it was 0.3% per year. Today's projections suggest that these trends will continue for the U.S. with U.S. population being almost 400 million by the middle of the 21st century.²⁴⁸

Environmental groups have often promoted the notion that population growth was a primary driver of disturbances to the U.S. ecological system. The high rate at which Americans consume energy and other resources has been of major concern to environmentalists. One often proposed solution is to stabilize population. However, of the 124 million U.S. population growth (almost 50% growth) expected by 2050, 80 million is the direct or indirect consequence of immigration policy. Because of the perception that immigration is a politically incorrect issue - most recent immigrants are so-called people of color from Asia and Latin America - most environmental groups are avoiding the subject.²⁴⁹

The Economist suggests that there are three resources that are being depleted - grain, fish and water - that are likely to attract much attention in the future.

Over the next few decades the prophets of doom and abundance will turn their attention to three resources - grain, fish and water - which are particularly important to developing countries. This time proving the doomsters wrong may prove trickier. ... According to the United Nation's Food and Agriculture Organization ... around 60% of the world's various commercial fish stocks are now being harvested near or beyond sustainable levels. ... In 50 years' time, not only will the world's population have almost doubled, but many more people will be able to afford meat, which will make huge demands on the supply of cereals. To produce a kilo of beef, takes an average of seven kilos of feedgrain. Between now and 2020, about 80% of the increase in demand for cereals is likely to be in developing countries. ... In 1990, 20 countries suffered chronic water scarcities (that is their yearly supply was less than 1,000 cubic meters of water per head), most of them in North Africa and the Middle East. By 2025, the World Bank expects the number to rise to 34. The conventional wisdom is that the wars of the next century will be over water.²⁵⁰

²⁴⁷ Bill McKibben, "Special Moment in History", The Atlantic Monthly, May, 1998, p.p. 55-78.

²⁴⁸ Carol J. De Vita, "The United States at Mid-Decade", Population Bulletin, Vol. 50, No. 4, March, 1996, p. 2.

²⁴⁹ National Journal, "Green Grows the Immigration Debate", March 7, 1998, p.p. 532-533.

²⁵⁰ The Economist, "A Survey of Development and the Environment", March 21, 1998, p.p. 13-15.

b. Are We Running Out of Oil? Apocalyptic energy supply scenarios, particularly those for oil, have so permeated the literature and the scientific community that it is very difficult to identify the truth regarding the availability of energy resources. Most of these grim predictions have been wrong.

In 1908, the U.S. Geological Survey (USGS) predicted that total future supply of U.S. oil would not exceed 23 billion barrels. In 1914, the U.S. Bureau of Mines was even more pessimistic, putting the limit at 5.7 billion barrels. In 1920, the USGS proclaimed the peak in U.S. oil production was almost reached. In 1939, the Department of Interior declared that there was only 13 years of production remaining. In 1977, President Jimmy Carter said, "We are now running out of oil." Despite those gloomy projections, the United States has produced over 200 billion barrels of oil since the early 1900s. ... Saudi Arabia has just begun to explore in older, deeper rocks that produce oil in surrounding countries. Iraq has the potential to surpass Saudi Arabia in oil reserves once exploration and development work is restarted there. Kazakhstan and Eastern Siberia are relatively unexplored potential oil producing giants. Deep-water technology is opening up large areas of the Gulf of Mexico for exploration and production. And some recent testing suggests there are oil deposits in the abyssal depths of the Atlantic Ocean. Then we have immense tar sand deposits in Canada and very heavy oil in the Orinoco Belt of Venezuela, both of which contain hundreds of billions of barrels of oil.²⁵¹

DOE's Energy Information Administration (EIA) estimates there are roughly 167 billion barrels of oil and condensate remaining in the West Siberian Basin, about the same as the 165 billion barrels remaining in the U.S., and 1,976 trillion cubic feet of natural gas in the Siberian basin, compared to 1,419 in the U.S. Saudi Arabia's oil resources are estimated at twice that of either the U.S. or the West Siberian Basin, but Saudi Arabia has significantly less natural gas than either the U.S. or the Basin. EIA predicts the West Siberian Basin will be a significant source of energy to Russia and world markets through the mid-21st century.²⁵²

Crying "wolf" about the availability of oil has left the public very skeptical, especially when it is paying less in real dollars for gasoline than at anytime in history. With gasoline prices near \$1.00 per gallon it is difficult to believe that a major problem is just around the corner. Nevertheless, it may well be. The independent oil reserve experts, Campbell and Laherrere²⁵³, point out,

From an economic perspective, when the world runs completely out of oil is ... not directly relevant; what matters is when production begins to taper off. Beyond that point, prices will rise unless demand declines commensurately. Using several different techniques to estimate the current reserves of conventional oil and the amount still left to be discovered, we conclude that the decline will begin before 2010.

²⁵¹ Robert W. Fisher, "The Future of Energy", The Futurist, September-October, 1997, pp. 43-44.

²⁵² Energy Information Administration, Oil and Gas Resources of the West Siberian Basin, Russia, December, 1997.

²⁵³ Colin J. Campbell and Jean H. Laherrere, "The End of Cheap Oil", Scientific American, March, 1998, p. 79.

Campbell and Laherrere argue that political forces encourage both oil companies and OPEC countries to exaggerate the magnitude of the oil reserves they hold and note that 80% of the oil produced today comes from fields discovered before 1973. Since 1990, oil companies have discovered about 7 billion barrels of new oil each year, but in 1997, about 21 billion barrels of oil were pumped. Yet, official estimates claimed that proved oil reserves grew by 11 billion barrels of oil in 1997. These experts believe that the oil industry has found about 90% of the world's crude oil.²⁵⁴ After 2010 as oil prices begin to rise, unconventional sources of oil - oil shale, oil sands, heavy oil - will become economical and extend the lifetime of oil sources; however, these unconventional sources will further aggravate the problems of environmental pollution. Conversion of natural gas to liquid forms of fuel will further extend the lifetime of liquid fuels.

*even today natural gas can be converted into liquid fuels at prices that are only about 10 percent higher per barrel than crude oil. Modest improvements in technology, along with the improved economics that come from making specialty chemicals as well from gas, will broaden the exploitation of this abundant commodity in coming years. Such developments will also provide remarkably clean fuels - ones that can be easily blended with dirtier products refined from heavier crude oils to meet increasingly strict environmental standards.*²⁵⁵

C. National Energy Strategy.

While one may recite a wide array of incremental advancements in energy technology, e.g., solar cells have now been improved to the point where only 7 years of operation are required to recover the electrical energy used in their manufacture²⁵⁶, it is discouraging that despite an over 20 year publicly-funded R&D program in energy, our great Nation has been unable to articulate a systems-level National energy strategy that clearly identifies the pros and cons of the issues, differentiates the roles of the private and public sectors, lays out a roadmap for energy technology development with multiple technology options, and rationalizes energy alternatives in terms of their environmental and economic costs. The President's Committee of Advisors on Science and Technology (PCAST) offered the following recommendation to the DOE,

We recommend that the Department make a much more systematic effort in R&D portfolio analysis: portraying the diverse characteristics of different energy options in a way that facilitates comparisons and the development of appropriate portfolio balance, in light of the challenges facing energy R&D and in light of the nature of private sector and international efforts and the interaction of U.S. government R&D with them.²⁵⁷ ... In the competitive environment of declining government spending on energy R&D, moreover, advocates of each energy option have tended to disparage the prospects of the other options, in hopes of gaining a greater share of the budget for their favorite. Thus, the energy community itself has formulated the arguments that budget-cutters have used to downsize energy programs one at a time ("renewables are too costly", "fossil fuels are too dirty", "nuclear fission is too risky", "fusion will never work",

²⁵⁴ Ibid.

²⁵⁵ Safaa A. Fouda, "Liquid Fuels from Natural Gas", Scientific American, March, 1998, p. 95.

²⁵⁶ Personal communication, Ward Bower, Sandia National Laboratories, to James Gover.

²⁵⁷ President's Committee of Advisors on Science and Technology Panel on Energy Research and Development, Report to the President on Federal Energy Research and Development for the Challenges of the Twenty-First Century, November, 1997, p. ES-10.

"conservation means sacrifice"), with no coherent energy-community voice calling for a responsible portfolio approach to energy R&D - that is, an approach that seeks to address and ameliorate the shortcomings of all of the options.²⁵⁸

Dr. John Gibbons, when he was Assistant to the President for Science and Technology, formed a panel of distinguished, independent experts to advise the White House on how to ensure that the United States energy program addresses the economic, environmental, and national security needs of the nation for the next century.²⁵⁹ This panel pointed out that the global warming issue is the most demanding driver for change in energy research and development. Panel members agreed that the Nation's research efforts should be modified to cope with the likelihood that man-made carbon dioxide and other greenhouses gases are changing the climate and called for tripling the federal R&D budget for nuclear fission power over the next five years. The panel recommended termination of several coal-related federal R&D programs.²⁶⁰

Mr. John A. Young, Co-Chairman of the President's Committee of Advisors on Science and Technology (PCAST) recently offered the following recommendation to President Clinton for the public investment in energy R&D,

We recommend focusing the government's energy R&D on projects where high potential payoffs for society as a whole justify bigger R&D investments than industry would be likely to make on the basis of expected private returns and where modest government investments can effectively complement, leverage, or catalyze work in the private sector.²⁶¹

D. Global Warming.

The primary issue driving the future of energy consumption is global warming produced by the combustion of oil and coal and the burning of rain forests. While it is widely accepted that global warming is a reality, it is not clear that these claims are real; if it is real, it is unclear just what is the magnitude of global warming, what the consequences will be, what it will cost to reduce global warming, and whether it is more cost effective to reduce global warming or learn to cope with it.²⁶² Schelling points out,

A committee of the National Academy of Sciences estimated in 1979 that the change in average global surface atmospheric temperature could be anywhere from 1.5 to 4.5 degrees Celsius. ... More important than the average warming is the effect it may have on climates.²⁶³

²⁵⁸ Ibid, ES-13.

²⁵⁹ The White House, Office of the Press Secretary, White House Taps Panel of Experts on Energy Research and Development, March 20, 1997.

²⁶⁰ The Wall Street Journal, "Clinton Panel Calls for \$1 Billion Rise in Energy Research Program's Spending", October 1, 1997, p. B10.

²⁶¹ Letter from John A. Young, Co-chairman of President's Committee of Advisors on Science and Technology to President William J. Clinton, dated September 30, 1997.

²⁶² Business Week, "Greenhouse Gases: The Cost of Cutting Back", December 8, 1997, pp. 64-66.

²⁶³ Thomas C. Schelling, "The Cost of Combating Global Warming", Foreign Affairs, November/December, 1997, p. 8.

Arthur Robinson and Zachary Robinson argue that while measurements show that carbon dioxide has increased its concentration in the atmosphere during the 20th century from 290 parts per million to 360 parts per million, this increased concentration has not contributed to global warming. They propose that the gradual warming the earth has experienced over the past 300 years since the Little Ice Age and the large temperature fluctuations have been caused by changes in solar activity. Their data suggest that over the past 20 years, atmospheric temperature has actually trended downward, not up, as global warming would suggest. Although the concentration of carbon dioxide in the atmosphere is increasing, increased heating of the Earth by the "thermal blanket effect" seems to not be taking place.²⁶⁴ They argue that instead of producing calamity, the increase in carbon dioxide concentration is actually promoting plant growth. They point out,

*What mankind is doing is moving hydrocarbons from below ground and turning them into living things. We are living in an increasingly lush environment of plants and animals as a result of the carbon dioxide increase. Our children will enjoy an Earth with twice as much plant and animal life as that with which we now are blessed. This is a wonderful and unexpected gift from the industrial revolution.*²⁶⁵

The Economist argues,

*Roger Revelle, nickname "Dr. Greenhouse", who fired Al Gore with global warming evangelism, wrote just before his death in 1991: "The scientific basis for greenhouse warming is too uncertain to justify drastic action at this time."*²⁶⁶

The President's Committee of Advisors on Science and Technology (PCAST) also point out the uncertainties surrounding the global warming issue,

*Some members of the research community think the Intergovernmental Panel on Climate Change (IPCC) projections of future climate change and its consequences are too pessimistic. Others think they are too optimistic. And some contend that adaptation to climate change would be less difficult and less costly than trying to prevent the change, whereas others argue that a strategy combining prevention and adaptation is likely to be both cheaper and safer than one relying on adaptation alone.*²⁶⁷

Frank Wentz, a physicist at Remote Sensing Systems, has recently found an error in satellite measurements of the earth's surface temperature, that indicate that the earth has been heating rather than cooling by 0.05°C per decade as satellite measurements have suggested. This discovery strengthens the case for global warming; nevertheless, to accurately track earth

²⁶⁴ A. B. Robinson, S. L. Balin, W. Soon, and Z. W. Robinson, Environmental Effects of Increased Atmospheric Carbon Dioxide, January, 1998.

²⁶⁵ Arthur B. Robinson and Zachary W. Robinson, "Science Has Spoken: Global Warming Is a Myth", The Wall Street Journal, December 4, 1997.

²⁶⁶ The Economist, Environmental Scars, December 20, 1997, p. 21

²⁶⁷ President's Committee of Advisors on Science and Technology Panel on Energy Research and Development, Report to the President on Federal Energy Research and Development for the Challenges of the Twenty-First Century, November, 1997, p. ES-10.

temperature changes by satellites over several decades, much more sophisticated instruments must be developed and placed in space.²⁶⁸

It has been predicted that global warming will cause flooding (sea levels will increase from 6 inches to 3 feet), severe windstorms and heat waves in cool regions. It is predicted to turn plush farmland into deserts and destroy wetlands. Diseases of Central America - malaria, dengue-hemorrhagic fever, etc - will move into the U.S. Calvin offers perhaps the grimdest scenario. He proposes that the additional rainfall that will fall in the North Atlantic because of global warming will disturb the evaporation of warm salt water that has flowed into this region from the South Atlantic. Dry winds blowing over Canada are warmed as they pass over this water. These winds cause the temperature of Western Europe to be raised by 10°C to 20°C degrees in the winter in comparison to equivalent latitudes in Canada. He predicts that the downwelling sites that carry the post-evaporated, dense, highly salty surface water to the bottom of the ocean for its return back to the South Atlantic region will be disturbed and the flow of warm water into the North Atlantic region will be stopped. When that happens, Calvin predicts that Europe will be abruptly triggered into a cold period and that our current unprecedented period of climate stability will come to an end.²⁶⁹ Fortune reported,

Scientists believe monster cold snaps can occur when a huge gyre of water in the Atlantic Ocean, called the thermohaline cycle stops flowing. ... Climate models suggest the cycle may shut down if a lot of fresh water flows into the North Atlantic, which is just what will happen as global warming melts Arctic ice. In a recent study published in the journal Nature, Swiss scientists projected that a thermohaline shutdown may be likely within a century if CO₂ emissions continue at today's rate.²⁷⁰

Global warming is principally caused by carbon dioxide (CO₂), carbon monoxide (CO), and other gas emission from combustion processes (Combustion of 1 gallon or 8 pounds of gasoline releases about 5.5 pounds of carbon in the form of carbon dioxide.) and processes related to the decomposition of organic materials. Carbon undergoes a very complex movement from plants, to the atmosphere, to the oceans and ground, into the atmosphere, into plants, etc. For example, the oceans annually absorb 93 billion tons of carbon in the form of carbon dioxide and annually release through biological and chemical processes 90 billion tons of carbon. Thus, oceans annually serve as a sink for 3 billion tons of carbon. Plant photosynthesis annually absorbs 110 billion tons of carbon, but decomposition of plants and animal life annually releases another 54 to 55 billion tons of carbon. Respiration by animal life annually releases 55 billion tons of carbon. Thus, respiration and decomposition are offset by photosynthesis. Fossil fuel combustion annually releases 5 billion tons of carbon and deforestation annually releases between 1 and 2 billion tons of carbon. Thus, the excess absorptive capabilities of the oceans are only able to offset 3 billion tons of the 6 to 7 billion tons of carbon released by man. Therefore, 3 to 4 billion tons of carbon remains in the atmosphere each year where it joins another 740 million tons of carbon that is already resident.²⁷¹

Measurements confirm that the concentration of carbon dioxide in the atmosphere is increasing. The debate is whether or not this increased concentration is causing the Earth's temperature to

²⁶⁸ Science News, "Satellites Misread Global Temperatures", August 15, 1998, p. 100.

²⁶⁹ William H. Calvin, "The Great Climate Flip-Flop", The Atlantic Monthly, January, 1998.

²⁷⁰ Fortune, "Science Says The Heat Is On", December 8, 1997, p. 129.

²⁷¹ These data were provided to James Gover by Ehsan Khan, U.S. DOE.

rise, and, if so, how much, or if the observed temperature rise, evidenced by melting glaciers and measurements of atmospheric temperature, is driven by other effects, e.g., increased sun intensity. However, classical models of radiation transport, thermodynamics, and heat transport suggest that increased concentration of carbon dioxide in the earth's atmosphere should cause increased heating of the earth.

Less than 4% of greenhouse gases are by man-made emissions; however, these man-made emissions are thought by some to have raised the temperature of the earth by between 0.3°C and 0.6°C over the past 100 years. A fall of 2°C is believed to have triggered the last ice age over 100,000 years ago.²⁷² So small temperature changes have monumental effects.

In 1987 Brazil released as much carbon into the atmosphere by burning trees in their rain forests as the U.S. produced by burning fossil fuels. Carbon release into the atmosphere is a direct consequence of energy consumption and economic development. Although the U.S. currently consumes about 25% of the world's energy, as the third world develops, it will increase its energy consumption. China, for example, has begun a massive program to build electric power plants largely fueled by coal. Major issues are how these will contribute to further degradation in China's environment and their impact on global warming due to growth in coal combustion. China is planning to build 135 GW of new electric power plants by the year 2,000 and 270 GW by the year 2010. In addition to 9 GW of nuclear powered electric plants, by the year 2000, China will add 40 GW of hydroelectric power and 86 GW of coal powered electric plants.²⁷³ By 2020, China will have increased its consumption of coal, 80% of it unwashed, by between 100% and 200% over today's use levels. Currently, China's carbon emissions are about one-half those of the U.S.; however, by 2050, their emissions will be several times those of the U.S.

Global warming could be aggravated both by population growth and the per capita increased consumption of energy by growing economies. Population doubling by the middle of the next century can stress the earth's grain-growing capacity, particularly as populations consume more meat. McKibben notes, however, that it is the world's affluent that most stress the people carrying capacity of the earth.

Even if all such effects as the clearing of forests and the burning of grasslands are factored in and attributed to poor people, those who live in the poor world are typically responsible for the annual release of a tenth of a ton of carbon each, whereas the average is 3.5 tons for residents of the "consumer" nations of Western Europe, North America, and Japan. The richest tenth of Americans ... annually emit eleven tons of carbon apiece.²⁷⁴

While we express concern about the future contribution of China to global warming, it is the developed nations that are currently responsible for global warming, it is the developed nations that are most affected by carbon emissions, and it is the developed nations that will have to pay for research on global warming. Schelling points out,

²⁷² The Economist, "A Cooling Off Period", November 29, 1997, p. 83.

²⁷³ Milton Russell, "Energy Prospects in China", in Energy and National Security in the 21st Century, edited by Patrick L. Clawson, National Defense University Press, October, 1995.

²⁷⁴ Bill McKibben, "Special Moment in History", The Atlantic Monthly, May, 1998, p.p. 55-78.

*Any costs of mitigating climate change during the coming decades will surely be borne by the high-income countries. But the benefits, despite what spokespeople or the developing world says, will overwhelmingly accrue to future generations in the developing world. Any action combating global warming will be, intended or not, a foreign aid program. The Chinese, Indonesians, or Bangladeshis are not going to divert resources from their own development to reduce the greenhouse effect. ... Their best defense against climate change and vulnerability to weather in general is their own development, reducing their reliance on agriculture and other such outdoor livelihoods. Furthermore, they have immediate environmental problems - air and water pollution, poor sanitation, disease - which demand earlier attention.*²⁷⁵

The agreements recently forged in Kyoto resulted in Japan agreeing to a 6% reduction in warming gases, the U.S. agreeing to a 7% reduction, and industrialized Europe agreeing to an 8% reduction between 1990 and 2010 emission levels. However, the U.S. Senate is unlikely to ratify the Kyoto agreement. Emerging countries agreed to no additional constraints. If the U.S. were to stabilize carbon emissions in 2010 at 1990 emission levels, it would be necessary to reduce emissions by about 400 million metric tons (mt) of carbon per year.²⁷⁶ To achieve this reduction requires that utilities reduce carbon emission by 8% to 22% of their projected 2010 emission level; industry reduce carbon emission by 10% to 17% of their projected 2010 emission level; buildings consumption of energy be reduced by 7% to 10% of 2010 projections; and transportation reduce carbon emission by 15% from projected 2010 projected emission levels. Estimates of the annual costs of achieving these reductions range from \$50 billion to \$90 billion; the annual economic benefits are estimated to be about \$20 billion.²⁷⁷

The importance of the issue of global warming and its impact on global climate change demand that modeling and research directed toward global warming be an international effort. U.S. efforts must involve multiple agencies; multiple laboratories, particularly those with access to supercomputers that can support modeling efforts; and universities. Bertholf and Dyer propose that the U.S. establish a consortium of agencies and a consortium of Federal laboratories that supports a long view of the nation's strategic response to global warming and global climate change. We must bring the best super computer modelers in the U.S. to bear on this issue, and immediately, before establishing regulations that are either ineffective or have costs that exceed benefits. It is especially important that we are able to predict climate effects and costs as well as the costs and benefits of regulations that global climate change might inspire. Bertholf and Dyer propose that a Federal Government Corporation (GSC) called Climatology Incorporated be established to govern U.S. climate research and modeling and that this GSC oversee and direct work that multiple agencies, Federal laboratories, and universities conduct on global climate change. This GSC would be configured much as the Galvin Task Force recommended for the DOE national laboratories.²⁷⁸

²⁷⁵ Thomas C. Schelling, "The Cost of Combating Global Warming", Foreign Affairs, November/December, 1997, p. 8.

²⁷⁶ DOE Interlaboratory Working Group, Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond, LBNL-40533 and ORNL/CON-444, September, 1997.

²⁷⁷ Joseph Romm, Mark Levine, Marilyn Brown, and Eric Petersen, "A Road Map for U.S. Carbon Reductions", Science, January 30, 1998, pp. 669-670.

²⁷⁸ Larry Bertholf and Mike Dyer, Climatology Inc.: A Governance Proposal for Global Climate Change, Sandia National Laboratories, March 4, 1998.

E. Other Environmental Costs/Concerns.

a. Air Pollution. Major environmental concerns surround water resources, air quality, waste production, and remediation efforts throughout the world. Most of these are directly or indirectly related to energy consumption.

While on the one hand the doom prophets tell us that we are choking on air pollution resulting from combustion of fossil fuels, we learn from other quarters that the U.S. is making great progress in cleaning up the air. It has been noted, for example, that total emissions of the six principal air pollutants monitored by EPA have decreased by 28 percent and lead concentration in the air has decreased by 78 percent while our population grew by 28 percent, we doubled our gross domestic product, we placed 60 percent more drivers and 80 percent more vehicles on the road, and we doubled the number of miles driven. The auto industry argues that it takes 20 of today's new cars to produce as much tailpipe pollution as one new car did 30 years ago.²⁷⁹

The purists argue that we have made progress, but that much more progress is needed to clean up air pollution. Although many U.S. cities have made dramatic improvements in their air quality, 40 urban areas continue to violate at least one of the U.S. ambient air quality standards. Most air pollution arises from consumption of fossil fuels.

The price that the American consumer pays for energy, particularly gasoline, does not include its environmental costs. It has been estimated that the annual environmental cost of gasoline due to air pollution is \$300 billion per year, or \$2.00 per gallon of gasoline consumed.²⁸⁰ If Americans were to pay for all the costs of their car culture, including noise pollution and environmental restoration costs, but not including global warming, it has been estimated that they would pay \$8.00 per gallon for gasoline.²⁸¹

While the U.S. is making progress in cleaning up air pollution, that is not the case in the developing world. Already 60% to 90% of the rainfall in Guangdong, the province that is the center of China's economic boom, is acid rain. Although China's economy has been growing at a 10% annual rate, it has been estimated that the environmental cost of this growth ranges between 7% and 15% of China's GDP. When China's political system trades-off the cost of environmental degradation and global warming against the cost of slowing economic growth, it becomes very difficult to take action to protect the environment despite the fact that 26% of all deaths in China are claimed to be due to respiratory disease caused by dirty air and smoking.

All Chinese over forty have firsthand memories of the greatest man-made disaster of the twentieth century, the famine caused by Mao Zedong's Great Leap Forward campaign. ... the famine killed some 30 million people from 1959 to 1961 and brought starvation, misery, and even cannibalism to rural China. ... Most Chinese accept the familiar idea that economic growth requires environmental damage, and they are quite ready to pay that price. ... The crowning irony is that even China's top environmental officials accept

²⁷⁹ Keep America Moving, Environment and Clean Air, 1997.

²⁸⁰ Jeffrey R. Vincent and Theodore Panayotou, "Consumption: Challenge to Sustainable Development or Distraction?", Science, April 4, 1997, p 54.

²⁸¹ J. Konheim and B. Ketcham, Costs of Roadway Transportation, Konheim and Ketcham, 1992.

*that economic growth must take precedence over environmental protection for years to come.*²⁸²

b. Water Contamination. Although 75% of the earth's surface is water, only 2.5% is fresh water and about two-thirds of this water is frozen in Antarctica and Greenland. Reducing use of surface water reduces the amount of wastes discharged into streams and it reduces the amount of energy needed to treat wastewater. The Economist reports,

*Dirty water costs millions of lives a year, but somehow global conferences on diarrhea do not make the front pages.*²⁸³

We must continue to make progress in controlling the pollutants that enter all of our surface waters. Asia's rivers have ten times as many bacteria from human waste as waterways in rich nations.

*A World Bank study last year put the cost of air and water pollution in China at \$54 billion a year, equivalent to an astonishing 8% of the country's GDP. Another study estimated the health costs of air pollution in Jakarta and Bangkok in the early 1990s at around 10% of these cities' income. ... In terms of the number of people it kills, dirty water is probably the world's most serious pollution problem.*²⁸⁴

Roughly 50% of all Americans get their house water from underground sources. In addition, underground water is used for about 50% of agriculture irrigation and it accounts for about 30% of industrial water use. Although contamination of underground water often goes undetected for many years, landfills, pesticides, septic tanks and other surface activities are increasingly spoiling underground water. Depletion of ground water reserves is a growing concern, particularly in the midwestern and western states. In the transportation of fresh water through city water systems as much as 25% is lost through leaks and broken water mains.

E. The Nuclear Power Option

Around the world, electric energy is produced 64% from fossil fuels, 17% from nuclear fission, and 18% from hydroelectric dams.²⁸⁵ The U.S. generates 55% of its electricity from coal; however, since 1984, most of the new electricity generating capacity in the U.S. has been natural gas-fired turbines. Combustion of natural gas releases about 40% less carbon dioxide than combustion of coal to produce the same electrical energy. The Economist reports that by 2002, Allied Signal expects to sell a 75 kw, natural gas powered, micro turbine capable of supplying power for a fast food restaurant at an initial capital cost near \$25,000.²⁸⁶ Although the jury is still out on the global warming issue, the fission-based nuclear power option, fuel cells, and renewable energy options must be reexamined from a systems perspective for generation of electric energy. Much attention must be given to including environmental effects and inherently safe systems when comparing the costs of nuclear and fossil fuel alternatives.

²⁸² Mark Hertsgaard, "Our Real China Problem", The Atlantic Monthly, November, 1997, pp. 97-114.

²⁸³ The Economist, "A Cooling Off Period", November 29, 1997, p. 85.

²⁸⁴ The Economist, "A Survey of Development and the Environment", March 21, 1998, p. 5.

²⁸⁵ Robert W. Fisher, "The Future of Energy", The Futurist, September-October, 1997, pp. 45.

²⁸⁶ The Economist, "Power to the People", March 28, 1998, p. 62.

Wolfe proposes that our energy future may require increased dependence on nuclear fission²⁸⁷,

Considering the growth in energy demand and the risks associated with other energy sources, the benefit-risk ratio for nuclear power is very attractive. ... The 74 nuclear energy plants that came on line (in the U.S.) in this period (1973-1995) increased nuclear's share of electricity generation from 4% in 1973 to more than 20% today, second only to coal. ... The substitution of nuclear for fossil-fueled plants has reduced present CO₂ atmospheric emissions by more than 130 million metric tons of carbon per year, roughly 10% of total U.S. CO₂ production. Nevertheless, the United States still needs to reduce carbon production by an additional 10% to reach its goal of returning to the 1990 production level. In addition, replacement of fossil-fuel plants with nuclear power has reduced nitrogen oxide emissions to the air by over 2 million tons annually, ... and has reduced sulfur dioxide emissions by almost 5 million tons per year, half the goal for the year 2000.

The People's Daily Overseas Edition reports that China expects nuclear power generation to increase by 400 percent - to 9,000 megawatts (9 GW) - by 2003. Over the next decade, China plans to build over 100 new electric power plants, annually adding 18 GW of capacity. Four of these will be new nuclear power plants built in China's energy-starved coastal regions by the year 2000. China has two operating nuclear plants, one in Daya Bay in southern Guangdong province and one in Qinshan in eastern Zhejiang province, south of Shanghai. Plans call for construction of new nuclear power plants in the provinces of Shandong, Fujian, Zhejiang, Guangdong, Jiangxi, and Hunan.²⁸⁸

In the U.S., nuclear power plants produce electricity at an average cost of 1.92 cents per kilowatt-hour in comparison to a cost of 1.88 cents per kilowatt-hour for coal.²⁸⁹ Natural gas costs 2.68 cents per kilowatt-hour and oil generated electricity costs 3.77 cents per kilowatt-hour. Over the last decade the production costs of U.S. nuclear power have decreased by 34%. In the U.S., 109 nuclear power plants provide 22% of the electric power we consume.²⁹⁰ Nevertheless, the public retains many fears about nuclear power. Part of the public's disaffection with nuclear power stems from the following.

- ◆ The \$230 billion clean-up cost of the U.S. nuclear weapons complex²⁹¹ (clean-up of the Hanford, Washington site is projected to cost \$49 billion over the next 75 years²⁹²) has led the public to believe that environmental contamination is an inevitable consequence of nuclear power.
- ◆ The over one trillion dollar cost of cleaning-up the Russian nuclear weapons complex and the high cost and loss of life stemming from the Ukrainian nuclear power accident at

²⁸⁷ Bertram Wolfe, "Why Environmentalists Should Promote Nuclear Energy", Issues in Science and Technology, Summer 1996, p.p. 55-60.

²⁸⁸ Sandia Daily News, August 7, 1997.

²⁸⁹ Pamela Newman-Barnett, "Is Nuclear Economic? Depends On Whom You Ask", The Energy Daily, vol. 24, no 240, December 18, 1996.

²⁹⁰ Bernard L. Weinstein, "Don't Write Off Nuclear Power Industry Just Yet", Albuquerque Journal, June 9, 1997, p. A7.

²⁹¹ The Economist, "Costing a Bomb", January 4, 1997, p. 30.

²⁹² The Washington Post Weekly Edition, "The Dark Side of Paradise", July 8-14, 1996, p. 6.

Chernobyl have also contributed to the above perception and led the public to believe that the risk of nuclear power plant accidents is unacceptable.

- ◆ Because of the hostility of the press toward nuclear power, nations' bureaucrats tend to not inform the public when there are problems with nuclear power plants. This contributes to further mistrust by the press and the public. For example, the chief investigator of Japan's Power Reactor and Nuclear Fuel Development Corp. shocked Japan's citizens with the announcement that the state-run nuclear oversight agency deliberately destroyed photos of the country's worst atomic accident in April 1997. In the accident at the Tokaimura processing plant, about 75 miles north of Tokyo, there was a fire, then an explosion caused by failure to extinguish the blaze properly. Several workers were exposed to radiation. A power plant at Fukushima, 125 miles north of Tokyo, had to be shut down because of a brief rise in radiation from exhaust gases.
- ◆ The news media, including senior commentators with the highest levels of public trust, led the public to believe that their health was threatened by the accident at Three Mile Island.
- ◆ The inability of the Nation to resolve the issue of nuclear waste storage and its apparent willingness to accept the most hazardous storage option, doing nothing, has further compromised public trust. For example, the WIPP site has been ready for low level waste storage for ten years while the politicians debated road construction and low-level medical waste continued to pile-up.
- ◆ The connection, both imaginary and real, between nuclear power and nuclear weapons proliferation has aggravated public concerns.
- ◆ The U.S. government and the press have failed to inform the public of all the dangers and costs associated with each energy alternative, including nuclear. The public has not been made to understand that none of the energy alternatives are risk-free. For example, largely because of fossil fuel consumption, over the past 200 years carbon dioxide levels in the atmosphere have increased almost 30% and, if fossil fuel consumption continues to grow as projected, atmospheric carbon dioxide concentration may double in the next century. Furthermore, coal combustion introduces more radioactivity into the atmosphere than nuclear power.
- ◆ By framing nuclear power as a technical issue when it is and has been, in fact, more an issue of public policy, public safety, sociology, economics, political science, and management of multi-billion dollar construction projects, the nuclear power technical community has not served its own interests. Ignoring these "soft science" areas as areas of legitimate research in professional conferences and university curricula in nuclear engineering while concentrating on relatively trivial technical issues such as detailed measurement of neutron cross-sections was nothing less than a strategic blunder and a classic case of "shooting oneself in the foot". Institutions and professions that wish to only concentrate on narrow technical areas will become increasingly irrelevant as we move into the 21st century and the public seeks systemic solutions to problems.

- ◆ The scientific community that is engaged in research on renewable energy sources and those agencies that fund them have led the public to have exaggerated expectations for the economic potential of renewable energy alternatives. A high-level, superficial look leads to expectations well in excess of what renewable energy alternatives can deliver. For 35 years we have been told that fusion power was only 35 years from realization. The potential of solar power has also been inflated.

While the public has been highly sensitized to the dangers of nuclear power, it is much less familiar with the public health dangers of coal consumption. Many in the scientific community have expressed opposition to nuclear power without examining the environmental consequences of alternative energy sources. For example, when one of us served in the American Association for the Advancement of Science Congressional Fellows Program, he was particularly struck by the strength of the anti-nuclear convictions of this group of Ph.D. scientists. Even though they were highly sensitive to the issue of global warming, they were unwilling to consider nuclear power as an alternative to fossil fuel consumption in order to protect against global warming.

The President's Committee of Advisors on Science and Technology made the following observation about nuclear fission,

Several problems compromise fission's potential as an expandable energy source today and into the future: disposal of spent nuclear fuel; concerns about nuclear weapons proliferation; concerns about the safe operation of (nuclear power) plants; and uncompetitive economics. But given the projected growth in global energy demand as developing nations industrialize, and given the desirability of stabilizing and reducing GHG (greenhouse gas) emissions, it is important to establish fission energy as a widely viable and expandable option if this is at all possible. A properly focused R&D effort to address the problems of nuclear fission power - economics, safety, waste, proliferation - is therefore appropriate.²⁹³

Senator Domenici emphasizes the importance of nuclear fission in curbing global warming. He recently remarked,

The President has outlined a program to stabilize the U.S. production of carbon dioxide and other greenhouse gases at 1990 levels by some time between 2008 and 2012. Unfortunately, the President's goals are not achievable without seriously impacting our economy. ... to (reach) the President's goals we would have to impose a \$50/ton carbon tax. That would result in an increase of 12.5 cents/gallon for gas and 1.5 cents/kilowatt-hour for electricity — almost a doubling of the current cost of coal or natural gas-generated electricity. What the President should have said is that we need nuclear energy to meet his goal. After all, in 1996, nuclear power plants prevented the emission of 147 million metric tons of carbon, 2.5 million tons of nitrogen oxides, and 5 million tons of sulfur dioxide. Our electric utilities' emissions of those greenhouse gases were

²⁹³ President's Committee of Advisors on Science and Technology Panel on Energy Research and Development, Report to the President on Federal Energy Research and Development for the Challenges of the Twenty-First Century, November, 1997, p. ES-19.

*25 percent lower than they would have been if fossil fuels had been used instead of nuclear energy.*²⁹⁴

F. Other Energy Alternatives.

Major companies are giving serious consideration to hydrogen power for use in automobile and power plant applications. Toshiba and United Technologies are developing phosphoric acid fuel cells as a distributed generation replacement for large power plants and Daimler Benz and Toyota are developing proton-exchange fuel cells. The latter would drive electric motors as a power source for transportation vehicles currently powered by combustion engines. A fuel cell converts 30% to 40% of its fuel energy into useful work in transportation applications in comparison to 20% conversion of gasoline in a combustion engine.

Toshiba plans to have natural gas powered commercial fuel cell products available by 2002 and have 2 Gw of generation capacity installed by 2010. The Toshiba fuel cells currently cost about twice as much to manufacture as alternative power sources. Both Daimler-Benz and Toyota have built ethanol-powered fuel cell driven small cars. Daimler-Benz plans to market a fuel cell powered Mercedes in 2003 and expects to sell 100,000 fuel cell powered engines by 2005. However, fuel cells for automobile applications currently cost about \$5,000 per kilowatt in comparison to \$50 per kilowatt for combustion engines. (The Mercedes power plant will provide 50 kilowatts.) U.S. auto manufacturers are concentrating on gasoline powered fuel cell development.²⁹⁵

Photovoltaic arrays are believed by many to be a credible energy alternative, and they are for selected applications. The problems with photovoltaic arrays use on the earth's surface include: the sun is available for energy generation by photovoltaic cells less than 50% of the time, photovoltaic arrays are not useful for extended periods of cloudy weather, photovoltaic arrays aren't cost competitive (when compared to bulk power generation, but they are competitive with diesel generators for remote power generation), and it takes 7 years of operation to recover the electrical energy used to produce the array. About 70% of the entire U.S. supply of photovoltaic sources are exported to developing countries for remote power applications where the costs of building power distribution networks are excessive.

It will likely take 20 years for renewable energy sources to have a major impact on global energy needs. If we are to meet the Kyoto targets, U.S. energy experts have emphasized the following actions must be taken.

- ◆ Major push for renewable energy.
- ◆ Major increase in the efficiency of energy use.
- ◆ Major push for nuclear fission including resolving the nuclear waste problem.
- ◆ Major reduction in fossil fuel use with natural gas serving as a replacement in some applications.

²⁹⁴ Senator Pete V. Domenici, Future Perspectives on Nuclear Power, keynote address at the annual meeting of the American Nuclear Society, Albuquerque, New Mexico, November 17, 1997.

²⁹⁵ The Economist, "At Last, the Fuel Cell", October 25, 1997, pp. 89-92.

- ♦ Maybe carbon sequestration.²⁹⁶

G. Energy and Environmental Research

About 90% of the Federal investment in energy R&D are managed by DOE who spent \$1.28 billion on R&D for applied energy technology in 1997. In addition, DOE spent \$640 million on basic energy sciences. It is estimated that U.S. companies are spending about \$2.6 billion on energy R&D and states are spending about \$200 million on energy R&D.²⁹⁷ Thus, the annual U.S. investment in energy R&D is about \$4.7 billion for an industry sector whose annual sales are about \$525 billion. Thus, the total public and private U.S. R&D investment in energy R&D is slightly less than 1% of sales. Furthermore, because the private R&D investment stream is focused on making profits for private firms while the public R&D investment stream is focused on issues of importance to the general public, there is little overlap in these two investment streams. The U.S. investment in energy R&D is at the level of investment characteristic of a mature industry in which few public issues remain for consideration and there are few economic opportunities for companies. However, as we have pointed out throughout this discussion, because of environmental issues, the energy industry is likely to undergo a great deal of change.

It became apparent as we examined the energy and environment issues that these two issues are so naturally linked that they must not be separated in systems modeling and analysis of either issue. Neither should their research be separated institutionally. We must explore extensive research related to global warming. This includes,

- ♦ Research that investigates ways to promote additional carbon dioxide absorption by the ocean.
- ♦ Global climate modeling that includes ocean currents and permits predictions of how global warming will affect various regions of the world and identifies the lowest cost ways to cope with these effects.
- ♦ Modeling of various energy alternatives and their impact on global warming.

6. The Crime Problem:

A. Economics of Crime

America's crime problem is estimated to have direct and indirect annual economic costs to victims (includes quantitative estimates of the cost of pain, suffering, and lost quality of life of victims) of \$450 billion. Its total social costs also include, in addition to victimization costs, judiciary system costs and the hidden costs of crime, e.g., altered behavior due to fear of crime. In 1990, the U.S. spent \$75 billion on the law enforcement and criminal justice systems, another \$50 billion on private security agencies, and untold amounts on technology to protect homes and businesses.²⁹⁸

²⁹⁶ Personal communication, Dr. Dan Arvizu, Director, Sandia National Laboratories.

²⁹⁷ President's Committee of Advisors on Science and Technology Panel on Energy Research and Development, Report to the President on Federal Energy Research and Development for the Challenges of the Twenty-First Century, November, 1997, p. ES-11.

²⁹⁸ National Institute of Justice Conference Report, Law Enforcement Technology for the 21st Century, June 1994.

Violent crime accounts for \$426 billion in personal costs to victims and property crime victimization costs are \$24 billion per year. These estimates include white-collar crime, personal fraud, and drug crimes. When pain, suffering, and lost quality of life are included, rape has the highest victimization cost - \$127 billion annually for the 170,000 rape victims - and well exceeds the estimated annual cost of either burglary or larceny.

The actual or real accountable economic cost of crime to victims may actually be less than \$20 billion per year. It must be emphasized that victimization data provides an absolute upper bound on the economic costs of crime. Irwin, Austin, and Baird argue,

Of the \$450 billion figure, 77% is attributed to so-called quality-of-life costs that are based on civil case jury awards. What is wrong with this approach is that very few criminal cases go to civil trials because the typical victim loss is minimal. The Department of Justice reports that most crimes have either no victim loss or less than \$200 in victim loss, including medical expenses and lost wages. To assume that the rarely invoked civil case awards are representative of all crimes is absurd.²⁹⁹

There are approximately 48 million crime attempts annually in the U.S. More than 16 million of these are violent crimes and attempted violent crimes (murder, rape, robbery, assault, child abuse, drunk driving, and arson). In 1990, 31,000 deaths, roughly 75 percent of the number of deaths attributable to automobile accidents, resulted from crime.

It is estimated that 5.5 million Americans are in need of treatment for drug abuse.³⁰⁰ About 3.6 million have a cocaine habit and there are 810,000 users of heroin. Of the total population of those abusing illegal drugs, about 850,000 are in prison for drug offenses. Research conducted in 1993 suggests that Americans spent between \$49 billion and \$90 billion on illegal drugs.³⁰¹ The U.S. expenditure on prescription drugs in 1998 is about \$80 billion and for over-the-counter drugs it is about \$20 billion. With the introduction of Viagra, an impotence drug projected to have annual sales of \$10 billion, and Lipitor, a cholesterol reducer projected to have annual sales of \$6 billion, prescription drug sales are likely to experience substantial growth in 1998.³⁰² The Economist reports,

Some surveys estimate that 140,000 people a year die from the side effects of prescribed drugs. That compares with some 14,000 who die each year from illegal drugs such as heroin.³⁰³

Americans are very worried about crime and often list it as their principal National anxiety. A survey showed that 61% of Americans are concerned that crime will increase in the future and 55% are concerned that the use of illegal drugs will increase.³⁰⁴

²⁹⁹ John Irwin, James Austin, and Chris Baird, "Fanning the Flames of Fear", Crime and Delinquency, January 1998, Vol. 44, No. 1, p. 38

³⁰⁰ Ted R. Miller, Mark A. Cohen, and Brian Wiersema, Victim Costs and Consequences: A New Look, National Institute of Justice Research Report, February, 1996.

³⁰¹ W. Rhodes, P. Scheiman, T. Pittayathikhun, L. Collins, V. Tsarfaty, What America's Users Spend on Illegal Drugs, Report to U.S. Executive Office of the President Office of Drug Abuse Policy, 1995.

³⁰² Business Week, "The New Era of Lifestyle Drugs", May 11, 1998, p. 94.

³⁰³ The Economist, "Give Them Their Pills, the Fuddled Massses", May 2, 1998, p. 24.

³⁰⁴ The Washington Post National Weekly Edition, "What About Us?", September 23-29, 1996, p. 9.

While one may look at absolute statistics, it is also important to compare the growth of crime in the U.S. to its growth in other countries and to compare the response of the U.S. political system to crime and criminals to that in other countries. Are we the sanctuary for criminals as many Americans fear? In fact, the only categories of crime frequency where the U.S. leads the world are murder and violent crime that seemingly lacks any rational motive.

*America is not obviously more criminal than anywhere else. You are more likely to be burgled in Australia or New Zealand. You are more likely to be robbed with violence in Spain; you are more likely to be robbed without violence in Spain, Canada, Australia, and New Zealand. You are more likely to be raped or indecently assaulted in Canada, Australia or western Germany. ... While you are more likely to be burgled in Sydney than in Los Angeles, you are twenty times more likely to be murdered in Los Angeles than in Sydney. ... Americans are right to think that they have a special problem of violence. They are wrong to think their country is being overwhelmed by crime of every sort. Yet because many people do think that, they are throwing their weight behind indiscriminate policies which, at huge cost, bludgeon crime as a whole but fail to tackle the problem of violence.*³⁰⁵

The inability of the U.S. to address the crime problem almost entirely stems from the fact that it is a public problem whose solution falls under the purview of our political system. For reasons that escape our understanding, the crime problem is one that every person in the country, including politicians, seems to believe has a straightforward answer and, therefore, does not need meaningful research.

*This makes it harder than ever to conduct an intelligent debate on crime and punishment. The traditional quarrel between the two rival camps - "liberals" emphasizing rehabilitation, the social roots of crime and the rights of the accused, and "conservatives" emphasizing deterrence, retribution and the rights of victims - never sheds much light. ... Instead of debate, there is a growing, unexamined consensus among politicians that the popular demand for greater severity, for sending more people to prison for longer, must be appeased. Yet the evidence suggests that such an approach will fail, may even make matters worse - and all at great expense.*³⁰⁶

The U.S. attraction to capital punishment appears to the rest of the civilized world to be inconsistent with our values and those values we attempt to impose on the rest of the world. The Economist reports,

*All of which makes the United States a puzzling anomaly. It has done more than any other country to promote human rights as a topic of international concern; its legal protections for accused individuals are among the most rigorous and long established in the world. Yet it is ever more gung-ho for capital punishment.*³⁰⁷

³⁰⁵ The Economist, "Crime in America: Violent and irrational - and that's just the policy", June 8, 1996, p. 23.

³⁰⁶ The Economist, "Crime and Punishment", June 8, 1996, p. 17.

³⁰⁷ The Economist, Review of Books and Multimedia, "Cruel and Ever More Unusual", February 14, 1998, p. 3.

Because the U.S. hands out only 250 death sentences each year for the 31,000 deaths that result from crime, the odds of someone committing murder being caught and given a death sentence are very low, particularly if the victim is black or the offender is white. When a death sentence is handed out the costs are outrageous and the only ones to benefit are lawyers.

Of the 4,016 people executed between 1930 and 1990, 53% were black, yet black people comprised only 12% of the American population. And death sentences are 4.3 times more likely to be imposed on convicted murderers if their victims were white than if their victims were black. ... After trials, appeals, reviews and years on death row, executions cost between three and six times what it cost to keep somebody in a maximum security prison for 40 years ... In California and Florida, for instance, the state supreme courts spend about half their time reviewing capital cases.³⁰⁸

Americans views on capital punishment have little to do with reason, cost analysis or pragmatism by either the pro-capital punishment advocates or the anti-capital punishment advocates. Authoritarians, who see social discipline, law and order and old-fashioned, God-fearing values slipping away support capital punishment. Political liberals and the deeply religious oppose capital punishment on moral grounds.³⁰⁹ The fact that capital punishment isn't cost effective, ties up the services of highly educated lawyers that might otherwise provide value-added services to society, and provides few or no social benefits are not arguments emphasized by either the critics or supporters of capital punishment.

B. Juvenile Crime.

In 1994, 45 percent of those arrested in the U.S. were under 25 years of age. Many of those arrested were under age 18. Of particular concern in crime growth in the U.S. is the increased role of juveniles in committing crimes, especially violent crimes. In 1995 law enforcement agencies arrested 2.7 million people under age 18 - juveniles accounted for 18% of all arrests. In 1995, juveniles were involved in 32% of all robbery arrests, 23% of all weapon arrests, 15% of all murder and aggravated assault arrests, and 13% of all drug arrests. In 1995, the racial composition of the juvenile population was 80% white (includes Hispanics), 15% black, and 5% other. Roughly equal numbers of violent crime arrests were for white juveniles and black juveniles.³¹⁰ Over the past 25 years, the arrest rate for murder by juveniles has quadrupled and their arrest rate for rape and robbery has more than doubled. About 70% of juvenile offenders come from single parent families. Putting a child in reform school for one-year costs about \$50,000.³¹¹ This is about 25 percent more than sending them to college at a private university.

Youth violence with guns in schools in Paducah, Kentucky, Jonesville, Arkansas, Pearl, Mississippi, and Springfield, Oregon, has inspired the media and some members of Congress to search for easy explanations such as gun proliferation, television violence, single parent families, and deterioration in family values. Dr Bruce Perry, Chief of Psychiatry at Baylor College of Medicine's Texas Children's Hospital points out,

³⁰⁸ *Ibid*, p. 4.

³⁰⁹ Kimberly Cook, Divided Passions: Public Opinions on Abortion and the Death Penalty, Northeastern University Press, 1998.

³¹⁰ Howard N. Snyder, "Juvenile Arrests in 1995", U.S. Department of Justice, Office of Justice Programs, Office of Juvenile Justice and Delinquency Prevention, Juvenile Justice Bulletin, February, 1997.

³¹¹ Lehman Brothers, Second Annual Education Industry Conference, February 11, 1997, p. 119.

*The truth is that these are complex problems with multiple factors, and all of these factors converge in one area, and that is the impact of experience on the brain. The more we know about the brain and how it develops, the better we are going to be able to devise solutions to these problems.*³¹²

The Economist comparison of handgun violence in the U.S. to that in other countries suggests that this is an area of particular concern,

*In 1996 handguns were used to murder two people in New Zealand, 15 in Japan, 30 in Britain, 106 in Canada, 211 in Germany and 9,390 in the United States. A 1997 study found that the firearm-related death rate among American children under 15 years old was nearly 16 times higher than among children in 25 other industrialized countries combined. There are about 35,000 firearm deaths, including homicides, suicides and accidents, in America every year. According to the FBI, nearly one out of every three reported murders, robberies and aggravated assaults involves firearms - about half a million incidents every year. ... Recent declines in murder and other violent crimes are welcome, but they have come after a sharp rise, only returning America to the violent-crime levels of the mid-1980s. They have barely dented the gigantic disparity between American levels of lethal violence and those in other rich countries.*³¹³

Shiraldi has attempted to put school crime in perspective,

*In 1992, 55 killings occurred in America's schools By 1997, that number dropped by more than half, to 25. By contrast, lightning in 1997 killed 88 people. ... Between 1994 and 1996, there was a 30 percent drop in juvenile homicides in America. ... Americans believe that juveniles are responsible for about half of all killings, even though juveniles are responsible for about one in 10 homicides.*³¹⁴

Genetic susceptibility toward violence, early childhood experiences (physical or mental abuse, violence, neglect, lack or nurturing, and fetal exposure to alcohol and drugs, etc.), brain chemistry and physics, inability of parents and educators to identify and respond to children at risk, the inability of certain youth to weigh the future impact of today's behavior, and a wide array of social, religious, and cultural factors all contribute to violent behavior. Knee-jerk reactions by the political system are unlikely to solve this problem, and they may aggravate it.

Juvenile crime is further complicated by juvenile's propensity to join gangs. Of 3,440 local police and sheriff's departments reporting to a DOJ sponsored survey, 54% reported youth gangs active in their jurisdictions in 1995. One-half of these departments serve localities with fewer than 25,000 residents.³¹⁵ Apparently the same factors that lead juveniles to commit crime also increase their chances of becoming a victim of crime. High rate criminal offenders

³¹² The Albuquerque Journal, "Research: Genes, Circumstances Spark Violence", Sunday, March 29, 1998, p. A1.

³¹³ The Economist, "America and Guns", April 4, 1998, p. 16.

³¹⁴ The Albuquerque Journal, "Hype Eclipses Drop in Killings by Kids", May 31, 1998, p. B3.

³¹⁵ John P. Moore, "Highlights of the 1995 National Youth Gang Survey", Office of Juvenile Justice and Delinquency Prevention Fact Sheet #63, April, 1997.

die and experience more violent deaths than low rate criminal offenders. This is especially true of juvenile offenders.³¹⁶

C. Preventative Measures.

RAND estimates suggest that three-strike laws like California's might reduce serious crimes by about 21% at an annual economic cost of \$5.5 billion. RAND analysis indicates that for another \$1 billion, graduation incentives and parent training could approximately double crime reduction. RAND's models indicated that graduation incentives that induce disadvantaged high school students to graduate could avert about 250 serious crimes per million dollars invested and have the potential to reduce crime by 15%. In comparison, California's three-strike law is projected to avert about 50 serious crimes per million dollars.³¹⁷

Dr. Lawrence Sherman, chair of the Department of Criminology and Criminal Justice at the University of Maryland, pointed out,

More effective ways of treating juvenile offenders and preventing drug abuse have been demonstrated by careful evaluation research. Teaching juvenile offenders skills like reading works better than boot camps. Making schools more firm and consistent in overall discipline works better than D.A.R.E. But these strategies lack political advocates and lose out in the competition for funding.³¹⁸

In 1996 Congress required the Attorney General to conduct a comprehensive evaluation of the effectiveness of the over \$3 billion annually spent by the Department of Justice in funding grants to state and local law enforcement and local communities in preventing crime. A team of researchers at the University of Maryland conducted this analysis. Their findings included:

- ◆ Substantial reductions in National rates of serious crime can only be achieved by prevention in areas of concentrated poverty where homicide rates are 20 times the National average.
- ◆ A much larger part of the National crime prevention portfolio must be invested in rigorous testing of innovative programs, in order to identify the active ingredients of locally successful programs that can be recommended for adoption in similar high-crime urban settings Nation-wide.
- ◆ Effective crime prevention in high-violence neighborhoods may require interventions in many local institutions (communities, families, schools, labor markets, place security, police, and criminal justice). The interdependency of these local institutions suggests a great need for rigorous testing of programs that simultaneously invest in multiple local institutions.
- ◆ The number and strength of available evaluations is insufficient for providing adequate guidance to the National effort to reduce serious crime. (Despite the recent emphasis at reinventing government to focus on results, most crime prevention evaluations still appear

³¹⁶ Pamela Lattimore, Richard Linster, and John MacDonald, "Risk of Death Among Serious Young Offenders", *Journal of Research in Crime and Delinquency*, Vol. 34, No. 2, May, 1997, pp. 187-209.

³¹⁷ Moore, Office of Juvenile Justice and Delinquency Prevention Fact Sheet #63, April, 1997.

³¹⁸ Lawrence W. Sherman, "Crime Prevention's Bottom Line", *The Wall Street Journal*, August 6, 1997, p. A15.

to focus on efforts.) This knowledge gap can only be filled by Congressional restructuring of the DOJ programs to provide adequate scientific controls for careful testing of program effectiveness. DOJ officials currently lack the authority and funding for strong evaluations of efforts to reduce serious violence.

- ◆ The strength of police effects on crime is generally moderate rather than substantial. Massive increases of police presence focused in a small number of high crime communities can have a major effect on preventing crime. It is possible that a focused crime prevention strategy could rely heavily on police presence to regain a threshold level of public order and safety. Once this threshold is reached, the effectiveness of family, community, schools, and the labor force in inhibiting crime could be substantially increased. The 1994 federal Crime Act puts a large portion of its 100,000 police where the people are, but not where the crime is.³¹⁹
- ◆ Measured purely by the amount of available time to reduce risk factors for crime, schools have more opportunity to accomplish that objective than any other agency of government. Succeeding at their basic job of teaching children to read, write, and compute may be the most important crime prevention practice schools can offer.
- ◆ No program has yet shown success in tackling the unemployment rates of high crime neighborhoods. Yet of all the dimensions of neighborhood life, this one may have the most pervasive influence on crime.
- ◆ There is very little evidence that increased incarceration has reduced crime. Yet variations in how the criminal justice system treats admitted offenders can make a great deal of difference. The evidence finds encouraging support for more correctional use of drug treatment programs, rehabilitation programs in prison, and institutionalization of some juvenile offenders rather than community-based supervision.

*The great strength of federal funding of local crime prevention is the innovative strategies it can prompt in cities like New York, Boston, and Kansas City where substantial reductions have recently occurred in homicide and youth violence. The current limitation of that funding, however, is that it does not allow the Nation to learn why some innovations work, exactly what was done, and how they can be successfully adapted in other cities. In short, the current statutory plan does not allow DOJ to provide effective guidance to the Nation about what works to prevent crime.*³²⁰

The bottom line of this analysis is that federal grants are being used to support programs in which many variables are being simultaneously changed, control groups are not identified and made part of the experiment design, and measurement of program effectiveness is something

³¹⁹ Lawrence Sherman, "Thinking About Crime Prevention", Chapter Two in Preventing Crime: What Works, What Doesn't, What's Promising, A report to the United States Congress, prepared for the National Institute of Justice, February, 1997.

³²⁰ Lawrence Sherman, Denise Gottfredson, Doris MacKenzie, John Eck, Peter Reuter, and Shawn Bushway, Preventing Crime: What Works, What Doesn't, What's Promising, A report to the United States Congress, prepared for the National Institute of Justice, February, 1997.

one does after-the-fact to a program rather than make metrics an integral part of program design and definition.

D. Incarceration

The RAND Corporation reported,

Headlines about falling crime rates notwithstanding, this year there will still be one violent crime committed for every 130 U.S. citizens - a rate several times that in other industrialized democracies. Yet despite the seriousness of America's crime problem, most of the money and effort devoted to solving it are restricted to one approach - incarcerating persons who have already committed crimes. Much less attention has been paid to diverting youths that have not yet committed crimes from doing so.³²¹

Irwin, Austin, and Baird have accumulated data on U.S. incarceration trends. Their data are shown in Table VIII.

Table VIII: 1980 and 1995 populations of adults on probation, in jails, in prison, and on parole compared to growth in the adult population over this same time period. Note that while the adult population only grew 19% over this time period, adult arrests and adults under some form of supervision grew at much higher rates. These data illustrate that 1 out of every 36 Americans is under some form of supervision by the U.S. correctional system.

Category	1980	1995	Percentage Increase
Probation	1,118,097	3,096,529	177%
Jails	163,994	499,300	204 %
Prison	329,821	1,078,545	227%
Parole	220,438	700,174	218%
Total of Above	1,832,350	5,374,548	193%
Adult Population	162.8 million	194.3 million	19%
Adults Under Supervision	1.1%	2.8%	154%
Adult Arrests	6.1 million	9.4 million	54%

While the doom prophets interpret these data to mean that America is on a crime binge, we think that they more likely show America to be on an incarceration binge. These authors also point out that one-third of all young African-American males are in jail, in prison, or on parole or probation and that in Washington, DC, the figure is now one-half.³²² African-American youth make up only 15% of our nation's young people, yet 49% of all youth arrested for violent crime are African-American and they occupy 65% of all bed space in detention facilities.³²³ Many in the non African American community interpret these data to mean that African-American males are predisposed to commit crime; the African-American community interprets these data to

³²¹ RAND Research Brief, *Diverting Children from a Life of Crime: What Are the Costs and Benefits?*, May 1996, RAND Home Page.

³²² John Irwin, James Austin, and Chris Baird, "Fanning the Flames of Fear", *Crime and Delinquency*, Vol. 44, No. 1, January, 1998, p. 33.

³²³ Judge Glenda Hatchett, "Why We Can't Wait: The Juvenile Court in the New Millennium", *Crime and Delinquency*, Vol. 44, No. 1, January, 1998, p. 85.

mean that the criminal justice system is predisposed to arrest, convict, and incarcerate African-American males. The reactions of the non-African American and African American communities to the court's decision in the murder prosecution of O. J. Simpson serve to illustrate this polarization. Substantive research could easily defuse these polarized perspectives.

Solutions such as building more prisons do prevent convicted criminals from committing additional crimes against the public (while they are physically incarcerated) and do offer a measure of social retribution to victims; however, imprisonment is neither cost effective, nor does it address the root causes of crime, and it often serves as a training ground for hardened criminals to further develop their core competencies.

In the early 1990s the Nation's prison population had an average annual growth rate of 7.7%. State's incarceration rates per 100,000 residents range from 90 in North Dakota to 659 in Texas. The District of Columbia has 1,444 incarcerated per 100,000 residents.³²⁴ For every person in prison, there are between three and four individuals under supervision outside of prison - parole, probation, or community-related service.

As we previously explained, about 50% of the prison population are incarcerated for drug offenses. However, the penalty for drug offenses is inconsistent and in the minds of many, racially biased. The Economist pointed out,

It would certainly be better to make use of supervised drug-treatment programs rather than long prison stretches. And it is wrong that a trafficker of just five grams of crack cocaine (usually caricatured as a black street hustler) should face a mandatory minimum prison sentence of five years while the threshold quantity of powder cocaine (the form preferred by rich whites) for such a sentence is 500 grams.³²⁵

Hoshen of Lucent Technologies, and his colleagues³²⁶ have shown that modern communications and information technology may be used to incarcerate prisoners electronically and reduce the need for prisons that cost \$125,000 per bed to build with an additional annual cost of \$25,000 per occupied bed. Society could send prisoners to Harvard for about the same cost as incarceration. House arrest backed-up by a primitive (in comparison to that possible with contemporary communications technology) form of electronic monitoring has been shown to be cost-effective for the 170 cases in which it was used in Pima County Arizona.³²⁷ George Drake of the New Mexico Corrections Department has proposed that the U.S. establish a National program for continuous electronic monitoring of criminal offenders that is a partnership between government, universities, National laboratories, and companies.³²⁸ The NIJ has

³²⁴ Darrell K. Gilliard and Allen J. Beck, "Prison and Jail Inmates at Midyear 1996", Bureau of Justice Statistics Bulletin, NCJ-162843, January, 1997.

³²⁵ The Economist, "Give Them Their Pills, the Fuddled Masses", May 2, 1998, p. 23.

³²⁶ J. Hoshen, J.D. Sennott, and M. Winkler, "Keeping Tabs on Criminals", IEEE Spectrum, February 1995, pp. 26-32. Republished in The Journal of Offender Monitoring, Vol. 8, No. 3, 1995, pp. 1-7

³²⁷ T. M. Forgach, "Cost Effectiveness and Use of House Arrest with Electronic Monitoring in Pima County, Arizona", Journal of Offender Monitoring, v 5, N 2, Spring, 1992, pp. 8-10.

³²⁸ George Drake, Joseph Hoshen, and Debra Spencer, "A Proposal for Developing a Continuous Electronic Monitoring System for Criminal Offenders", an unpublished white paper.

pointed out that a technology that would safely and effectively permit an alternative to incarceration for only 1% of our current prison population would annually save \$159 million.³²⁹

E. Technology.

The criminal justice system is attempting to deal with 21st century crime issues with mid 20th century technology. Crime experts have identified a wide array of technology needs. These include: rapid return forensics; separation of violent criminals in a crowd; implement video and audio surveillance to monitor criminal activities (e.g., pick-up conversations between criminals or between criminals and hostages); detect body heat inside a building, so that police can determine where people are located; lift prints on site at a crime scene; create a two-way "dialog" with criminals, instead of the traditional bullhorn "monologue"; identify the criminal quickly by processing a verbal description or mugshot; enable the officer to communicate the officer's actions to superiors in "real time", as the situation unfolds; tagging and tracking vehicles; sensors installed along the highway that identify stolen cars as they pass the sensors; retractable barriers that can be deployed in front of fleeing vehicles; an electromagnetic pulse source that can disable cars by interfering with their electrical systems; paint darts for marking vehicles for later interception; radio transmitters attached to cars to allow for predeploying of cruisers; phototechnology for a wide range of applications; concealed weapons detection; coordinated information systems that can give authorities comprehensive material on an individual's criminal history; encryption systems that ensure that only law enforcement has access to and can operate some technologies; a "smart gun" with biometrics interlocks that can only be used by the person owning the gun.³³⁰

There is much evidence that the limited amount of technology that has been introduced into the criminal justice system has been useful in improving the productivity of police work. For example, MacDonald, Alpert, and Gover have synthesized research comparing the utility of helicopters to police cruisers for controlling crime. Several of the studies they cited indicate that a helicopter patrol can do the work of 10 to 15 ground units. Other studies indicate that a police car can effectively patrol one-fifth of a square mile in one hour, while a helicopter can patrol 7.6 square miles with the same effectiveness.³³¹

Sandia National Laboratories recently helped Belen, New Mexico, school officials address their concern for rising truancy, vandalism, violence, theft, and drug and alcohol use, by introducing security systems technology concepts developed for protection of weapons facilities. Sandia first conducted systems engineering analysis with participation by students, faculty and the community to identify unique needs and develop an integrated systems approach. In a letter sent to President Clinton by Belen High School Principal Ron Marquez, it was noted that vandalism was reduced by more than 75%, vehicle theft was reduced by more than 80%, and truancy was reduced by 30%. In addition, fights, previously a weekly occurrence, have been

³²⁹ National Institute of Justice Conference Report, Law Enforcement Technology for the 21st Century, June, 1994.

³³⁰ National Institute of Justice Report, Law Enforcement Technology for the 21st Century Conference Report, June, 1994.

³³¹ John M. MacDonald, Geoffrey P. Alpert, and Angela R. Gover, "The Use of Helicopters in Policing: Necessity or Waste?" Police Forum, April, 1998, p. 12.

reduced to one per month and what was once a daily false fire alarm is now a monthly incident.³³²

There are many other areas in the criminal justice system where technology may be introduced to reduce costs or drop the frequency of crime. It was determined by law enforcement officials from around the Nation attending the conference, Coupling Technology to National Need, held in Albuquerque in 1993, that creation of a National law enforcement technology center at a national lab that was not part of the existing federal law enforcement bureaucracy would accelerate the introduction of technology into federal, state, and local law enforcement agencies. The center envisioned by conference participants would serve to review the latest technology developments, facilitate the access and exchange of technology information, showcase specialized products and certify products for use by law enforcement officers.³³³ The last of these activities would emphasize testing and evaluation of law enforcement technology being developed in the private sector and offering unbiased procurement recommendations to local and state law enforcement bodies.

Although he failed to create the center recommended at the 1993 Albuquerque meeting, Vice President Gore has demonstrated that he is sensitive to the need for making use of technology to combat crime. He recently announced that the Department of Energy (DOE) will work with the Departments of Justice (DOJ) and Treasury to give law enforcement new cutting-edge technologies. Mr. Gore pointed out,

If we're going to fight the criminals of the future, we need to develop the crime fighting tools of the future. We must put the best possible tools in the hands of our law enforcement community so they can identify, apprehend, and prosecute criminals -- swiftly and effectively.³³⁴

F. Crime Research

Even though Americans consistently express concern about crime, the nation's investment in crime research is very small. While the National Institutes of Health annually spend \$15 billion searching for cures to diseases, all Federal agencies cumulatively invest about \$50 million on crime research. The Federal government annually spends about \$13 billion enforcing drug laws that are not well supported by a research. Some are even in conflict with the limited research that exists.

research findings make it quite clear, for example, that punishment for reasons of incapacitation and deterrence is not very helpful in disrupting drug markets, and that increasing the certainty of punishment is more effective than increasing its severity.³³⁵

Blumstein and Petersilia³³⁶ argue that there are four explanations for the limited financial support of justice research,

³³² Kathy Kuhlmann, "Sandia Earns A+ on School Security Program Achievements in Belen", Sandia Lab News, March 14, 1997.

³³³ Special Technologies, "National Law Enforcement Technology Center Needed", September 15, 1993.

³³⁴ News Release, The White House Office Of The Vice President, May 19, 1998, Vice President Gore Announces New Effort To Provide High-Tech Tools.

³³⁵ Alfred Blumstein and Joan Petersilia, "Investing in Criminal Justice Research", in Crime, edited by James Q. Wilson and Joan Petersilia, Institute for Contemporary Studies Press, 1997.

- ◆ Crime policy is driven by ideology based on deeply held beliefs. Research findings might well be in conflict with these beliefs and every Tom, Dick and Harry is confident he knows what to do about America's crime problems.
- ◆ Social science researchers sometimes allow their beliefs to bias their research. Even those that do not make this mistake may be perceived as having done so.
- ◆ Law enforcement practitioners believe that practitioners, not researchers, have the best answers for solving crime problems.
- ◆ The legal profession, which dominates the professional side of law enforcement and law making, does not have a tradition in empirical research.

In addition to the above arguments, we would add that social scientists, like other scientists, have developed a vocabulary that only allows them to communicate with their own kind. Of all the areas of science, social scientists must learn to communicate with the public, if their research is going to be understood, respected, and implemented by the public. In addition, physical scientists who often regard social science as the inferior science or the non-science science have long disdained social science. In other areas of our research we argue that most Federal R&D is spent on topics recommended by R&D performers. Since most R&D performers are physical scientists, their principal areas of research interest are in the physical sciences, not the social sciences.

We recommend that the U.S. establish a \$1 billion Federal program on crime research including the establishment of the technology and evaluation center recommended at the Albuquerque National Need Meeting in 1993. This \$ 1 billion program should be equally invested in (1) research on the causes and effectiveness of measures to limit crime and (2) technology that prevents crime, increases the risk of being caught when committing crime, and reduces the cost of incarcerating those convicted of crime.

7. Low Productivity Growth Services Industries

A. Data.

There are two primary measures of productivity - total factor productivity (total output of an economy divided by total input, including labor) and labor productivity (total output of an economy divided by total labor input). While the quality of output may be included in output measures, output quality is not included in the calculation of gross labor productivity. This term is a measure of the number of units of observable output per unit of labor input.³³⁶ Because the per capita output is an indicator of the current standard of living or the overall welfare of a nation, gross labor productivity is a measure of economic welfare. As a nation approaches full employment, as the U.S. is currently doing, and its population stabilizes, as many European countries are currently doing, further economic growth must come from increases in the gross labor productivity of the workforce.

³³⁶ Ibid, p:p. 468-471.

³³⁷ William J. Baumol, Sue Anne Batey Blackman, and Edward N. Wolff, Productivity and American Leadership: The Long View, The MIT Press, 1989, pp. 241.

During the 1970s and 1980s, the fraction of the U.S. workforce that worked in goods production - manufacturing, construction, and mining - dropped from 26% of the workforce to 19% of the workforce. During the same period, those employed in services industries grew from 62% to 70%. By the mid 1990s, 72% of the workforce was employed in services industries.

Between 1980 and 1990 the growth rate in gross labor productivity of the U.S. manufacturing sector was 3.3% in comparison to 0.8% for the services sector. Gross labor productivity growth in the services sector was unchanged from that of the 1970s. The productivity revival that took place in the manufacturing sector during the 1980s did not penetrate the services sectors. Productivity growth in many of the services sectors has been stagnant for several years. Baumol, et.al, have compared the productivity growth of various sectors over the post-war period from 1946 to 1976. A reduced set of their data is shown in Table IX.

While many debate our measures of productivity, particularly services productivity, and argue that official U.S. productivity measures understate true productivity, Krugman explains,

this discussion is really a side issue, because if we are asking what growth target is appropriate, it doesn't matter whether the official numbers are right. The important point to remember is that productivity, by definition, is measured as output per worker. When we talk about productivity in the U.S. economy as a whole, we are talking about real gross domestic product per worker employed in the United States - nothing more, nothing less. (It is worth remembering that neither the output generated nor the workers employed by U.S.-based companies outside the United States plays any role in the calculation of either GDP or productivity.)³³⁸

Table IX: A comparison of the annual percentage growth in gross domestic product in the U.S. for the 30 years following the end of World War II. Gross domestic product per worker includes a correction for inflation. Progressive services sectors include communications, broadcasting, trade, real estate, business and professional services. The stagnant services sectors are those with low productivity growth, headed by medical services, education services, and government services. The percentage of workers employed in stagnant sectors increased from 31% of the workforce in 1946 to 42% in 1976.³³⁹

Sector	Annual Percent Growth of Gross Domestic Product per Worker
Agriculture	4.47
Mining	2.76
Manufacturing - durables	2.80
Manufacturing - nondurables	3.23
Construction	1.19
Transportation and warehousing	2.74
Communications and broadcasting	5.50
Utilities	4.77
Finance and insurance	0.31

³³⁸ Paul Krugman, "How Fast Can the U.S. Economy Grow?", Harvard Business Review, July-August, 1997, p. 127.

³³⁹ William J. Baumol, Sue Anne Batey Blackman, and Edward N. Wolff, Productivity and American Leadership: The Long View, The MIT Press, 1989, p.p. 128-133.

Real estate	3.10
Hotels, personal, and repair (except auto)	1.37
Business and professional services	1.70
Auto repair and services	1.45
Movies and amusement	0.99
Medical, educational, and nonprofit	-0.46
Household workers	-0.21
All progressive sectors (manufacturing and services)	3.04
Stagnant sectors	0.56
Progressive services sectors	2.79
Overall for all sectors	2.18

As Paul Krugman recently pointed out, the U.S. economy has a growth trend that is about 2.4%. This is the growth rate of our economy when unemployment is unchanged. It represents the economy's capacity for growth and includes the additional increase of employees into the workforce required to maintain unemployment constant and it includes productivity growth. Krugman explains,

The U.S. economy's productive capacity is, by definition, the number of employable workers multiplied by productivity, or output per worker. The reason the growth in that capacity seems rather slow is that productivity, according to official estimates, has risen at a modest pace - just over one percent annually during the 1990s to date, a rate similar to that during the previous two decades.³⁴⁰

Okun's Law relates changes in the economy's utilization of capacity, measured by unemployment rate, to the economy's growth rate. According to Okun's law, one percentage point decrease in unemployment adds two percentage points to the output of the economy. In 1997, unemployment decreased from 5.3% to 4.7% for a net decrease of 0.6%. Okun's Law suggests that the economy should have grown by 2.4% plus $2 \times 0.6\%$ or 3.6%. It actually grew by 3.7%, but, according to Krugman, this difference is well within the normal fuzziness of economics.³⁴¹ Thus, adding additional workers to the workforce explains the high rate of economic growth the U.S. experienced in 1997. The question is how can we increase the contribution of productivity growth to the economy's capacity for growth, i.e., the 2.4%, particularly as our economy becomes increasingly dominated by services industries.

B. Consequence of Productivity Stagnation.

As manufacturing productivity continues to grow in comparison to services, the fraction of the workforce employed in services will continue to grow. The U.S. will eventually reach a point where economic growth will stagnate unless there is improvement in the productivity of the stagnant services sectors. Of course, the Luddites in our society object to productivity growth on the grounds that it promotes unemployment. And it does, temporarily. Productivity growth in farming has reduced the number working on farms to less than 3% of the workforce, yet agriculture continues to be important to U.S. economic health. As we increase the productivity of services, new services will emerge to employ displaced employees. Eventually, as

³⁴⁰ Paul Krugman, "America the Boastful", Foreign Affairs, May/June, 1998, p. 36.

³⁴¹ Ibid, p. 34.

manufacturing productivity continues to grow, workers can no longer increase their workweek, and unemployment is very low, we will reach the point where further growth in the economy will require an increase in stagnant services productivity.

C. Analysis.

Several explanations have been offered to explain productivity stagnation in certain sectors of services.

- ◆ Productivity measurements are inadequate.
- ◆ Lack of exposure to international competition.
- ◆ Lack of R&D investment in services industries.
- ◆ Inadequate training of services workers.
- ◆ Government regulations inhibit productivity growth.
- ◆ Poor management in the services sectors.³⁴²

In many of the stagnant services sectors, there is not only lack of exposure to international competition, there is lack of exposure to domestic competition. Many of the stagnant services sectors, e.g., medical services, education services, and government services operate as oligopolies. While many arguments have been offered to explain stagnation of services productivity, van Bieman and Greenwald argue that the primary problem is services sector management.

The problem ... is that service sector companies operate below their potential and increasingly fail to take advantage of the widely available skills, machines, and technologies. The main reason the service sector has not reached its total potential output is management. If managers were focused energetically and intelligently on putting the existing technologies, labor force, and capital stock to work, rapid productivity growth would follow. To be sure, the management challenges are more severe in the service sector than in the manufacturing sector. However, the high productivity levels attained by leading-edge companies indicate that attention from management can result in vastly improved performance throughout the service economy. ... What is required to fulfill this potential is a better understanding of services and a set of tools, techniques, and policies to help keep management's focus on productivity improvement. ... The villains ... are not the deficit or the educational system or lagging government support for R&D; rather, they are all the forces - takeovers, financial manipulations, government regulation, and the general fixation on high growth - that distract managers from the fundamentals of their business³⁴³

While we agree with Bieman and Greenwald that the quality of services management well lags that of the manufacturing sector (University administration serves as an example.), we believe

³⁴² Michael van Biema and Bruce Greenwald, "Managing Our Way to Higher Service-Sector Productivity", Harvard Business Review, July-August, 1997, p. 88.

³⁴³ Ibid, p. 88.

that management education as well as much higher levels of R&D investment will be required to make significant increases in services sector productivity. However, without competition there is no incentive for either managers or workers to increase productivity, invest in R&D, or improve their skills.

D. Comparison of Services and Manufacturing

We have added our assessment of the major differences between services and manufacturing to those made by Bieman and Greenwald.

- ◆ Services encompass a much wider range of activities than traditional manufacturing.
*although medical care, investment management, retail distribution, private education, telecommunications, dry cleaning, and check processing may all be service activities, they present very different productivity challenges.*³⁴⁴
- ◆ Services sector jobs are inherently functionally complex and multifunctional in ways that manufacturing jobs often are not.
- ◆ Manufacturing capacity can be spread out across time through physical inventory, whereas service capacity is relatively fixed and cannot rely on inventory to store capacity.
- ◆ Manufacturing output is transportable, and economies of scale are either global or nonexistent. Services are primarily local and are not transportable. Therefore, competition is locally driven rather than globally driven.
- ◆ Consumers may be less sensitive to the costs of services than they are to the costs of manufactured products. This is particularly the case when consumers pay for these services through taxes, e.g., government, health care, and education. In fact, in some services sectors, the consumer may equate inefficiency with quality. For example, an excess of nurses on a hospital floor may be interpreted as high quality service rather than inefficient service. The lower the gross labor productivity of education, number of students (output) per teacher (input), the higher many interpret the quality. The more time a physician spends with a patient, the higher the perceived quality.
- ◆ Innovations in services productivity are very difficult to appropriate, (competitors can copy the innovation) therefore, there are few incentives for private investment in productivity enhancement in services. **This observation suggests that the public must increase its role in funding productivity-enhancing innovation in the services sector and it must create incentives for private investment.**
- ◆ Although government often makes major R&D investments in manufacturing sectors, it has not seen fit to invest in R&D designed to improve the productivity of services even though as we point out above, there is a market failure due to lack of appropriability. Furthermore, government is in the services business in a very, very big way, i.e., **public service is a service**, and it is not in the manufacturing business. In other areas of our research, we argue that most Federal R&D is spent on topics recommended by R&D

³⁴⁴ Ibid, p. 94.

performers.' Since, most R&D performers are physical scientists, their principal areas of research interest are more closely related to manufacturing industries than to services industries.

There are three major services sectors that are in the greatest need of productivity growth. These are healthcare, education, and government. (We have previously discussed the education and healthcare issues.) Of course, institutions in all three of these sectors have operated as monopoly or oligopoly institutions, and like most of the services sectors, they are largely local and non-transportable, so there is little incentive for managers to increase the productivity of these sectors. Unlike the manufacturing sector, competition has not forced these services sectors to search for productivity growth.

E. Technological Solutions

Computing and information technology was supposed to lead a revolution in productivity growth in both the manufacturing and services sectors. Most analyses have shown that has not happened. Blinder and Quandt report that even though the U.S. investment in computers is the fastest growing area of business investment, it still accounts for less than 10 percent of gross investment. Computer impact on productivity growth is about the same as other capital investment. Blinder and Quandt point out,

Daniel Sichel, an economist at the Federal Reserve, estimates that investment in computer hardware accounted for only 0.2 of the total 2.3 percent average annual growth rate of nonfarm business output from 1980 to 1992, and even less in the preceding years. ... Ironically, the most profound benefits of information technology may be found not in the economic arena at all but in the political sphere. ... In the end, the primary payoff from advances in information technology may be not in new and better goods and services but in new and better democracies.³⁴⁵

A Morgan Stanley Dean Witter study revealed,

According to U.S. Department of Commerce statistics, fully 82% of the nation's total stock of information technology is installed in America's vast services sector - retailers, wholesalers, telecommunications, transportation, financial services, and a wide array of other business and personal service establishments. Not by coincidence, around 85% of the U.S. white-collar work force are employed in the same services sector. Thus, the U.S. productivity quandary is all about the synergy or lack thereof, between IT and white-collar workers.³⁴⁶

In addition to the healthcare and education sectors, there are numerous major industrial sectors, e.g. construction, where there is little productivity growth. Much of this stagnation stems from R&D investments less than one percent of sales and in some cases, relatively low investment in new equipment. We need to rank industry sectors, particularly the services sectors, according to their productivity growth and their potentials for increased productivity and then develop programs that focus on the slow productivity growth industries with the highest

³⁴⁵ Alan S. Blinder and Richard E. Quandt, "The Computer and the Economy", The Atlantic Monthly, December, 1997, p.p. 26-32.

³⁴⁶ Steven S. Roach, The Boom for Whom: Revisiting America's Technology Paradox, Morgan Stanley Dean Witter Special Economic Study, January 9, 1998, p. 4.

improvement potential. Much of the public investment in industrial R&D has been in manufacturing-intensive industrial sectors, e.g. electronics, where productivity growth is already high and there was no evidence of market failure.

The construction market is particularly susceptible to the threat of a virtual marketplace developing as the Internet expands its international web. Educators have largely ignored the fact that U.S. construction suppliers are decades behind information technologists in the automotive and aerospace sectors. As the distance between construction sites and suppliers become less important and the ability of architects and builders to use information technology grows, foreign suppliers will gain equal footing to domestic suppliers. With higher quality products, the foreign suppliers will have distinct advantages.

F. Government Response: Research Recommendations

Unfortunately, the track record of the U.S. government has been weak in previous attempts to rectify stagnation in services industries. For example, regular attempts to initiate R&D at NIST and at some of the DOE laboratories in roofing materials, building procedures, energy conservation, fire protection, heat exchangers, efficient windows, and other economically important, low productivity growth sectors have been met with charges of "industry welfare" from politicians and "mundane science" from the scientific community. Never mind that the marketplace is failing to provide for these public needs, that foreign competition is eroding the building supply market, and that U.S. houses have inferior plumbing in comparison to those in most European homes.

There are numerous actions that government might take to improve the productivity of the stagnant services sectors.

- ◆ Recognize that government is a services industry and that it is desirable to increase the productivity of government-provided services.
- ◆ Support R&D that searches for ways to improve the productivity of services, particularly those services in which government makes major investments, e.g., healthcare and education.
- ◆ Improve education, particularly the education of those that might work in the services sector, by introducing the management concepts of total quality management, benchmarking, just-in-time, process reengineering, teaming, continuous improvement, and competitive principles in K-12 education.
- ◆ Maintain a stable macroeconomic environment.
- ◆ Avoid regulations whose public and private cost exceed their public benefit, particularly those that impose great costs on services companies and reduce their productivity.

Regulations should be carried out in both spirit and practice to minimize the demands made on businesses' attention and resources. This means that if the government is serious about enhancing productivity performance, it should

*formulate stable, cooperative long-term regulatory policies, rather than aggressive responses to the latest crisis.*³⁴⁷

It is clear that increasing the productivity of productivity-stagnant services industries is a subject well worthy of research and well worthy of research funded by the public. The three largest offenders of low productivity growth are all closely affiliated with services owned or heavily subsidized by the public: government, education, and healthcare.

8. The Income Distribution Problem

A. Introduction.

Stagnation or reduction in income of middle and low-income wage earners is a ticking time bomb that will eventually stimulate social instability, economic class conflicts, less education, political instability, growth in crime, and slow economic growth.³⁴⁸ This taboo issue is deserving of the attention of America's most intellectually capable. In Table X we show data compiled by the Hudson Institute on wage growth over the past 16 years.

Table X: U.S. wage growth since 1980. All financial data are in 1996 dollars.³⁴⁹

Year	Median Income All Households	Median Income Male Workers	Average Hourly Wage	Average Annual Hours Worked
1980	\$33,763	\$35,483	\$12.63	1,816
1988	\$36,108	\$35,354	\$12.40	1,903
1992	\$34,261	\$33,770	\$12.03	1,876
1993	\$34,922	\$33,016	\$11.99	1,905
1994	\$34,158	\$32,665	\$12.01	1,920
1995	\$35,082	\$32,426	\$11.99	1,940
1996	\$35,492	\$32,144	\$12.06	1,960

According to the Gini scale of income distribution, income inequality in the U.S. grew steadily, especially in the South and Southwest, throughout the 1980s and has surged in the early 1990s.³⁵⁰ The following statistics were reported in Harvard Business Review,

*In Western Europe, a male worker in the bottom 10% of the earnings distribution earns 68% of the median worker's income; in Japan, that male worker earns 61% of the median. In the United States, he earns 38% of the median. ... That so many workers in the United States fare poorly compared with their peers in other countries shows that the problem of low pay is not simply a matter of low-skilled immigrants or poorly educated minority youths. It is a problem of the overall distribution of income.*³⁵¹

³⁴⁷ Michael van Biema and Bruce Greenwald, p. 95.

³⁴⁸ The Economist, "Slicing the Cake", October 19, 1996, p. 82.

³⁴⁹ Edwin S. Rubenstein, "Clinton Boom a Burden for Full-Time Employees", National Review, November 10, 1997.

³⁵⁰ USA Today, "Mapping Income Inequality", September 20, 1996, p. 3B.

³⁵¹ Richard B. Freeman, "Toward an Apartheid Economy?", Harvard Business Review, September-October, 1996, p. 116.

The 20% of households with the highest incomes received 44% of all household income in 1974. By 1994, their share had increased to 49%. During this 20 year period those households whose income was in the bottom 20% slipped from 4.3% of all household income to 3.6% of all household income. During this same 20-year period, the share of household income going to the middle 60% of households dropped from 52% of all household income to 47% of all household income. In 1974 the income of the top 5% households was 6 times the income of the bottom 20%. By 1994, this ratio had increased to 8 to 1.³⁵² Although over this 20 year period the U.S. economy grew about 2.4% per year, those with incomes in the lowest 20% group received very little of the growth. The rising tide of national income growth has not lifted all boats.

The median U.S. family income after inflation was \$36,959 in 1993 in comparison to \$36,893 (1993 dollars) in 1973 in spite of the fact that there was a significant increase in two income wage earners.³⁵³ Although median household wages rose from \$35,082 ('96\$) in 1995 to \$35,492 ('96\$) in 1996, the wage increase was fully accounted for by gain in women's wages which offset a net loss in men's wages. Six years after America's economic boom began; the median worker has experienced a net wage decrease of 5%. Longworth explains,

*Fully 99% of the increase (in median family income) has gone to the top 20% of all wage-earners: The top 1%, all by itself, has claimed 62% of the growing pie. ... this middle two-thirds of the American work force now earns less, collectively, than the one-fifth-at the top. Inequality has become an end-of-century blight on American life.*³⁵⁴

Kotkin and Friedman point out,

*By most measurements, the Clinton recovery has been far less egalitarian than the much-criticized Reagan "era of greed." Between 1990 and 1995, the median family income actually declined slightly while the number of people with a net worth over \$1 million more than doubled. Since 1979, the wages of the bottom 20 percent of workers dropped nearly 12 percent, and by 1.6 percent since 1990 alone. ... adjusted for inflation, compensation for the bottom half of the wage scale is 75 cents less per hour than 20 years ago. In Silicon Valley, according to a study by the labor-backed Economic Policy Institute, real wages for the bottom 20 percent of the workforce have declined during the decade as the ratio of top corporate to production worker salaries skyrocketed from 41 to 1 to (1991) to 2220 to 1(1996). ... This growing gap between the affluent and the working poor threatens America's future prosperity. The percentage of Americans who feel the interests of employers and employees are in conflict has increased from 25 percent during the Great Depression - the supposed heyday of class-consciousness - to 45 percent today, according to polling data. These sentiments, notes author Alan Wolfe, cut across standard ideological lines, including both traditional liberals and Christian conservatives.*³⁵⁵

³⁵² Carol J. De Vita, "The United States at Mid-Decade", Population Bulletin, Vol. 50, No. 4, March 1996.

³⁵³ Competitiveness Policy Council News Release, New Studies Find American Families Are Working Harder, But Making Less, September 12, 1996.

³⁵⁴ R. C. Longworth, Chicago Tribune, "Surging Inequality Erodes Democracy's Foundation", Albuquerque Journal, October 26, 1997, p. B3.

³⁵⁵ Joel Kotkin and David Friedman, "Don't Pop the Champagne Yet", The Washington Post National Weekly Edition, June 1, 1998, p. 18.

While entry of women into the workplace has been publicly promoted as a women's rights issue, the reality is that it was primarily driven by couples attempting to acquire or retain middle income stature in a period of decreasing wages. The Washington Post recently reported,

Men and women have declared a cease-fire in the war that raged between the sexes through much of the last half of this century. In its place, they face common new enemies - the stress, lack of time and financial pressure of modern life. A new national survey has found that after nearly a generation of sharing the workplace and renegotiating domestic duties, most men and women agree that increased gender equity has enriched both sexes. But both also believe that the strains of this relatively new world have made building successful marriages, raising children and leading satisfying lives ever more difficult. ... Surprisingly, although men and women agreed they should have equal work opportunities, and men said they approved of women working outside the home, large majorities of both said it would be better if women could instead stay home and take care of the house and children.³⁵⁶

The public is uncertain about how the influx of mothers into the work force is affecting children's performance in schools and youth crime.

People have reservations about more mothers with young children working, said public opinion analyst Karlyn H. Bowman of the American Enterprise Institute for Public Policy Research. ... She cites a December NBC News/Wall Street Journal poll in which 42 percent of adults called the trend of more mothers working outside the home "a step in the wrong direction," compared with 31 percent who cited it "a step in the right direction" and 20 percent who said it made no difference. ... A couple of years after World War II, 27 percent of women with children between the ages of 6 and 17 were in the workforce... Fifty years later, that figure had risen to 78 percent. Women with children under 6 ... have always worked less than women with older children, but their labor force participation has seen an even more dramatic increase - from 12 percent in 1947 to 65 percent in 1997.³⁵⁷

While lower income wage earners are experiencing wage stagnation, they are working longer hours.

According to the results of a recent Harris Poll, the median number of hours worked per week in the United States rose from 40.6 in 1973 to 50.8 in 1997. ... A detailed industry-by-industry analysis of these results suggests that the potential under-reporting of work schedules since the late 1970s have been concentrated in the services sector. ... I find it ... difficult to believe that workers will continue to acquiesce to a system that rewards few for the efforts of many, especially in the context of a dramatic cyclical tightening of the labor market that has taken the national unemployment rate to its lowest level in 24 years ...³⁵⁸

³⁵⁶ The Washington Post National Weekly Edition, "The Politics of Fatigue", April 20, 1998, p. 6.

³⁵⁷ National Journal, "The Divide Over Day Care", January 24, 1998, p. 167.

³⁵⁸ Steven S. Roach, The Boom for Whom: Revisiting America's Technology Paradox, Morgan Stanley Dean Witter, Special Economic Study, January 9, 1998, p. 6.

Low-income wage earners are likely to experience further salary compression as welfare reform introduces even more low-skilled workers into an already overpopulated segment of the workforce. Of course, as Borjas and others have noted, the large-scale migration of less-skilled workers to the U.S. has done harm to the economic opportunities of less-skilled natives. Borjas estimates that one-third of the recent decline in the relative wages of less-educated native workers is accountable to immigration policy.³⁵⁹ Note that the hourly labor costs for Americans in manufacturing is \$17.20 in comparison to \$31.88 for Germany and \$23.66 for Japan.³⁶⁰ While Japan's unemployment rate is less than that of the U.S., Germany's is over twice that of the U.S. Although salaries represent an equilibrium point between the supply of workers and the demand for workers, part of the salary stagnation of U.S. workers can be attributed to the cost of healthcare. Employer-sponsored healthcare outlays for U.S. employees have grown from 2% of wages and salaries in 1975 to 8.2% today.³⁶¹ These are dollars that could have been used to increase wages. In comparison, German companies spend 6.4% of wages on healthcare outlays and Japanese companies spend 4.2%.³⁶²

Signs of the social unrest that accompany the disparity between low and high wage income was recently reported in The Economist,

The cliché that America's poor are too busy striving to have time for envy still rings true. Just now the economy is doing so well that everybody is getting ahead. But inequality has increased sharply over the past 30 years, and this has not gone unnoticed. In newspaper cartoons, Bill Gates has evolved from geek-hero to bullying monopolist - very Rockefelleresque. "Titanic", the blockbuster movie, offered a bracingly Marxist view of events, and the delight of American audiences when one or two rich passengers went under was, er, chilling. Barely a week passes without news of some executive hauling home a planet-sized pay packet, often for merely keeping his own company's performance in line with the stockmarket's. And the fattest pay packets often occur at companies where "downsizing" is most vicious. Can it be long before populists such as Pat Buchanan begin to tap directly into these resentments, before politicians say that "something must be done" to rein back American capitalism?³⁶³

B. Globalization. Some suggest that the radical income distribution problem that the U.S. is experiencing is a consequence of our devotion to laissez-faire market ideology. George Soros, one of the world's most prominent financiers warns that leaving social decisions to the market poses a danger to society. He notes,

I can assure you that all attempts at redistribution interfere with the efficiency of the market, but it does not follow that no attempt should be made. The laissez-faire argument relies on the same tacit appeal to perfection as does communism. It claims that if redistribution causes inefficiencies and distortions, the problem can be solved by eliminating redistribution - just as the communists claimed that the duplication involved in competition is wasteful and therefore we should have a centrally-planned economy.

³⁵⁹ George J. Borjas, "The New Economics of Immigration: Affluent Americans Gain; Poor Americans Lose", The Atlantic Monthly, November, 1996, pp. 72-80.

³⁶⁰ The Economist, "Sliding Scales", November 2, 1996, p. 77.

³⁶¹ Business Week, "Solving the Savings Riddle", November 11, 1996, p. 26.

³⁶² Council on Competitiveness, Highway to Health, March, 1996.

³⁶³ The Economist, "The Challenge for America's Rich", May 30, 1998, p. 15.

*But perfection is unattainable. Wealth does accumulate in the hands of its owners, and if there is no mechanism for redistribution, the inequities can become intolerable.*³⁶⁴

The Economist, apparently stung by Soros' analogy to communism, was particularly harsh in declaring that Soros was hallucinating to suggest that there is any nation where laissez-faire doctrine rules supreme. Its editors pointed out that the U.S. spends up to one-third of national income on redistribution of wealth from the rich to the poor and emphasized that economic theory suggests that governments can intervene when markets fail.³⁶⁵

Nevertheless, Soros is one of the few that are attempting to assess the problems and consequences of global capitalism. He argues that even though the global capitalist system has many attributes, it also has five principal deficiencies³⁶⁶:

- ◆ the uneven distribution of benefits,
- ◆ the inherent instability of the global financial system,
- ◆ the incipient threat of global monopolies and oligopolies,
- ◆ the ambiguous role of the state, and
- ◆ the question of values and social cohesion.

As Soros points out, in addition to markets, society needs public institutions to assure that social needs, e.g., political freedom and social justice, are attained. We fear that the globalization of the world is moving so fast that U.S. public institutions, particularly education and government, as well as weakly competitive service industries, e.g., healthcare, are being left behind in the dust. While there is an entire new set of public problems that the market can not and will not address, governments' hierarchical agencies are still discussing the old, largely irrelevant issues of the Cold War. Therefore, the issue is less what the role of government should be in addressing social needs such as income redistribution, but how to keep government current with emerging trends and problems.

Congressman George Brown, an honorable gentleman for whom we hold immense respect, recently brought attention to this issue,

Our economic well-being masks an old set of problems that are made worse in a technology-based society. People who are simply standing still will be left farther behind as the pace of scientific discovery continues to accelerate. This knowledge gap leads to grave divisions in the distribution of the benefits generated by a knowledge-based society.... As we right-size and replace permanent jobs with temporary positions, we

³⁶⁴ George Soros, "The Capitalist Threat", The Atlantic Monthly, February, 1997, p. 52.

³⁶⁵ The Economist, "Palindrome Repents", January 25, 1997, p. 18.

³⁶⁶ George Soros, "Toward a Global Open Society", The Atlantic Monthly, January, 1998, p. 22.

*increasingly resemble a feudal state with a serf class of part-time and contract workers employed by a class of owners.*³⁶⁷

Others note that the global economy is slowly shifting power from the public to the elite in corporations and that corporations are increasingly gaining control of world events and the social systems of nation states. Much of the recent problems in Asian economies are attributable to the domination of large corporate conglomerates, particularly in Japan and South Korea. Kaplan notes,

*In this historical transition phase, lasting perhaps a century or more, in which globalization has begun but is not complete and loyalties are highly confused, civil society will be harder to maintain. .. This rise of corporate power occurs more readily as the masses become more indifferent and the elite less accountable. ... An elite with little loyalty to the state and a mass society fond of gladiator entertainment form a society in which corporate Leviathans rule and democracy is hollow. ... Modern democracy exists within a thin band of social and economic conditions, which include flexible hierarchies that allow people to move up and down the ladder. Instead of clear-cut separations between classes there are many gray shades, with most people bunched in the middle.*³⁶⁸

This complex issue can be addressed through public policy; however, public policy initiatives are about as likely to be destructive as constructive. What the rich might do to assuage the anxieties and resentments of the public was recently addressed in The Economist.

*Few of the new rich seem to be aware they are doing anything questionable at all. This conviction ... reflects two tenants of modern American business. The first is the perception that a businessman's value to society lies solely (as opposed to chiefly) in being a good businessman, in starting companies and making better products. Medical and law schools teach the value of pro bono work, business schools rarely do. The more dangerous second idea is the notion that America's rich owe their wealth entirely to their own brilliance, when in fact they also owe much of it to the system that allows and encourages great wealth to be created. Philanthropy is part of the unspoken contract that underpins the American dream. If that contract is broken, a backlash is likely. Every American, rich and poor, would lose.*³⁶⁹

While we are unsure how to solve this growing problem, we are confident that as the income split between the poor and the rich grows, social unrest will grow. Furthermore, we do believe that this issue is highly worthy of systemic research. We suspect that the approach taken by France to sustain its bloated public sector as it saps economic growth and wastes vital resources, is not the best way to redistribute wealth.

One obstacle to change is France's addiction to a paternalistic government. Many French workers are demanding even more largesse from the state, leaving Jospin's

³⁶⁷Congressman George E. Brown, Jr., Past and Prologue: Why I am Optimistic About the Future, a speech given on April 29, 1998. Mr. Brown was the William D. Carey lecturer at the AAAS Colloquium on Science and Technology Policy.

³⁶⁸ Robert D. Kaplan, "Was Democracy Just a Moment?", The Atlantic Monthly, December, 1997, p. 80.

³⁶⁹ The Economist, "The Challenge for America's Rich", May 30, 1998, p. 15.

*Socialists little room to maneuver. Government officials hint they will use external pressure stemming from European monetary union to carry out public-sector reforms, including overhauls of the tax and social security systems.*³⁷⁰

C. Recommended Research. While some have touted professional education as the solution to the income distribution problem, it just isn't that simple. For example, engineers' incomes were stagnant for over a decade.³⁷¹ This situation makes engineering less attractive than other career options for U.S. citizens. Immigrants to the U.S. who pursue an engineering education and then remain here to work are meeting many U.S. graduate engineering employment needs.³⁷² Michael Teitelbaum, the esteemed Sloan Foundation demographer, reported,

*There is no shortage of scientists, engineers or software professionals. If anything, there is a surplus. ... Engineers and software professionals who have lost their jobs could be easily retrained by the big high-tech companies. However, there is no incentive to do so, as long as they can easily hire from U.S.-educated foreign nationals. As one software engineer let go by a computer company reported, he and his colleagues are "disposable" rather than "recyclable".*³⁷³

It is clear that the issue of how the benefits of economic growth are distributed to a society and how that distribution affects future economic growth, unemployment, inflation, and the ability to maintain a liberal democracy is well worthy of systems modeling and simulation. With no redistribution of wealth it is clear that workers have little incentive to provide the work necessary to create wealth. At the other extreme, very high wealth redistribution, entrepreneurs have little incentive to create the innovations that drive wealth growth. Somewhere between these extremes there must be an optimum level of wealth redistribution that maximizes wealth generation. We are not comfortable that political processes can find this elusive optimum. Research that addresses this issue is worthy of public investment.

9. The Regulatory Problem

A. Regulatory Costs

Various estimates of the cost of regulations range between \$500 billion and \$800 billion per year. Of course, these costs are passed from companies to the consuming public. Some propose that regulations average adding \$6,000 to the annual family tax burden³⁷⁴; others conservatively estimate that federal regulations in 1995 cost Americans \$654 billion (47% of the federal budget) or cost the average American family \$7,000 in comparison to \$6,000 per family for income taxes.³⁷⁵ The IRS estimates that it costs taxpayers an additional \$8.35 for every \$100 they pay in taxes. The compliance cost of the income tax is \$157 billion with about two-

³⁷⁰ Business Week, "An Economy Ripped in Two", January 26, 1998, p. 44.

³⁷¹ M. F. Wolfe, "As Their 'Shelf Lives' Shrink, an NSF Study Finds Half of U.S. Engineers Working Outside Engineering", Research Technology Management, July-August, 1996, pp. 1-5.

³⁷² David S. North, Soothing the Establishment: The Impact of Foreign-Born Scientists and Engineers on America, University Press of America, 1995.

³⁷³ Michael S. Teitelbaum, "Too Many Engineers, Too Few Jobs", New York Times, March 19, 1996.

³⁷⁴ Testimony of Jerry Jasinski at Hearing on Risk Assessment and Cost Benefit Analysis, before the Committee on Science, U.S. House of Representatives, February 3, 1995, p. 3.

³⁷⁵ The Economist, "Over-Regulating America: Tomorrow's Economic Argument", July 27, 1996, p. 19.

thirds of these costs paid by businesses, the rest by individuals.³⁷⁶ Thomas Hopkins, Rochester Institute of Technology, has reviewed those studies of Federal rules and regulations for which compliance cost estimates have been made (these studies do not include the cost of loss of company productivity accruing from compliance) and concluded that Federal regulations annually cost \$668 billion.³⁷⁷ Of course, regulations and rules of local and state governments are often heaped on to Federal regulations. If all of the hidden costs of regulations were included, the annual price tag would be close to that of health care.

Porter explains,

*Regulation itself is thought to result eventually in inefficient outcomes, rather than just income redistribution toward politically powerful groups, because of bargaining and other transaction costs incumbent in the process of regulatory reform. Even when an initial set of regulations is efficient, the inertia of the regulatory process will ultimately lead to inefficiencies, and the coalition building necessary for reform will occur only when these inefficiencies are extreme.*³⁷⁸

B. Industrial Impact

There are many federal regulations that affect industry. These include environmental safety and health laws; antitrust/monopoly policies; tax structure; intellectual property/patent laws; laws regarding product liability; labor regulations including social security payments, minimum wage laws, worker safety regulations, unemployment insurance requirements, fair employment laws, workers compensation laws; health care requirements including insurance, Medicare; utility regulations that affect the cost of energy and telecommunications services to corporations; monetary policies including inflation control, influence on the cost of capital, federal deficit, currency exchange rates; education including public funding, university research funding, student loans; trade policies including pressuring international competitors to open their markets to U.S. made products, fair trade agreements, tariffs and other protectionism practices; subsidies to industries; loan guarantees to private companies and individual borrowers; procurement practices; control of international sales for security purposes; and R&D policies.

Because of the economic impact of regulations, it is extremely important that they be optimized for public and private good with great attention focused on economics. Political processes, taken alone, are unlikely to find this elusive optimum. In fact, one can cite obvious flaws that the political process introduces into the development of regulations. In some cases U.S. regulatory costs are compared to those of other nations on a regulation-by-regulation basis and differences that disadvantage U.S. industry are addressed by our political system. The converse is also practiced. For example, the fact that gasoline costs are much less in the U.S. than in Japan is sometimes used to support the argument that the U.S. should increase taxes on gasoline. The fact that corporate income taxes in the U.S. are much less than in Japan or Germany is used to justify increasing corporate income tax or not reducing capital gains tax rates. The fact that wages are less in the U.S. than in Japan or Germany is used to support increasing the minimum wage.

³⁷⁶ Investor's Business Daily, "Hidden Costs of the Tax Code", April 14, 1997, p. A1.

³⁷⁷ The Economist, "Over-Regulating America", July 27, 1996, p. 19.

³⁷⁸ Robert H. Porter, "A Review Essay on Handbook of Industrial Organization", Journal of Economic Literature, Vol. XXIX, June 1991, p. 568.

Assurance that U.S. businesses are not disadvantaged in international competition and that the U.S. is a favored site for all corporations - both foreign-owned and domestically-owned - demands a systems approach to regulatory policy development. Federal regulatory policies that affect industry must be collectively reformed so that no other nation is a more attractive site for the location of manufacturing and services facilities than the U.S. Industry will locate facilities in the U.S. only if it is comparatively advantageous. To understand the costs and advantages of regulations we must be able to fully analyze how systems are impacted by new regulations and be able to predict how those affected by a new regulation will respond.

C. Regulation Development Processes

In the absence of quantitative knowledge, regulations are qualitatively selected by subjective means on a regulation-by-regulation basis by forging compromise between competing political forces. For example, environmental policies have been determined through political compromise between those in the environmental movement who want them to be more rigid and those in industry that want them to be relaxed. Regulator behavior can be influenced by the career goals of bureaucrats and this can lead to regulator capture by the interests of those regulated (this usually means less regulation) or regulator behavior can be driven by the desire of officials to expand their agency's purview or its budget (this usually means more regulation).³⁷⁹

If U.S. companies in a particular sector are losing market share to foreign competitors, one response of government could be to offer some form of tax relief, e.g., allow an acceleration of equipment depreciation schedules or multiple deductions for R&D expenditures. The political solution can be based simply on recognition that the system isn't working as well as expected; therefore, provide regulatory relief. If that doesn't work, more regulatory relief can be offered, perhaps in another area. The response of the political system to regulatory issues is analogous to the empirical control of a system in which algorithms linking output to controlled parameters aren't available. In response to political pressures, simply make a change, usually an incremental change, and see what happens. In engineering this is sometimes called, "cut and try". However, the "cut and try" method can either miss the target entirely or it can be gamed by those affected by the regulation.

The U.S. regulatory process is piecemeal and Congress and regulatory agencies often changes the rules of the game in midstream. Consequently, regulations sometimes combine with other factors and have unanticipated effects, but the *public outcome* is usually the same - companies raise prices and the public often pays for them without being sure what their return is and if their return exceeds their costs.

D. Examples of Regulations that Miss Their Target

Examples of regulations failing to accomplish their intended goal follow. Each of these occurred because of a flaw in the regulation development process, not flawed legislators or flawed regulators. Quite simply, there are some things that political process do not do very well.

³⁷⁹ Roger G. Noll, "Economic Perspectives on the Politics of Regulation", in Handbook of Industrial Organization, Volume II, edited by Richard Schmalensee and Robert D. Willig, Elsevier Science Publishers, 1989.

- ◆ To assist a particular industry sector that was having difficulty competing in international markets, a tax credit was provided on R&D growth to all industries. In response to an R&D tax credit, it was anticipated that companies would increase R&D investment. Little concern was given to the fact that an increase in R&D investment would likely be accompanied by a decrease in plant and equipment investment. Furthermore, this regulatory change was made without any knowledge as to whether this offer was sufficiently generous to overcome other barriers to competition, if the marginal return on R&D was sufficient to justify additional investment in R&D in the sector having difficulty, or if the new ratio of R&D investment to plant and equipment investment was optimum for other sectors.
- ◆ To stop foreign firms from dumping DRAMs on the U.S. market at prices below their manufacturing cost, a minimum price was established for DRAMs sold in the U.S. This helped foreign firms reap windfall profits and drove-up the cost of U.S. built products that used DRAMs.
- ◆ To stop foreign firms from dumping flat panels on the U.S. market, a tariff was placed on imported flat panels. In response, some U.S. firms that were manufacturing products that used flat panels moved their assembly operations offshore.
- ◆ To protect the public health, the FDA requires that chemistry, manufacturing, and control changes to a manufacturer's previously FDA-approved drug or medical device must be reviewed and approved by the FDA regardless of how minor the change may be. Unless these changes increase product margins, companies are encouraged to not introduce incremental changes that could benefit public health.
- ◆ The National Task Force on AIDS Drug Development was unable to quickly determine which companies were developing which drugs because a government regulation prohibited them from surveying more than 8 people at a time. The government regulation requiring that all meetings be open to the public prevented this Task Force from getting to the roots of the AIDS problem. The Task Force is generally regarded to not have accomplished its goal of identifying and removing any barriers or obstacles to developing effective treatments for AIDS.³⁸⁰
- ◆ While most regulations are created with public benefits in mind, there are often many hidden public costs. For example, most U.S. families have seen no growth in their real income over the last 15 years. A Brookings Institution study reveals that the large transaction costs and often paltry net benefits associated with much contemporary social regulation and related legal wrangling are at least partially implicated.³⁸¹
- ◆ In 1971 Congress was concerned about the cost of election campaigns, particularly the cost of television spots, so they passed the Federal Election Campaign Act, which required television networks to give political candidates an advertising rate equal to the lowest rate offered any commercial customer. In response, the TV networks raised their

³⁸⁰ Science, "AIDS Task Force Fizzles Out", January 26, 1996, p 439.

³⁸¹ Pietro S. Nivola, "Having It All?", The Brookings Review, Winter, 1996, p 18.

minimum advertising rates for commercial customers, so everyone paid higher rates, including political candidates.³⁸²

- ◆ In 1990 Congress observed that some of the large HMOs were paying less for drugs than Medicaid was paying so it passed the Omnibus Budget Reconciliation Act to reform Medicaid reimbursement. Medicaid payments were limited to the lower of 88 percent of the average price paid for a drug or the lowest price paid by any purchaser.³⁸³ It is estimated that this provision drove up the price of patented branded drugs by 9 percent, off-patented branded drugs by 5 percent, and generic drugs by 2 percent.³⁸⁴
- ◆ Government responded to high loss of life in automobile accidents by requiring that automobile manufacturers install air bags. Because only 10 percent of Americans were wearing their seat belts, additional seat belt regulations requiring air bags were instituted to protect an average-sized male adult not wearing a seat belt. Even though automobile manufacturers expressed concern about the safety of children and small women when impacted by an air bag expanding at a rate of 200 miles per hour, the more demanding standards were imposed. We now know that nearly 70 percent of Americans wear their seat belts and since 1991 32 children's lives have been taken by air bags³⁸⁵.

E. Regulatory Process Reform.

Recognition that the U.S. regulatory process is in need of reform is widespread. At a CEO summit meeting hosted by Bill Gates, Vice President Gore, the keynote speaker, told executives that the U.S. must prepare for the new global economy with a new appreciation for the key role of innovation. He emphasized, however, that this doesn't mean slashing government regulations, but making regulations flexible.³⁸⁶

Regulatory practices must be adjusted

- ◆ to favor the U.S. over other international alternatives when companies are choosing the location for new manufacturing and services facilities,
- ◆ to encourage industries to continue operating manufacturing facilities in the U.S., even after competition is dominated by the need to improve products and processes or the product has entered a commodity phase, and
- ◆ to favor the competitiveness of U.S. companies in international markets, regardless of where they manufacture their products.

To achieve these adjustments, the regulation development process must be reformed.

³⁸² Alam M. Brandenburger and Barry J. Nalebuff, Co-opetition, Currency Doubleday, 1996, p. 163.

³⁸³ Ibid, p. 164.

³⁸⁴ Fiona Scott Morton, "The Strategic Response by Pharmaceutical Firms to the MFN Clause in the Medicaid Rebate Law of 1990", Ph.d. dissertation, MIT, 1994.

³⁸⁵ Senator Dirk Kempthorne, "The Government Must Change Air Bag Standards to Protect Children", Statement to the Senate Commerce, Science, and Transportation Committee, January 9, 1997.

³⁸⁶ USA Today, "Gates Pitches Paperless Office", May 8, 1997, p. 3B.

- ◆ The cost of regulations on businesses located in the U.S. and in nations that are primary competitors of the U.S. must be modeled and integrated with other cost models so that the cost of locating businesses in the U.S. can be quantitatively compared to other international alternatives.
- ◆ Restrictions must be added so that no new regulation can be passed into law until the cost of the regulation is estimated by this model; the overall economic impact is estimated; and in the event that the regulation has great public value, other areas of corporate regulatory relief identified so that National economic growth is preserved.
- ◆ We must be able to assess in advance how those affected by the regulation will react to it - will they "game" (i.e., get around) the regulation or will the regulation close the company and remove critical jobs from the economy?
- ◆ In order to avoid the "fox in the chicken house syndrome", agency-level regulatory bodies must be tasked to only enforce regulations. The Atomic Energy Commission was removed because it had a conflict of interest in filling both regulatory and advocacy functions for nuclear power. To be consistent with this principle, regulatory enforcement bodies should have no advocacy or problem-solving role to play for those being regulated. Clearly, regulatory bodies restricted to only enforcement activities can only err by under-enforcement; therefore, they tend to be risk-averse and over-enforce and their style is often perceived to be petulant and punitive. On the other hand, there can be a conflict of interest when regulatory agencies have a role to play in the development of regulations or in calculating the costs and benefits of regulations.

By emphasizing violations rather than problems, regulation creates bitterness and adversariness. Everything must be put on the record. Businesses will not share information. A culture of resistance sets in.³⁸⁷

Chertow and Esty used a football metaphor to point out the conflicting roles that government attempts to fill in implementing its regulatory function,

It is difficult to simultaneously be referee and quarterback. Under the current regulatory scheme, government sets the rules, which is necessary and appropriate, but also tries to dictate exactly which plays to use. Now we see that this approach is stifling to innovation, does not account for differences across industries and ecosystems, and creates incentives to try to get around the law.³⁸⁸

³⁸⁷ Philip K. Howard, The Death of Common Sense: How Law Is Suffocating America, G. K. Hall & Co., 1994, p 69.

³⁸⁸ Marian R. Chertow and Daniel C. Esty, "Environmental Policy: The Next Generation", Issues in Science and Technology, Fall 1997, p. 77.

Step 1: Knowledge Input

Step 2: Consensus

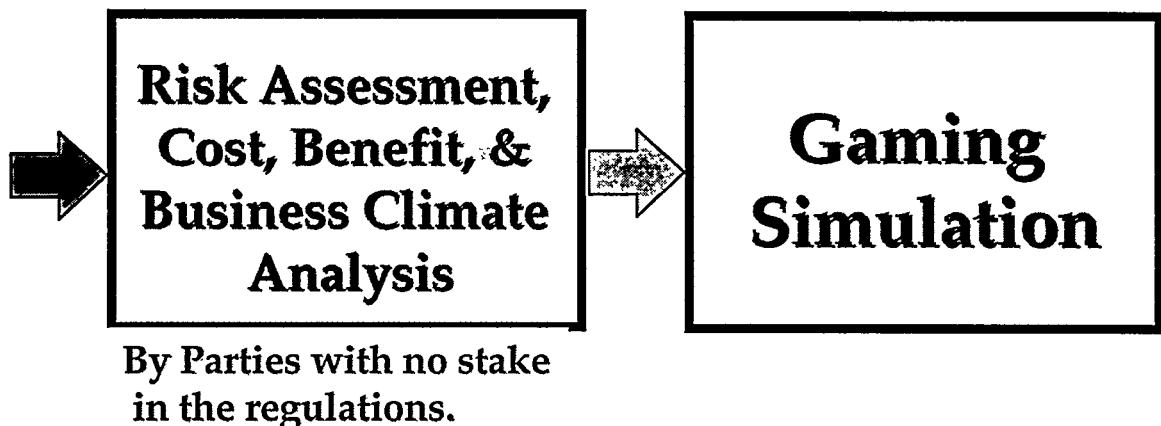


Figure 3: Changes proposed for the process of developing regulations. Goals we propose for regulatory reform are: know for sure how much regulations cost, know the risks of doing nothing in comparison to the regulatory risks, know their public and private benefits, and reduce public and private regulatory costs by \$160 billion/year.

Weaknesses in the regulatory development process often lead to regulations whose public costs exceed their public benefits. Even though regulations are based on compromise among those with a stake in the regulations, today's processes rarely lead to win-win solutions that stakeholders support. An improved process that promotes buy-in by all of those affected by regulations is needed. Cost/benefit analyses performed by "honest-brokers" with no particular stake in the regulatory debate can be combined with the war game process to introduce and test major improvements in the regulatory process. These steps are illustrated in Figure 3.

F. Current Reform Activities.

Congress is currently considering two regulatory bills. One is S 981, introduced by Senators Thompson and Levin. The other is S 1728, introduced by Senator Lott.³⁸⁹

S 981 would require that agencies proposing regulations that would cost businesses more than \$100 million must conduct cost-benefit analyses. A 1993 executive order by President Clinton already requires cost-benefit analyses by agencies. S 891 also requires risk assessment calculations for major rules that could impact the public health and safety or impact the environment. All cost-benefit analyses and risk assessment analyses would be subject to peer review by an independent panel of experts. This bill has been reported out of the Senate Governmental Affairs Committee.

S 1728 goes further in demanding the use of risk assessment analyses, but neither bill has addressed the organizational issue of regulations. We are arguing that if regulatory analyses are to be removed from political considerations, an independent group with no vested interest in regulations should provide the cost-benefit and risk assessment analyses and leave agencies to implement regulations and work with Congress on the development of regulations.

³⁸⁹ Congressional Quarterly, "Rival Bills Cloud the Scene for Regulatory Overhaul", March 14, 1998, pp. 658-659

Furthermore, neither bill puts in place a mechanism to determine whether or not the regulated might identify ways to game regulations and neither bill establishes a goal for how much the public and private costs of regulations are to be reduced. We recommend investing \$1 billion per year in cost-benefit analysis, risk assessment analysis, and gaming processes with the requirement that within three years these activities must identify ways to reduce regulatory costs by \$200 billion or the analysis groups would lose their funding. Again, Congress is addressing a complex system with piecemeal steps with no real goals in mind other than the appeasement of special interests. Political processes don't always lead to the best solutions.

10. The Infrastructure Problem

A. Introduction

The U.S. infrastructure is a complex system of interdependent elements whose combined operation is vital to the security and well being of the U.S. The three primary elements of the U.S. infrastructure include telecommunications, transportation, and the power grid. Additional infrastructure elements include: oil and gas delivery and storage, water supplies, emergency services, and government services. The telecommunications and power grid infrastructure elements are privately owned; the public has no responsibility for their operation and maintenance. The transportation element is largely privately owned; an exception is highways and bridges that are publicly owned. Therefore, the public has responsibility for building and maintaining highways and bridges. However, because the U.S. infrastructure is vital to the economic security of our Nation, the public shares responsibility with the private sector for protecting the infrastructure against those that might threaten its existence.

B. Transportation Infrastructure Construction, Maintenance, and Safety.

The U.S. has over 175 million passenger cars and light trucks that annually travel more than 2 billion miles over 3.9 million miles of public roads. Only 161,000 miles of these roads are part of the national highway system (NHS), but 40 percent of all highway travel, 75 percent of freight, and 80 percent of vacation travel are on the NHS. (The Interstate Highway system is part of the NHS. Interstates make up 1.2 percent of U.S. road mileage, but carry 23 percent of all traffic and 48 percent of all truck traffic.³⁹⁰)

America's transportation infrastructure is congested, it is slowly deteriorating, and it is in need of repair and improvement. Traffic jams are thought to cost Americans \$80 billion a year in lost time.³⁹¹ Automobiles idling in traffic jams use about 12% of transportation energy consumption. The Federal Highway Administration (FHA) has determined that 28 percent of U.S. roads are in poor to mediocre condition and 32 percent of the Nation's bridges are deficient. One of four bridges on the National Highway System, the backbone of America's road network is obsolete or has structural problems.³⁹² Over 12,000 of the 42,000 annual highway deaths are believed to result from poorly designed roads, roads whose automobile capacity exceeds design limits, and roads that are inadequately maintained.³⁹³ Highway vehicle accidents are estimated to annually cost \$150 billion with about one-third of this being property damage.

³⁹⁰ Keep America Moving, The Federal Highway Program and the States, 1997.

³⁹¹ Paul Krugman, Development, Geography, and Economic Theory, MIT Press, 1996.

³⁹² Federal Highway Administration, Conditions and Performance Report, November, 1995.

³⁹³ Keep America Moving, How Much Funding for Highways?, 1997.

Of the \$31.5 billion the federal government collects in motor fuel taxes, less than \$20 billion is actually spent on maintaining and building roads and bridges. When state, local, and federal taxes on motorists are added, the total transportation tax comes to \$142 billion each year. This includes \$60 billion in motor fuel taxes, \$23 billion in license and registration fees, \$5 billion in tolls, and \$55 billion in motor vehicle sales taxes, vehicle property taxes, and miscellaneous taxes levied on motorists. Of this total collected, expenditures on roads are \$82 billion. These include \$42 billion on capital outlays, \$24 billion on maintenance and traffic services, \$8.4 billion on administration and research, and \$8 billion on law enforcement and safety.³⁹⁴ Because of the lack of incentives for highway and bridge construction companies to invest in construction R&D, there is very little private investment in bridge and highway R&D.

The American Society of Civil Engineers (ASCE) estimates that we are underinvesting in our roads, bridges, and transit systems by \$18.2 billion annually to maintain current conditions, and by \$42.3 billion to improve conditions and performance. ASCE calculates that driving on roads in need of repair costs American motorists \$23.7 billion a year in extra vehicle repairs and operating costs.³⁹⁵ In March 1998, ASCE estimated that 59% of U.S. roadways were in poor, mediocre or fair condition and that it would cost \$437 billion to bring the system into top condition. This includes \$80 billion to repair the one-third of U.S. bridges that are structurally deficient.³⁹⁶

It has become increasingly difficult to set aside funds to support the testing and evaluation of new highway technologies (for example, seismic isolation and dissipation devices, high performance concrete and steel, bonding agents for pothole repairs, a heated pavement system, a high retroreflectivity traffic sign system, and a precast segmental overpass system³⁹⁷) that increase the lifetime and reduce the cost of highway maintenance. Regulatory barriers inhibit the introduction of new, proprietary technology into surface transportation systems.

A systems solution that minimizes long-term maintenance and upkeep costs is required for our highway system. The Rebuild America Coalition estimates that as much as \$1.1 trillion is needed over the next 15 years to provide a minimally satisfactory public works infrastructure. Others estimate the annual aggregated construction, maintenance, and repair costs of infrastructure to be over \$100 billion. About \$10 billion is required per year to meet regulatory requirements for water systems. In addition to highway infrastructure needs, U.S. air traffic grows about 50% each decade.³⁹⁸

U.S. transportation systems have long:

- ◆ emphasized autonomy of the individual (Between 1980 and 1990 the percentage of people driving to work alone increased from 64 percent to almost 73 percent; the growth

³⁹⁴ Keep America Moving, Highway Users Fees and Taxation, 1997.

³⁹⁵ Ibid.

³⁹⁶ Congressional Quarterly Weekly, "America Hits the Highways, and Congress Must Navigate", May 16, 1998, p. 1266.

³⁹⁷ Dr. C. Michael Walton, American Society of Civil Engineers, testimony before the Subcommittee on Technology of the Committee on Science, United States House of Representatives, April 23, 1997.

³⁹⁸ Data were provided by Dr. Will Kirksey, Vice-President, CERF, Washington, DC.

rate of registered vehicles was twice the population growth rate; and the growth rate of miles driven was four times the population growth rate.),

- ◆ under emphasized public transportation (Despite numerous attempts by government to promote mass transit systems, less than 3 percent of surface travel occurs on mass transit and most of that is on highways for school and bus transit. The U.S. currently has 14 subway systems, 16 commuter rail lines, 22 light-rail networks and 2,250 bus systems.³⁹⁹ Not a single U.S. mass transit system collects user fees that cover even half of its capital and operating costs and few mass transit systems provide the suburb to suburb transportation needs of working Americans. New rail systems typically require operating subsidies between 50 percent and 90 percent of operating costs and capital subsidies of 100 percent. Mass transit transportation costs about 60 cents per passenger mile. Approximately 20 cents of this is paid by fares and 40 cents comes from government subsidies. Amtrak costs about 30 cents per passenger mile. Approximately 15 cents comes from fares and 15 cents is paid by government subsidies. ⁴⁰⁰)
- ◆ maximized fuel inefficiency and air pollution. (Ridesharing, including carpooling and vanpooling, is 70 percent more fuel efficient than heavy rail or Amtrak, is 80 percent more fuel efficient than light rail and is even slightly more fuel efficient than intracity buses.)

This entire area is in need of systemic research that identifies options for the future, estimates the costs and benefits of these various options and lays out research roadmaps for realizing the preferred options.

C. Protecting the U.S. Infrastructure Against Threats

In January of 1997 a task force of The Defense Science Board (DSB) pointed out that it is possible for an adversary to mount a structured offensive against the U.S. infrastructure, while disguising the attack. This task force issued an urgent report warning that the U.S. computer systems network is so vulnerable to malicious assaults that we may one-day face "an electronic Pearl Harbor". Examples of catastrophe include: Wall Street computer screens go blank during an especially busy trading day. Automobile manufacturing lines are brought to a halt due to a programmed power outage. Air traffic control systems bring airliners in to land on a crowded Los Angeles runway where planes are taking off in the opposite direction. All of the bank accounts are emptied throughout a major city. In addition, physical attacks on infrastructure could include regional power disruptions, disruption in 911 calls because of repeat call flooding, bridges carrying automobiles, trains, and telephone cables are destroyed, Internet service providers in a major city are disabled, etc.

These are not just make-believe cyber attacks. Actual attacks have the potential for even greater consequences. In 1989 cyber thieves placed logic bombs in public telephone networks in Atlanta, Denver, and Newark. In 1995, cyber thieves stole 60,000 calling card numbers. In 1994, a Russian crime ring stole \$12 million by gaining access to Citibank computers. During the Gulf War a group of teenagers in the Netherlands gained access to computer files at 34

³⁹⁹ Congressional Quarterly Weekly, "Mass Transit in Growth Mode", May 16, 1998, p. 1270.

⁴⁰⁰ Keep America Moving, Subsidizing Mass Transit, Amtrak and High-Speed Rail, 1997.

American military Internet sites and identified the exact location of U.S. troops and identified their weapons.⁴⁰¹

*Waging the domestic version of what security experts call "infowar" means applying computer viruses, hidden codes, data-destroying software programs and other electronic mechanisms that could, among other things, halt the operations of electric power grids, natural gas pipelines, railroad switching facilities and air traffic control systems. Infowarriors could also scramble the software used by banks, hospitals and emergency services, and break down telephone and other telecommunications networks.*⁴⁰²

Varnado has pointed out that there are many interdependencies between elements of the U.S. infrastructure. For example, an extended power outage could lead to computers' emergency power supplies being extended beyond their service life. Failure of the computers that control the power grid could further compound the severity of the power grid failure that initiated the computer failure. Thus failures can propagate through the infrastructure network. Varnado recommends that these infrastructure dependencies be modeled.⁴⁰³

An attack on the U.S. information infrastructure might be disguised as a series of apparently unstructured, random events that appear to be the uncoordinated work of hackers or splinter terrorists groups. Despite the difficulty in providing a specific definition of just exactly what constitutes a cyber attack, it is particularly important that the U.S. be able to detect cyber threats when they occur.⁴⁰⁴ It is clear that we need to model the infrastructure, provide for the early detection of infrastructure failures, and develop a consequence-based identification of critical nodes in the infrastructure network.⁴⁰⁵

President Clinton has established a Commission on Critical Infrastructure Protection to make recommendations for government's response to threats to the Nation's infrastructure. Early recommendations⁴⁰⁶ from this commission include,

Federal research and development efforts are inadequate to meet the challenge presented by emerging cyber threats. About \$250 million is spent each year on infrastructure assurance-related R&D, of which 60 percent -- \$150 million is dedicated to information security. There is very little research supporting a national cyber defense. The Commission believes that real-time detection, identification, and response tools are urgently needed, and we concluded that market forces are currently insufficient to meet these needs. Thus, we recommend doubling federal R&D funding for infrastructure

⁴⁰¹ Graeme Browning, "Counting Down", National Journal, April 19, 1997, p. 746.

⁴⁰² Ibid.

⁴⁰³ Dr. Sam Varnado, Modeling Interdependencies in the U.S. Infrastructure, 1997 white paper provided to James Gover.

⁴⁰⁴ Dr. Sam Varnado, Assessment of the Feasibility of Developing an Indications and Warning System to Protect Critical U.S. Infrastructures, an unpublished white paper, 1997, provided to James Gover.

⁴⁰⁵ Dr. Sam Varnado, Consequence Based Rationale for an Infrastructure Assurance Program, 1997, provided to James Gover.

⁴⁰⁶ Robert T. Marsh, Chairman, The President's Commission on Critical Infrastructure Protection, Before the Subcommittee on Technology, Terrorism and Government Information, Committee on the Judiciary, United States Senate, November 5, 1997.

protection to \$500 million the first year, with 20% increases each year for the next five years. We recommend this funding target:

- ◆ *Risk management, simulation and modeling, and decision support;*
- ◆ *Contingency planning, incident response, and recovery;*
- ◆ *Information assurance, vulnerability assessment, and system analysis; and*
- ◆ *Early warning and response, monitoring, and threat detection.*

V. Findings and Recommendations

A. Findings

We have reached several conclusions regarding the ten public problems we have described.

- ◆ The economic consequences of these problems are immense. A 20% reduction in the costs of healthcare, education, and regulations would allow an additional \$500 billion to be injected into the U.S. economy for use for other purposes. However, because of the economic magnitude of these problems, there are many very influential, financially secure special interests that will prefer maintenance of the status quo. Every shred of research that contributes in a major way to solving these problems will be challenged and the credibility and competence of the researchers will be impugned. Those researchers and research institutions that prefer political lite should avoid these issues.
- ◆ Most of these problems have been around for several years. Each is a complex problem whose solution will have to be introduced through and by the U.S. political system. The U.S. political system for a variety of reasons has been unable to address these problems at the systems level. Rather, it has only been able to introduce piecemeal solutions. If our political system as currently configured and by making use of its current processes, were able to solve these problems, most of them would already have been solved.
- ◆ The primary output of research on these problems must be models that permit informed decisions to be made. Therefore, the emphasis of researchers addressing these problems must be less on solving them than providing useful, data-based predictions of future events and interrelationships of controllable parameters that can be used to guide the political system in forging policy decisions that address these problems. To accept and adopt research input into the political system, research findings must be made widely available to the public in a language familiar to most of the public, the U.S. policy development process must be adjusted to accept additional informed input, and the U.S. policy development process must develop a meaningful way to prioritize problems and solutions. In the Appendix we offer our suggestions for how the political system should be altered to address these problems.
- ◆ The major components of most of these problems are socio-economic and socio-political. For researchers to make significant contributions to these problems, those with computer-based modeling and simulation skills must team with sociologists, economists, management experts, systems engineers, political scientists, physicists, chemists, public

policy experts, lawyers and others. For this to occur, major changes must take place in the culture of U.S. researchers, a community that has often eschewed teamwork and often functioned as independent individual investigators. Members of the U.S. research community are reminded that unless some of these problems are solved, there will not be any public funds available for pursuit of that favorite research topic they have pursued for the last 25 years.

- ♦ Because of the complexity of these problems, modeling and simulation research will never lead to “clean”, indisputable answers; rather, these tools will permit comparisons of alternatives and provide new insight into the interrelationships between parameters and it will offer insight into the root causes of many of these problems. Consequently, the political system must evolve solutions in an atmosphere of experimentation in which several alternative solutions, each supported by limited simulation and modeling and each well-supported by public outcome metrics, are pursued in parallel.

B. Recommendations

We recommend that 10 publicly owned laboratories be selected from the Nation’s 515 Federal laboratories through a multi-agency led competition to lead a National effort to develop models and to simulate these complex systems we have described. Each laboratory would lead and manage a \$1 billion program. The funds for these activities would be appropriated to each laboratory’s agency owner for transfer to the laboratory selected to manage the activity. After 3 years, each lead laboratory would begin to offer policy recommendations, including policy experiments, for pursuit by Congress. Some of these must be long-term continuing activities, e.g., developing cost benefit models for regulations, while others should be completed within five years leaving only a continuing, low-level research effort.

Appendix I: A Revolution in Science and Technology Policy Making

Abstract

We have examined Federal science and technology (S&T) policy and concluded that the public would benefit from an improved policy development process for both authorizing programs and appropriating funds to programs. We recommend that S&T policy development shift from an almost entirely political process driven largely by self-interest of R&D performers and by market solutions to one that incorporates recommendations from a technocracy representing the interests of the public. We call that technocratic body the Science and Technology Policy Board (STPB) and recommend that it be patterned after the Federal Reserve. The STPB would consider all public problems, including those not currently being addressed, recommend programs to solve these problems, and prioritize these programs based on public need, economic cost and risk-consequences analysis. The STPB would test the response of those affected by their recommendations by making use of scenario planning and gaming technology. Politics would not be removed from the policy development process - Congress would continue to authorize and appropriate funds considering recommendations of the STPB, and The President could exercise veto authority. Furthermore, The President could recommend an entirely different suite of programs to The Congress from that recommended by the STPB. The necessary political features of policy making would thus be retained while introducing recommendations from a technocracy with less vested personal interest. Under this new

model, agencies would retain responsibility for program execution and management, areas in which they excel, but their role in program selection would change. As an independent agency, the STPB would also analyze current and proposed “big science” programs.

A. Background

We have been challenged to identify an organizational structure for crafting National science and technology policy that would better serve the Nation, that is, produce higher *public outcomes* in those areas most needed by the public. In addressing that challenge, it was tempting to review proposals that others have offered (e.g. reorganize the Congressional authorization and appropriations committee structure, create a Department of Science and Technology, convert the Department of Energy (DOE) into a Department of Technology, transfer all technical functions out of the Department of Commerce (DOC) and convert the residual into a Department of Trade, transfer all defense work from the DOE to the Department of Defense (DoD), etc.). We could have analyzed the pros and cons of each proposal and perhaps recommended one that would seem to work the best. After reviewing several of these proposals, we concluded that Congress hasn't adopted them principally because these⁴⁰⁷ were little more than exercises of moving boxes around on an organizational chart. We wished to examine government at a higher level and have, therefore, taken a different approach.

B. R&D Program Authorization

a. Introduction. Those that authorize and appropriate Federal R&D funds have the following questions to address:

- ◆ Are we working on the right problems?
- ◆ Are we doing the right type and amount of R&D to solve these problems?
- ◆ Are we doing the R&D right?

In this paper we address the issue of selecting the right problems and defining the R&D that must be done to solve these problems. The data seem to suggest that for the most part, federal R&D are done right.

It is important to optimize the technology and science policy development process and, in particular, to establish formal and defensible processes for selecting programs and determining funding priorities. We suggest that the knowledge-deficient, technology-reluctant political process that is used to develop legislation, while powerful and effective at converging to the “right answer” over the “long-haul”, is unnecessarily slow and critical front-end analysis is rarely accommodated. Furthermore, it is susceptible to ideological shifts among policymakers. We first examine today's process to identify its flaws.

b. Today's Legislative Process. Review of the S&T policy development process used today that is illustrated in Figure 4 reveals several weaknesses:

⁴⁰⁷ The Galvin proposal recommended a more substantial change but it only addressed a single agency (the Department of Energy) and a subset of that agency's laboratories (its nine multiprogram national laboratories).

- ◆ R&D Performers' Needs Drives Policies - R&D performers naturally tend to identify problems and research and development programs that are within their areas of technical capabilities and experiences. (R&D performers are said to sometimes have solutions seeking problems.) In addition, R&D performers may regard advancements in science and technology as their program's desired outcome rather than outcomes that meet **public needs**. Performers of publicly funded R&D are rarely aware of the economic, social, political and other conditions that must prevail, in addition to R&D, in order to accomplish the **public outcome** that they hope their R&D project will stimulate.
- ◆ Little Real-Time Learning - Because agencies serve as advocates for their programs, they often continue to promote programs to the President and Congress even when there is much evidence that programs are unlikely to accomplish their advertised **public outcomes** or new evidence suggests that the program is no longer needed. Even slight changes in programs that could lead to increased public outcomes are rejected because this could be interpreted as admission that a program had weaknesses. This distortion results in an adversarial, cynical atmosphere between Congress and the executive branch that encourages some in Congress to overlook successful programs and highlight, in a spirit of ridicule rather than learning, those that fail, and it encourages Congress to micromanage programs, a task ill-suited to a legislative institution.
- ◆ Most Analysis Is Retrospective, Not Predictive or Real Time - Because of the lack of pre-program and an ongoing **outcome analysis and outcome linkage to R&D activities through roadmaps**, Congress and the President have difficulty ascertaining how well federal programs, particularly research and development programs, are working. Sometimes, near the end of a program's life Congress learns that the **public outcomes** it is seeking will not be satisfied. The Government Performance and Results Act (GPRA) is an attempt by Congress to introduce strategic planning and obtain better data on how programs are progressing; however, agencies are having difficulty bringing their R&D programs into compliance with GPRA.

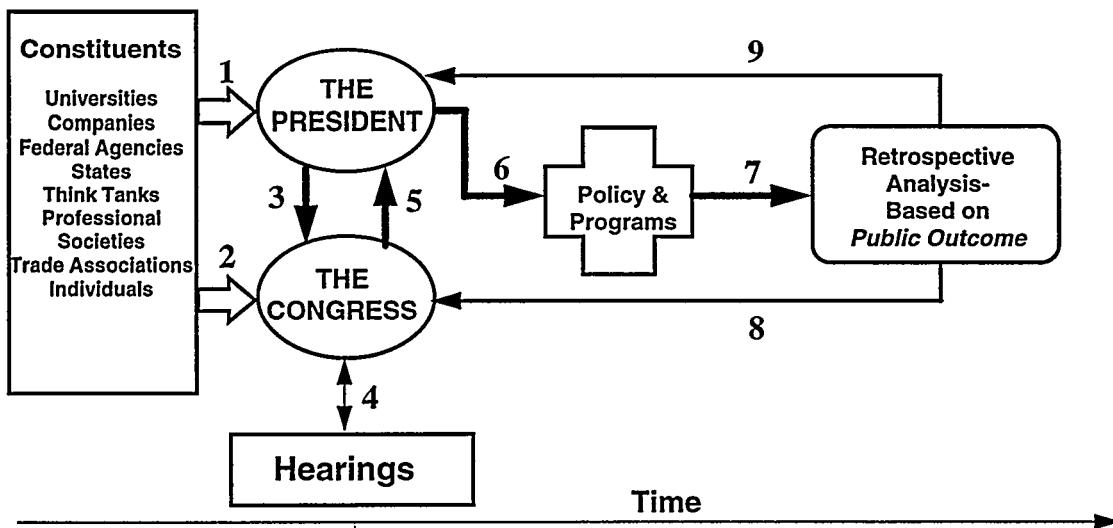


Figure 4: The annual process that is used to develop Federal S&T policy starts with constituents proposing to The President (1) and The Congress (2) that certain programs or policies are needed to satisfy some public need. The President, relying on requests passed

from the federal agencies through the OMB, may ask Congress (3) to authorize and appropriate funds for selected ones of these programs. Congress may hold hearings to gather information or gauge public sentiments. (4) Most of the time Congress supports, at least partially, the President's request. Sometimes Congress creates programs that are not requested by the President and other times Congress may fund a program requested by the President, but often at different funding levels from those requested by the President. Congress then sends their authorization bills and appropriations bills to the President. (5) Finally, some of the policy measures and programs authorized and appropriated by Congress are signed into law by the President (6) and programs and policies are created or extended. Much later, even five years into the life of a program, analysts may conduct retrospective analyses (7) to determine the public outcomes from programs. Their conclusions are passed to the White House (8) and the Congress. (9) Rarely are the retrospective analyses sufficiently timely to influence programs and policies.

- ◆ **Public Return Metrics Are Weak** - Metrics that measure and predict the *public outcome* from government-sponsored research and development programs lag companies' research and development metrics by perhaps one or two decades. Consequently, Congress and the President have difficulty establishing funding priorities based on their *public return*.
- ◆ **Political Process Doesn't Always Involve all Stakeholders** - Except for certain classes of medical research, usually research to find cures for diseases, the public that pays for federal research and development programs has little involvement in the development of national technology and science policy. In view of the relatively few informative news media discussions of technology and science, this should not come as a surprise.
- ◆ **Process Doesn't Anticipate and Address Long-Term *Public Needs*** - When new *public needs* emerge that do not fit the mission of an existing federal agency, no agency advocate exists to propose programs to address these new needs. Furthermore, both Congress and commissions that study various agencies and their laboratories consistently emphasize that Federal laboratories should "stick-to-their-knitting" and not address issues that might lie outside their mission. (Agencies have missions that are designated by Congress. If Federal laboratories have missions, these are either mission functions delegated by an agency or self-proclaimed missions.) Washington has developed the term "mission creep" to describe Federal labs working on issues that Congress has not designated to be part of the mission of their primary Federal supporting agency. Consequently, the current agency structure and policy development process encourages agencies to continue to argue for old programs whose *public utility* has matured if not expired. The real issue is one of "problem creep"- emerging problems that aren't being addressed - rather than "mission creep" - agencies working outside of their mission area.
- ◆ **Process Relies too Heavily on Experts with Vested Interests** - Peter Schwartz, one of the world's leading futurists, used scenario planning to help guide Shell Oil Company executives to make billions of dollars for Shell investors in the 1970s. When he attempted to use this long-range planning technology to help a previous administration anticipate problems, he was unable to influence government. While the White House was looking to avoid future surprises such as the oil crises of the 1970s, the distinguished scientists that were members of the President's Science Advisory Council had a different agenda. Schwartz interpretation of what happened was,

I concluded that the federal government in Washington, DC, was systematically unable to think about the future. By definition, all of their policies must be successful and they have foreseen every problem. To think about any other possibility is to imply the impossible, that they are less than all knowing and powerful.⁴⁰⁸

This example illustrates that addressing S&T policy by relying exclusively on the opinion of scientists that have distinguished themselves by their contributions to science has many weaknesses.

- ◆ Process Cycle Is too Short - Despite the lack of knowledge injection into the S&T policy development process, the authorization and appropriations process is an annual event. The time Congress and the Executive spend rehashing last year's decisions in the face of no new knowledge could be better spent doing oversight and assessing ***public outcomes***. In the case of S&T policy, it is far more important to get the policy right in the first place and review the policy once every two years, as Senator Domenici⁴⁰⁹ has proposed, to make sure that the program is on a path that will lead to the desired ***public outcome***.
- ◆ The traditional policy development process is input or budget-driven rather than ***public outcome***-driven. Most of the planning debates are concentrated on budgets (inputs) rather than the ***public problems*** these programs are intended to solve. We do not intend to suggest that budget considerations should not weigh heavily in the S&T policy development process; rather, we are arguing that it overshadows all other issues, particularly the questions of "how will the public benefit from this program and by how much?"
- ◆ The traditional policy development process does not make use of emerging planning technology. Companies have found scenario development and gaming technology to be useful for strategic planning. These tools can also be useful to government in crafting S&T policy.

The policy development process can be altered to address some of these weaknesses. The U.S. technology and science policy development process could benefit from recommendations made by experts that are well versed in public policy issues relative to the mission area of government they are tasked to address. In Figure 5 we depict the observation that there are a continuum of states between a purely technocratic process in which experts make all decisions, and their decisions cannot be challenged by the political system, and a purely political process in which all decisions are based entirely on their political merit.

To introduce expert opinion into the S&T policy development process, we wish to slightly shift along this continuum toward a new state that is closer to the technocratic process.

⁴⁰⁸ Peter Schwartz, The Art of the Long View, Currency Doubleday, 1991, p. 37.

⁴⁰⁹ Senator Pete V. Domenici, "Make It a Two-Year Budget", The Washington Post, December 8, 1996.

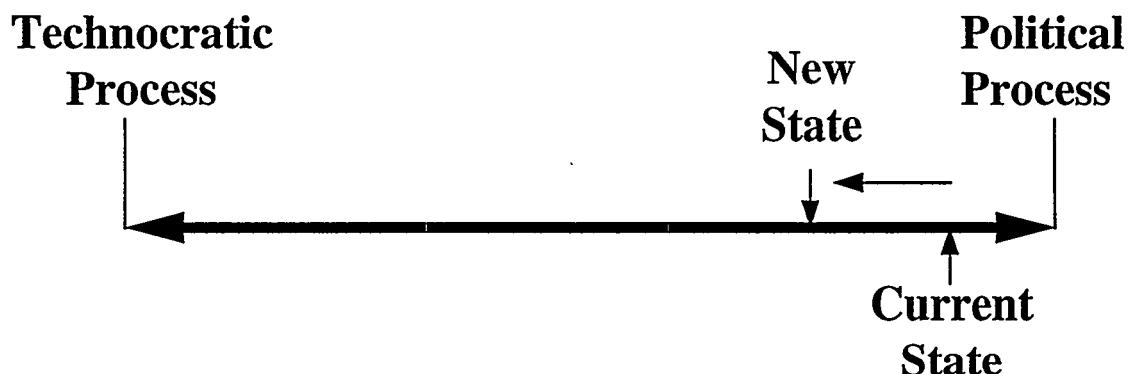


Figure 5: A process model is offered that assumes a continuum of states between a purely political process and a purely technocratic process. We are seeking a state that is responsive to the best qualities of both political and technocratic processes. We propose to shift the science and technology policy development process toward a slightly more technocratic state but not as far as was recommended by Vannevar Bush.

c. Synthesis of an Organization. We recommend that a new independent Federal organization be established to implement this process, that this new agency be called the Science and Technology Policy Board (STPB) and that it be patterned after the Federal Reserve. Since its creation in 1913, the Federal Reserve has provided our Nation with a safer, more flexible, and more stable monetary and financial system. The Fed, as the Federal Reserve System is called, has slowly gained the respect of the economics profession, Congress, the business community, and the public. The visibility of the Federal Reserve was highlighted during the 1970s when the U.S. was experiencing rapid escalation in inflation. Blinder describes proceedings at the Federal Reserve as,

At the Federal Reserve ... the pace is deliberate, sometimes plodding. Policy discussions are serious, even somber, and disagreements are almost always over a policy's economic, social, or legal merits, not its political marketability. Overtly partisan talk is deemed not just inappropriate, but ill-mannered. The attitudes of particular legislators, interest groups, or political parties toward monetary policy are rarely mentioned, for they are considered irrelevant. And the Fed rarely discusses its "message." The Fed does not always make the right call, but its criteria are clearly apolitical. And its decisions are arguably better, on average, than those made in the political cauldron.⁴¹⁰

Like the Federal Reserve, we recommend that the President subject to confirmation appoint the chairman of the STPB, the vice-chairman, and the STPB's five member Board of Governors by the Senate. However, once appointed, the chairman and governors must not be obliged to follow the bidding of either the President or Congress. The STPB would be insulated from politics and expected to recommend science and technology policy based entirely on its expected public return. Employees of the STPB would be members of the public policy, science and technology, economics, management of technology, and business communities that have distinguished themselves by their research and knowledge on those various models

⁴¹⁰ Alan S. Blinder, "Is Government Too Political?", Foreign Affairs, Vol. 76, No. 6, November/December, 1997, p.117.

that are relevant to Federal science and technology policy and their analyses of S&T policy. The committee would be tasked to evolve a set of recommendations for how the federal government should best support technology and science in their particular area of focus, e.g., energy, medical, commercial technology, etc. in order to maximize return on the public investment (*public outcome* or return divided by public cost). A great deal of attention and focus would be directed toward identification of the market failure the recommended program was designed to correct. This committee as deemed appropriate would use scenario planning and other emerging methods of strategic planning.

We propose that this STPB structure be used to address all federal R&D. A report of the findings and recommendations of the STPB would include the proposal for a National program for each major mission area (which could certainly include a recommendation for no program). Roles for agencies, universities, federal laboratories, states, and companies in executing this program would be emphasized in their report, as would an assessment of how current programs could be improved. Recommendations for the agency infrastructure required to manage these programs would also be emphasized. Upon completion of this report, the next step would be to assess the response of those stakeholders that would be affected by these recommendations. War-game technology provides a vehicle for finding the high-probability *public outcomes* that stakeholders will support by consensus.

War-game technology, extensively used by military planners, has been used as a tool for strategic planning by businesses.⁴¹¹ (Both of us have participated in war game exercises and strongly endorse them as tools for time compression of political processes.) War game processes provide a framework for analyzing situations in which people's and/or institutions' fortunes are interdependent and it provides a systematic way to develop strategies when one person's or one organization's fate depends on what other people or other organizations do.⁴¹² It also has demonstrated its utility for supporting policy development.

Prosperity Games⁴¹³, a high-level interactive forum for exploring complex issues in a gaming environment, could be reconfigured to test the response of companies, Federal agencies, the Congress, Federal laboratories, universities, and states to the recommendations of the STPB. Prosperity Games are an adaptation and extension of move/countermove and seminar war-games. They have already been successfully used to address electronics manufacturing, the future of the DOE laboratories, and international competitiveness issues. Prosperity Games provide opportunities for exploring current realities while simultaneously creating and studying other revolutionary alternatives. Prosperity Games are not a replacement for the political process; rather, they complement political processes by facilitating the political interactions on a highly compressed time scale. This two-step modification of the traditional political process is illustrated in Figure 6.

⁴¹¹ Adam M. Brandenberger and Barry J. Nalebuff, "The Right Game: Use Game Theory to Shape Strategy", Harvard Business Review, July-August, 1995, pp. 57-71.

⁴¹² Adam M. Brandenburger and Barry J. Nalebuff, Co-opetition, Doubleday, 1996, p. 40.

⁴¹³ Marshall Berman, Ivan Berry, and J. Pace VanDevender, Prosperity Game for the National Electronics Manufacturing Initiative, Sandia National Laboratories Report, SAND95-0724. UC-900, May 1995.

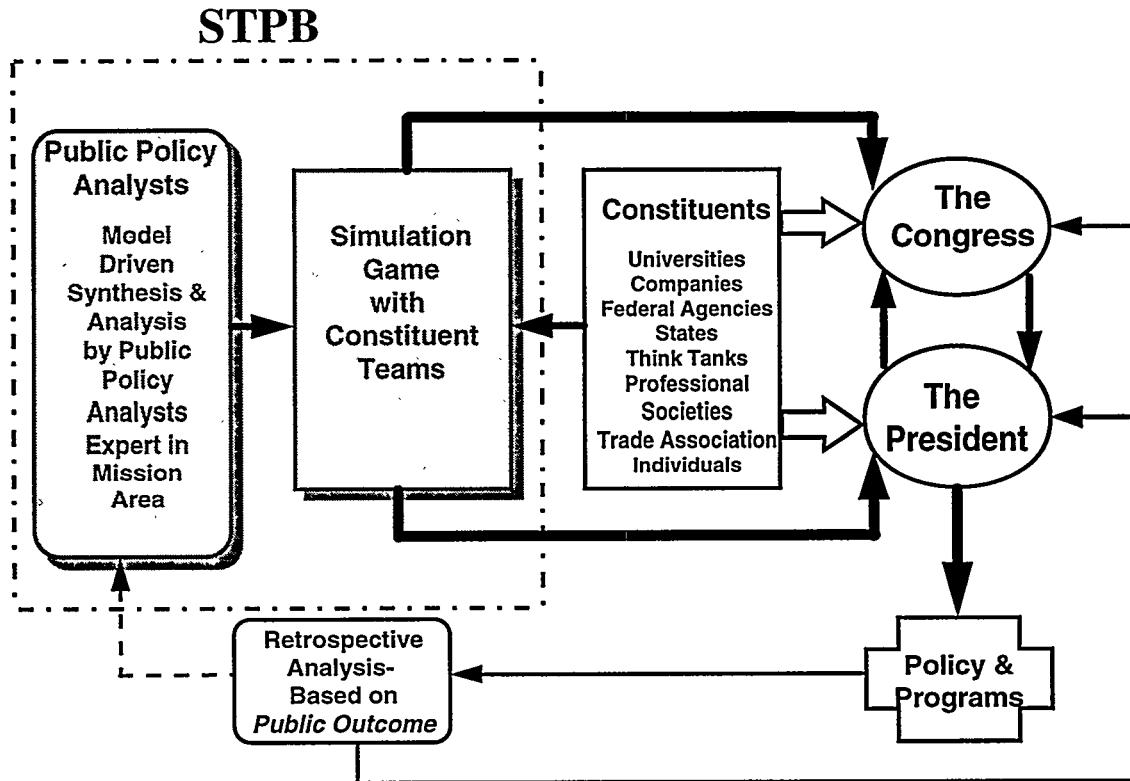


Figure 6: A modified T&S policy development process would be used by the STPB to address each major mission area of government that had a substantial component of technology and science. We recommend that Congress and the President to strengthen the authorization process for federal R&D use this process. This modified process incorporates in a formal way the informal processes that were used to develop the HPCC program; however, the simulation game should compress the consensus building process used by the HPCC into a much shorter time frame. Note that the recommendations of the STPB would be passed on to Congress and The President where each recommendation would undergo the traditional political process.

An important aspect of these games is that they include the participation of the actual stakeholders just as war-games include participation by military leaders. A report including the findings and recommendations of this committee and the response of the legislative and executive branches of the federal government, industry, federal laboratories, states, and universities to these recommendations gathered at the Prosperity Games exercise would be delivered to the President, Speaker of the U.S. House of Representatives, and the Majority Leader of the U.S. Senate. Appropriate Congressional authorization committees would consider the program recommendations of the STPB and overrule those they did not like with a simple majority vote.

C. Prioritizing Programs for Appropriations

a. Introduction. While the President may propose programs to Congress and congressional authorization committees may authorize the President's request or modify it to suit their preferences, programs aren't real unless congressional appropriations committees have

appropriated funds to Federal agencies. The fact that few members of Congress refuse an opportunity to serve on an appropriations subcommittee is evidence of the power and importance of the appropriations committees of both the House and Senate. Like the authorization committees, the appropriations committees rely on political processes to determine which programs are most worthy of funding and to determine how many funds to appropriate.

The matter of how to establish funding priorities among diverse areas of technology and science has been contentious for many years. Facing this challenge, Congress has often turned to the engineering and science community and asked it to recommend priorities. Within a particular area of science, members of that community have, on rare occasion, been able to recommend funding priorities.⁴¹⁴ However, the issue of how to establish priorities among different areas of technology and science has not been addressed.

b. Criteria for Prioritizing Programs. There are at least three criteria that can be used to establish priorities for R&D funding. The first of these is public opinion. The political process is responsive to public opinion; however, public opinion usually favors health and defense R&D, it ebbs and flows according to the extent to which the public is directly affected and the timing of the public impact, it is rarely anticipatory, and the needs of R&D performers may take precedence over the needs of the public. To illustrate the time scale of the ebb and flow of public opinion we note that in May, 1992, almost 40% of Americans listed the economy or jobs as their top concern; by September, 1996, about 10% of Americans listed the economy and jobs as the Nation's main problem. During the years between these surveys, those listing crime, education, the federal budget, or health care as their top concern doubled.⁴¹⁵ Congressional concern about issues generally mirrors public opinion.

A second criterion for establishing S&T funding priorities is the economic cost to the public of the issue being addressed. For example, healthcare annually costs the public \$1 trillion, regulations may cost as much as \$800 billion, education costs about \$700 billion, and crime costs over \$400 billion. It has recently been determined that the 50 year economic cost of the U.S. nuclear weapons program was \$4 trillion (1996 dollars), whereas the economic costs of this century's two world wars was \$22 trillion (circa 1950 dollars).⁴¹⁶ For many issues, particularly when the public is insulated from the direct cost of an issue, public concern may lag the economic cost of the issue.

A third criterion for establishing funding priorities is the consequences of the issue weighted against the risk that the consequences will occur. Most defense issues have very high consequences (as shown above - high economic costs and in the case of W.W.II, the loss of over 20 million lives) and low to medium risk of occurrence. The healthcare cost issue has high consequences and high risk of occurrence, but is saddled with the perception (incorrectly, we believe) that R&D has little role in alleviating the problem.

While the public worries about pesticides and power-line induced cancer, risk experts worry about the excessive use of routine X-rays in dental and medical examinations and smoking. The public worries more about air travel which results in a few hundred deaths each year and

⁴¹⁴ National Research Council, The Decade of Discovery in Astronomy and Astrophysics, National Academy Press, Washington, DC, 1991.

⁴¹⁵ The Economist, "America's Angry Voters: Where's the Outrage", November 2, 1996, p22.

⁴¹⁶ The Economist, "Costing a Bomb", January 4, 1997, p 30.

less about automobile travel which kills over 40,000 U.S. citizens each year.⁴¹⁷ Consequently, the public's perception of consequences and risk are not always well supported by data.

The obvious question is which of these three methods is the best for establishing priorities? The answer is none of the three, exclusive of the other two. In other words, the political process should still be used to establish program priorities, but it should be fully cognizant of what each of these three prioritization methods would suggest when choosing priorities among programs. Thus, we hope to bias the political process through knowledge injection into the process.

c. Modified Prioritization (Appropriations) Process. We recommend that the political process used to establish funding priorities be slightly modified to accommodate additional consideration of economic and consequences-risk analysis and that public opinion be addressed in a more formal way than constituents calling the offices of members of Congress. The technique of program analysis should be implemented by a group of distinguished policy **analysts** in STPB who would estimate the public and private cost, public and private consequences and survey the public to determine public interests. (As with any program analysis, consideration must be given as to whether or not R&D are the best way to solve the problem.) These analysts would recommend a priority list to Congress and the President based upon their calculations and survey data. Upon completion of this report to Congress, the next step would be to assess the response of those stakeholders that would be affected by these recommendations. Game technology, previously described, provides the vehicle for this. The game simulation would determine the response of stakeholders to these analyses and allow them to be modified by the STPB through the political process inherent in the game. This two-step modification of the traditional funding authorization process is illustrated in Figure 7.

Note that teams participating in the simulation would represent not only the constituent groups affected by the priority list supplied by the policy analysts, a team of policy experts representing each of the mission areas of government would also participate in the simulation.

⁴¹⁷ Parade Magazine, "What's Really Risky?", June 15, 1997, p. 16.

STPB

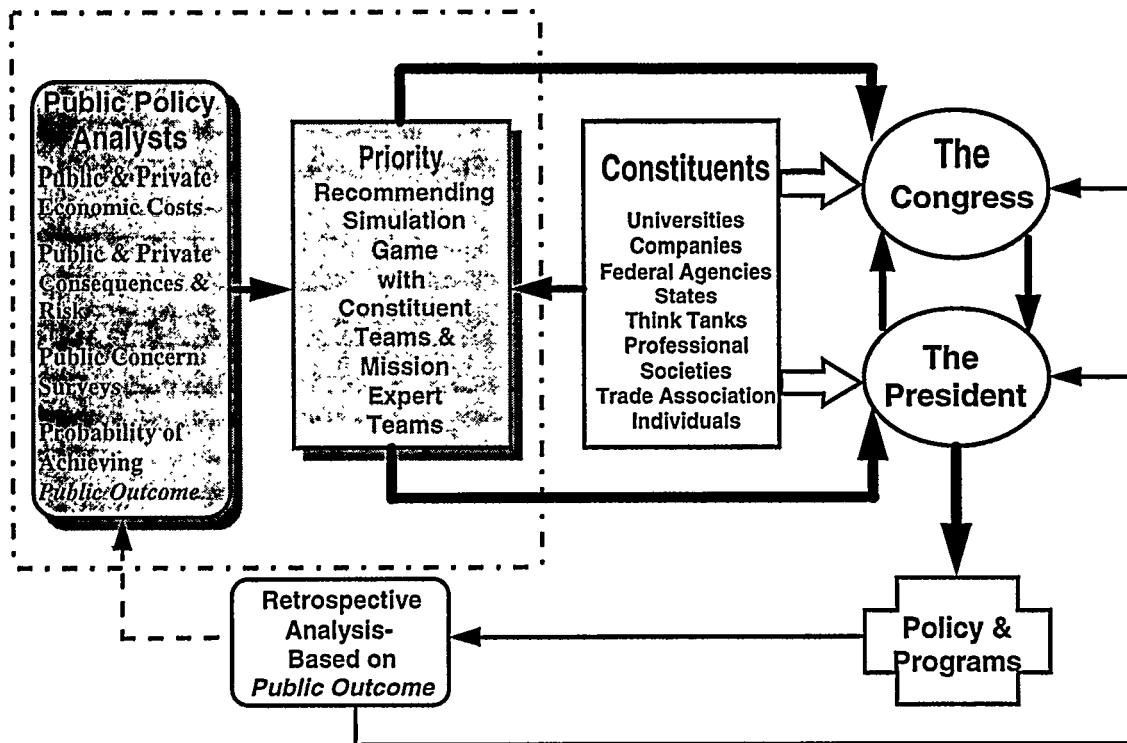


Figure 7: The modified political process that would be used to establish the overall priority of the various programs proposed by mission area experts. We recommend that Congress and the President to strengthen the appropriations process for federal R&D use this.

D. Analysis of Recommendations

a. **Comparison to Recommendations of Vannevar Bush.** In some ways our recommendations are similar to those made by Vannevar Bush at the end of World War II.⁴¹⁸ Dr. Bush recommended that government establish a National Research Foundation and task it with responsibility to **develop and promote a national policy for scientific research** and scientific education, support basic research in nonprofit organizations, develop scientific talent in American youth by means of scholarships and fellowships, and by contract support long range military research. He proposed that the National Research Foundation would have major divisions in medical research, natural sciences, national defense, scientific personnel and education, and publications and international scientific collaboration. Dr. Bush pointed out,

effective discharge of these responsibilities will require the full attention of some over-all agency devoted to that purpose. There should be a focal point within the government for a concerted program of assisting scientific research conducted outside of government. Such an agency should furnish the funds needed to support basic research in the colleges and universities, should coordinate where possible research programs on matters of utmost importance to the national welfare, should formulate a

⁴¹⁸ This observation was made by Dr. Sharon Hays, Office of Congressman Ehlers.

*national policy for the government toward science, should sponsor the interchange of scientific information among scientists and laboratories both in his country and abroad, and should ensure that the incentives to research in industry and the universities are maintained.*⁴¹⁹

Note, however, that the recommendations of Dr. Bush were limited to research programs and did not include technology development efforts, and the responsibilities he proposed for the National Research Foundation included distribution of research funds to performers of federal research projects. Instead of creating the single agency that Dr. Bush recommended, government created the National Science Foundation for the purpose of project selection and distribution of research funds to universities, DARPA was established to manage long term defense research, the National Institutes of Health were created for medical research, and the Office of Science and Technology Policy was created in the White House to frame S&T policy on behalf of the President. In practice, each federal agency makes policy recommendations for its particular mission area and OSTP adds little to this process.

An umbrella organization that included science and technology policy among its responsibilities was not created, principally because President Truman correctly recognized that the technocracy proposed by Dr. Bush would have excessive power. There was fear that the National Research Foundation proposed by Dr. Bush would spend public funds according to the priorities of scientists rather than the priorities of the public.⁴²⁰ We are not proposing to go back to the recommendations of Dr. Bush. Rather, we are recommending that the policy creation task that he proposed be vested in the STPB, but that it be vested with less power than Dr. Bush proposed, that it not be exclusively staffed with scientists and engineers, and that it have responsibility to propose policies for both science and technology. Other of the recommendations of Dr. Bush - defense, medical, and university research support - have been implemented and need not be reopened.

b. Recommendations of House of Representatives Science Committee. Our recommendations also bear some resemblance to those reached by the House Science Committee in 1988. After an extensive study of the competitiveness of U.S. companies and U.S.-based technology by the House Science Committee's bipartisan Technology Policy Task Force, the Science Committee recommended,

*An organization (Federal) should be created which can ... while preserving the "separation of powers", ... transcend the executive and legislative branches of government and recommend technology policy for government agencies to carry out. This body could elevate the ... importance of technology in government policy decisions across the complete range of national issues. It should ... include a body of elite engineers and scientists in order to incorporate the knowledge and experience essential to provide qualified judgment in making decisions on technical matters.*⁴²¹

⁴¹⁹ Vannevar Bush, Science: The Endless Frontier, A report to the President by Vannevar Bush, Director of the Office of Scientific Research and Development, July 1945.

⁴²⁰ Claude E. Barfield, Science for the Twenty-first Century: The Bush Report Revisited, The AEI Press, Washington, DC, 1997.

⁴²¹ Report of the Committee on Science, Space, and Technology, House of Representatives, Technology Policy and Its Effect on the National Economy, October 19, 1988, Washington, DC., 46, Ron Williams, Study Director, James Gover and Iris Rotberg, Principal Investigators.

Appendix II: Development of the Internet

Although not an integral institutionalized part of the Federal government's policy development process, the notion of expert input has been successfully used on many occasions. On other occasions, as Peter Schwartz noted, it has not been successful. As an example of indisputable success, we highlight the very inclusive Federal Coordinating Committee on Science Engineering and Technology (FCCSET) process that was used by the Federal agencies and OSTP to develop a new focus area in High Performance Computing and Communications (HPCC) in the 1980s. Driven by very experienced agency program officers (especially in DARPA, NSF, and DOE), the NSF invited the scientific community to develop white papers about the opportunities to advance the state of computing and communications. Following the development of the white papers, an open meeting was held in California to allow the papers to be debated among the authors. The NSF organized a panel of external reviewers to listen to the discussion and to consolidate the best ideas into a summary set of papers for presentation at a workshop held in Washington.

The summary concepts were then presented to the FCCSET committee on Computer Research and Applications, a group of Federal agency scientists with the best knowledge about computing and communications. Knowledgeable representative program officers from DARPA, NSF, DOE, National Institute of Standards and Technology (NIST), Strategic Defense Initiative Office (SDIO), NASA, National Institutes of Health (NIH), Air Force Weapons Laboratory (AFWL), Supercomputer Research Center (SRC), National Security Agency (NSA), Air Force Office of Scientific Research (AFOSR), Computer Science Technology Board (CSTB), Central Intelligence Agency (CIA), State Department (DOS), Office of Naval Research (ONR), and Health and Human Services (HHS) served on the committee. The group wrestled with what opportunities had come from the scientific community combined with their knowledge of what programs were being supported by the Federal agencies. Their enthusiasm was tempered by the knowledge that their agency budgets would likely require reductions in other areas if they recommended an increase in HPCC. A series of non-disclosure reports were requested from the HPCC industry so that recommendations would be consistent with commercial endeavors. At the time it was believed by many involved in the HPCC that the private telecommunications sector had an interest in milking existing technology rather than advancing the state of the art.

With complete input from the academic and industrial community, the FCCSET committee first produced a coordinated strategy report to the Executive Office of the President (EOP) that was also transmitted to the U.S. Congress.⁴²² (The path of these activities has been well documented in reports and journal articles.⁴²³) The FCCSET committee then followed up with a detailed program plan for conducting a multi-agency coordinated effort with shared common goals. The reports addressed both the opportunities for the disciplines, the payoff to the American taxpayer, and the cost of conducting the program. The director of the OSTP then brought the benefit/cost issue before the agency directors in a closed meeting that allowed real concerns to be aired. Only

⁴²² A Research and Development Strategy for High Performance Computing, from the Executive Office of the President to the United States Congress, 29 pages, Nov. 20, 1987. By the Federal Coordinating Council on Science Engineering and Technology (FCCSET) committee on Computer Research and Applications, chairman, Dr. Paul Huray.

⁴²³ David Nelson and Paul Huray, "The Federal High-Performance Computing Program," EDUCOM Review Magazine, volume 25, number 2, pp. 17-24, Summer 1990.

after a consensus was developed was a plan recommended by the EOP⁴²⁴. The reports were considered in a series of hearings before the House Science and Technology committee and the Senate Committee on Commerce, Science and Technology over the course of the FCCSET studies.⁴²⁵

The HPCC recommendations spanned three administrations, with three different presidential science advisors, and several changes in agency program officers. There were, of course, some concerns about which administration would receive credit (blame) for a successful (unsuccessful) program and there were unrelated political considerations involved in the final decisions. But the process allowed all interested parties to participate and was balanced against other competing priorities by higher level bodies. The result was one of the most successful programs ever created for the public by the Federal government: The Internet.

Was serendipity involved in the outcome? Yes! Was the process long and involved? Yes! Were there negative aspects to the final program funding decision? Yes! Were some individuals acting out of self-interest? Yes! Were some individuals unhappy with the result? Of course there were! Would the computing industry have made the same progress in higher performance with reduced costs without the government's strategic planning process? Probably! Would the telecommunications industry have produced the Internet on its own? Not likely, at least as far into the future as HPCC members were able to see at the time.

The question is not; "Did the public realize a benefit from its investment in the FCCSET process?" The question is, "How many orders of magnitude return on their investment did the public realize?"

We suspect that the process involved in this example has been repeated by other examples in manufacturing, materials development, the human genome, and global warming, just to name a few. Has the process also yielded modest or no results? Yes, the search for high temperature superconductors has not progressed as well as expected and cold fusion was a bust. But compared to a purely political process or a set of recommendations by a single Federal agency vying for an increase in its budget, the results are superior and this process maintained its scientific integrity.

We thus recommend that a revised policy development process, similar to the original FCCSET program, be instigated for development of Federal science and technology policy. The process should include the stakeholders, industry representatives, Federal program officers, the EOP and the Congress. Some will claim that such a legacy survives in the form of the President's Committee of Advisors on Science and Technology (PCAST) or the National Science and Technology Council (NSTC) or their committees, but it does not! The evolution of the FCCSET methodology has followed almost predictable progression. As the FCCSET recommendations have succeeded, ever-higher administration officials have moved in to conduct the studies. These

⁴²⁴ The Federal High Performance Computing Program, from the Executive Office of the President to the United States Congress, 89 pages, Sept. 8, 1989. By the Federal Coordinating Council on Science Engineering and Technology (FCCSET) committee on Computer Research and Applications, chairman, Dr. Paul Huray.

⁴²⁵ Paul Huray, "Computer Networks and High Performance Computing," principal testimony for a Hearing before the subcommittee on Commerce, Science and Transportation of the United States Senate, chaired by Senator Gore, U.S. Government Printing Office 91-313 p. 8-17, August 11, 1988.

officials do not have the expertise of their highly qualified program officers, they do not have the time to concentrate on proposals from the scientific community, they are not motivated to share common goals with other agency heads, and they often work at odds with the Congress out of perceived partisan motives. The result is a process that does not efficiently lead to the desired public outcome from the federal investment in R&D.

We are seeking to avoid the pitfalls identified in retrospective analyses and to institutionalize the process used to establish the HPCC. We want to assure that the analysis that supported HPCC work is deployed for all programs that have a high content of science and technology research and development. We believe that the HPCC process had two key features. First, it methodically sought expert advice from a wide array of computing and policy experts. Second, it involved all of the stakeholders in the HPCC initiative in reviewing and updating the policy recommendations until finally a consensus was reached on what the policy should be. Thus, the technocratic component of this successful science and technology policy development program was higher than that traditionally resident in political processes and the involvement of stakeholders to arrive at a consensus was higher than that traditionally resident in political processes.

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