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Global Change

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(04/13/90, 6:30 p.m.)

**OPENING PLENARY SESSION:
GOALS AND OBJECTIVES OF THE CONFERENCE**

D. ALLAN BROMLEY

Assistant to the President for Science and Technology

Executive Office of the President

**White House Conference
on Science and Economics Research
Related to Global Change
Washington, D.C.
April 17, 1990**

I would like to add my welcome to those of Secretary Brady and President Bush. Working together with you, we look forward to very real accomplishments over the next two days. In a moment, I will describe what the President views as some of the objectives of the conference.

GLOBAL STEWARDSHIP

But first let me elaborate briefly upon the conferences's theme, that of Global Stewardship. As President Bush has stated, Global Stewardship is not a fixed state. It is a process of continual change that balances environmental and economic values to meet human needs and expand human prospects.

Global Stewardship is a complex, multifaceted concept, yet I believe that it can be summed up in remarkably succinct fashion. On December 22, 1968, as the crew of Apollo 8 became the first humans to leave Earth orbit and head toward the Moon, they turned their frail spacecraft back toward the Earth and took the first photographs of our planet from deep space. I firmly believe that thousands of years in the future perhaps the one most lasting thing for which our age will be remembered will be those photographs. They show the Earth as a beautiful blue and white sphere floating quietly in the immense blackness of space. They emphasize that

this planet is mankind's common heritage. It is ours to cherish; it is ours to destroy. We are all truly in this together.

We will achieve Global Stewardship in the same way that we achieve scientific knowledge -- through careful study of the environment and of ourselves coupled with effective and timely action. We must come to understand the extent and limits of the resources available to us on this planet. And we must come to understand how humans can use those resources in a sustainable fashion to achieve a more prosperous and productive future.

We are not here to make a global warming policy. That will emerge from the broad array of research and policy reviews now ongoing. Rather, we are here to try to determine what will be required in order that such policies be based on sound scientific understanding and that they be both technologically and economically feasible.

THE LINK BETWEEN SCIENCE AND POLICY

Much has been written and said during the past few months about the scientific understanding of global change and about policy responses to global environmental concerns. But conspicuous by its absence in almost all of these discussions has been a careful and detailed analysis of the economic causes or consequences of global change. For example, we will talk at length over the next two days about various ways of taking out insurance policies against possible adverse

effects of global warming. But there are good insurance policies and bad ones, and we very much need the input and expertise of economists to discriminate between them.

In a very real sense, we should perhaps look on economics as the glue that binds scientific understanding of global change phenomena to the policies -- both national and international -- that we adopt to address this issue.

In general, the social sciences -- economics, psychology, sociology -- must be an integral part of any approach to the understanding of global change. Even when the physical and biological aspects of a problem are understood, all too often agreement is lacking on the underlying social, behavioral, and economic causes and consequences of an action. This conference will focus as much on these aspects of global change as on the purely scientific aspects. In this way, we hope to add a new dimension to the international dialogue on global change.

GOALS OF THE CONFERENCE

As President Bush noted, the foundation of this conference is what we do know and what we do not know about the science and economics of global change. At a more detailed level, we seek to determine which uncertainties might be reducible in the foreseeable future and which are not and to understand how scientific uncertainties affect our economic modeling and vice versa.

The conference is designed to achieve several other objectives. Among them are the following:

- o To increase the mutual understanding and sensitivity of the scientific and economic research communities to each other's needs and to the needs of the policy makers who look to them for guidance.
- o To foster a solid and well-implemented international research effort that can address the scientific, economic, and policy questions of global change, drawing on the expertise, experience, and data of all the world's nations.
- o To forge a worldwide communications network among the researchers and policymakers concerned with global change.

REVIEW OF THE AGENDA

To achieve these objectives, the conference is organized around three themes.

- o The science and economics research challenge.
- o Integrating science and economics research in the policy process.
- o Building a partnership for science and economics research.

Later this morning, I shall speak on the first of these themes. My cochairmen Michael Boskin and Michael Deland will speak on the second and third.

Following those presentations, the agenda calls for us to divide into three Working Groups that will then meet in four sequential sessions. Each of the Working Groups will have about 25 members, with roughly equal representation from the three disciplines of science, economics, and the environment.

The first three Working Group sessions will be devoted to the three themes of the conference. The fourth will be devoted to integration of the discussions and preparation of a summary report of each Working Group's deliberations.

These summaries will form part of a Cochairmen's report, which we would suggest as the primary product of the conference. In this report, we would expect to outline the deliberations of the conference and set forth agreed-upon common actions designed to expand research and cooperation among nations.

CONCLUSION

This conference is only one of many national and international actions being taken to address issues of global change. We must therefore seek to integrate the accomplishments of the next two days into these ongoing efforts -- and, in particular, into the deliberations of the IPCC, the international research programs of the World Meteorological Organization and International Council of Scientific Unions, and the programs of individual countries focused on the global environment. At the same time, we will work to coordinate the many activities now going on in the United States

and abroad. They will all be stronger if carried forward in a unified, coherent fashion.

We want to emphasize that the President has instructed us from the outset of our planning to design this conference with a primary goal of complementing, strengthening, and supporting the entire IPCC process, which he considers to be the central and appropriate forum for our joint efforts toward understanding of, and responding to, the questions of Global Stewardship.

Louis Pasteur wrote that, "Science knows no country because knowledge belongs to humanity and is the torch which illuminates the world." We will be the carriers of that torch for the next two days. And we must keep it burning as we leave to face the great challenges that lie ahead.

*Global Conference
file.*

SPEECH OF

ADMIRAL JAMES D. WATKINS, U.S. NAVY (RETIRED)
U.S. SECRETARY OF ENERGY

BEFORE

THE WHITE HOUSE CONFERENCE
ON
SCIENCE AND ECONOMICS RESEARCH RELATED TO GLOBAL CHANGE
WEDNESDAY, APRIL 18, 1990

D R A F T

APRIL 12, 1990
5:00 p.m.

Speech of Admiral James D. Watkins, U.S. Navy (Retired)
U.S. Secretary of Energy
before
The White House Conference
on
Science and Economics Research Related
to Global Change
Wednesday, April 18, 1990

Good afternoon, ladies and gentlemen. It is a pleasure to have the opportunity to talk to you about my views on developing an international consensus to protect our environment. As President Bush said in his State of the Union Address two months ago, we have a special responsibility, which he called "global stewardship," to pass on to our children a world rich in natural wonder and capable of supporting economic growth for all regions.

The record of international responses to regional and global environmental concerns is limited -- it is only over the last 10 years that nations have agreed worldwide to cooperate to solve environmental problems. While the U.S. has had tough legislation to protect the Nation's waterways and air since 1970, and first developed legislation to study how to protect these resources in the 1950's, concerted international responses did not begin until the end of the 1970's. In 1979, for example, the United Nations Economic Commission of Europe (ECE) developed the Long Range Transboundary Air Pollution Convention, the world's first framework for coordinating responses to regional industrial pollution.

In the early 1980's, the U.N. Environmental Programme attempted to reach a global agreement on the protection of the stratospheric ozone layer. The U.S. and other countries sought both a framework convention and a control protocol as one single step. But that effort failed, primarily because no global consensus had been developed on the extent of the problem and on the appropriate response. We learned our lesson from this failure -- the lesson of the pitfalls of premature action. Then in 1985, the Vienna Convention established a process to develop a consensus that was previously lacking. Negotiations began in December 1986 in Geneva and a mere nine months later culminated in the Montreal Protocol. The same process is expected to lead to a phasing out of primary ozone depletion substances, with agreement expected by this June.

The Intergovernmental Panel on Climate Change (IPCC) was established in November 1988 with a clear mandate to conduct the science and impact assessments crucial to understanding the problems of climate change. These studies, to be completed this summer, will lay the basis for a framework convention. In fact, many heads of state have already committed to this convention. The U.S. has proposed that it host the initial negotiating session for the convention.

We are continuously gaining new insights into the complex phenomenon of global climate change. Our estimates of

temperature increase and sea level rise expected from a doubling of atmospheric carbon dioxide are constantly under revision.

For example, scientists in the United Kingdom recently introduced better simulation of cloud processes in their climate change model. For an effective doubling of carbon dioxide, their estimate of average global surface warming dropped from 5.2 degrees Celsius to 1.9 degrees Celsius. Another forecast, using models with improved representation of ocean heat uptake and circulation has predicted that the Southern Hemisphere will not warm at the rate of the Northern Hemisphere -- in fact, parts of the southern regions may actually cool.

These forecasts are based on calculations from the General Circulation Models (GCMs). These models simulate the physical results of climate change on powerful supercomputers. Unfortunately, the GCMs are inadequate in predicting the role of clouds in reradiating heat, and the role our oceans play in absorbing heat and removing carbon dioxide from the atmosphere.

A major component of the U.S. climate research program is aimed at improving the predictability of the GCM's within the next five-to-ten years. We recognize the pivotal role that clouds play in the climate feedback balance and have launched research activities to better include them in the climate models. Data from the earth's surface to the top of the atmosphere will

be used to solve the puzzle of cloud interactions. We have also realized the importance of the oceans in climate change and have joined with other nations in studies of both ocean circulation and biology.

Processing vast amounts of climate data acquired by both satellite and ground-based observing systems requires greatly expanded data processing systems. We are aggressively pushing forward the frontiers of scientific computing with innovative computer architectures and advanced software systems.

To achieve our overall research goals, we are proposing to spend more than \$1 billion in FY 1991. The NASA Mission to Planet Earth will be the centerpiece of an integrated international satellite program for monitoring global change.

Although the detail from the GCMs is inadequate, they will influence the assessments made by the IPCC working groups. Impacts of potential change cannot be measured currently, although there have been efforts to estimate the impacts assuming that certain ranges of regional climate change occur. Response strategies involve both limitation of change in the form of reduced emissions, and adaptation to climate change. Adaptation is particularly sensitive to the lack of regional detail and the uncertainty surrounding the timing, and magnitude. The IPCC assessments will provide valuable guides for future negotiations

and future research directions, both internationally and nationally.

The completion of the IPCC report is not a goal unto itself, but it is only the beginning of our deliberations and debate.

An environmental era is beginning. An era in which environmental goals can be integrated with our economic policies, our energy policies, and our international financial and technology assistance programs. The promise of this era can be fulfilled only if we understand that economic growth and environmental protection need to be mutually sustaining. A sound environmental policy and a strong economy need to be hand-in-hand -- both are key to environmental stewardship. The economy is not sound if the environment is in ruins and the environment won't be healthy if a nation's economy cannot afford to protect environmental quality.

For these reasons we must usher in a new era of global cooperation: for environmental protection and economic growth; for intelligent management of industrial and natural resources; and above all, for sustainable development -- around the world.

We cannot afford to embark on this era unwisely or rashly. We must have the knowledge, the technological expertise and the

economic tools to ensure that we head down the best paths to sustainable economic development.

I am concerned about calls by some for precipitous actions. Some are suggesting that we must act now without credible scientific or economic analysis. They believe that there is enough evidence to take action. Some even call for the imposition of international sanctions to significantly reduce greenhouse gases. Some have suggested that we must impose heavy taxes on coal use. Such taxes intended to stabilize and then reduce emissions of carbon dioxides by 20 percent, have been estimated to reduce some nations' gross domestic product by up to five percent per year. Actions that impose heavy economic penalty, delay our ability to negotiate an international agreement. To act without knowing the magnitude and dimensions of mitigation costs is to doom international cooperation to failure.

Likewise, it is equally unsound to commit to quantitative targets before the IPCC assessment is complete. Otherwise we must ask ourselves: Can we ignore the scientific evidence? Can we afford to act before we have assessed the costs? Can we build a true global consensus without allowing the IPCC process to lay the foundation for it?

It is time to put emotion, politics, self-serving assumptions, and beliefs that are unsupported by available

evidence aside; and to look objectively at the scientific and economic data.

[One example is the recent Alar scare in the United States. The Alar scare began with a TV report that warned that 6,000 children would eventually get cancer from apples treated with Alar. Apple sales nosedived. Schools pulled apples from their lunch programs. Parents poured apple juice down the drain. Even those growers who did not use Alar and did not sell apples treated with Alar, saw customers switch from their red apples to green apples. Orchards in the country lost an estimated \$250 million.]

Shortly after the report aired, the National Research Council released a three-year study reporting no evidence that pesticides or natural toxins in food contribute significantly to cancer risks in the U.S. According to the Food and Drug Administration, cancer risks posed by diet mostly result from naturally occurring substances, not man-made contributions to the food chain.

Then there's the asbestos saga. Science magazine recently published the results of a study finding that the available data does not support the notion that low-level exposure to asbestos in buildings and schools is a health risk.

~~Although asbestos has caused disease in the work place, recent epidemiological data suggest that exposure to chrysotile at the current occupational standards does not increase the risk of asbestos-associated diseases.~~

~~Yet, asbestos engenders fear and panic in U.S. society. Extensions of EPA requirements to approximately 733,000 public and commercial buildings containing asbestos will cost \$53 billion in today's dollars over the next 30 years.~~

~~We must work to ensure that similar stories are not told of us and how we interpreted -- or misinterpreted -- the often conflicting information on the understanding of the science and impacts of climate change.~~

~~We must work to ensure that climate change science produces credible and substantial recommendations for prudent action. Theories alone will not mobilize the world community to action.]~~

This does not mean that we should ignore the warnings that climate change, sufficient to be a threat, may someday occur. We should respond today in a sound and reasonable manner by applying the knowledge that we possess. In many areas we can act to pursue objectives that make sense both for mitigation of potential climate change and for other social, economic and

environmental reasons. Or stated differently, we are purchasing an insurance policy at a reasonable premium while we verify the scientific uncertainties. In the U.S. and in many of your countries, positive steps are being taken now.

Let me provide some examples of initiatives we have taken:

- o To reduce demand for new power plants and additional pollutants, we are employing new energy efficiency programs and more stringent standards for:
 - refrigerators, freezers, residential furnaces; and commercial buildings;
 - more efficient lighting in Federal Government buildings;
 - improved fuel efficiency for automobiles; and
 - through better Utility Resource Planning, we are also reducing energy demand through encouraging greater load management and energy efficiency investments.
- o We are joining many of you in the Montreal Protocol by phasing out CFC's and reducing halons to stop the depletion of the ozone layer.
- o We will be implementing a revised Clean Air Act that will curtail acid rain, urban ozone and toxic

pollutants. Because the programs allow market choices to meet the emissions reductions, we believe that as much as 10 percent of electricity emission reductions will occur due to conservation measures.

- o We will plant one billion trees a year as sinks for carbon dioxide from the atmosphere. This program alone could capture close to one-half billion tons of atmospheric carbon dioxide by the year 2000.
- o We are considering legislation that encourages the use of alternatives to gasoline as a way to reduce CO2 emissions from automobile fuels.
- o We have deregulated the use of natural gas to promote greater use not only for the home, but for transportation fuel and for generating electricity. Natural gas is safe, cost-effective, and emits less CO2.
- o We are spending \$5 billion on clean coal technologies. These new technologies can reduce CO2 emissions by 20 to 40 percent compared to existing technologies through enhanced plant performance.

- o We are spending \$138 million in 1990 on renewable energy, such as solar energy, biomass, wind, hydro and geothermal, that emit no CO2.
- o We are developing safer, more cost-effective nuclear power plants that also emit no CO2.
- o We are developing a National Energy Strategy that will, among other objectives, provide the Nation with a focused, long-range approach for reducing pollution, including greenhouse gases, in the most economic way possible.
- o Finally, we announced this week that we will take steps to upgrade public housing units to reduce their energy consumption, thereby reducing emissions.

If successful, these actions could reduce greenhouse gas emissions by as much as 300 million tons per year by 2000 from current projections. The U.S. tree planting initiative would capture another half-billion tons by the year 2000. National efforts like these in energy efficiency, tree planting and the promise of clean coal technology, increased use of natural gas, safer nuclear power, and expanded use of renewable energy, increase our potential to limit greenhouse gas emissions into the next century.

No one nation, nor even all the industrial countries together, can resolve the climate change issue. For example, to reduce CO2 globally by 20 percent by the year 2005, efforts that would involve stabilizing Eastern European emissions and totally eliminating OECD emissions would not be enough if developing countries continued their current emission trends.

Obviously, the solution must involve all nations -- and nations at all levels of development. For each nation has a right to expect a better life for its citizens. We must work together to develop effective steps to transfer the best of our emission reduction technologies -- in energy, industry and agriculture -- to other countries.

In the U.S. we are taking steps to transfer clean coal technology and greater energy efficiency to other countries. Specifically, through the Support for Emerging European Democracy (SEED) Act of 1989, we will be providing valuable assistance to Poland and Hungary, in support for their efforts to promote more environmentally sound energy production. For example, in FY 1991, the President has proposed that \$20 million be authorized to help Poland burn fossil fuels more cleanly.

In some countries, there are immediate opportunities for expanding the use of renewable energy options. The U.S. is

actively involved in transferring such technologies to other countries through various government programs. These efforts are coordinated by the Committee on Renewable Energy Commerce and Trade. We call it CORECT.

By employing greater energy efficiency, investing in new, less polluting energy technology and sharing that technology with emerging nations, we can begin today to build consensus on the appropriate, sustainable steps to curb greenhouse gases.

To that end, the international community must focus its efforts on the IPCC process. All other international efforts need to serve the IPCC process and be judged in that light. The basic question for other international meetings is: Do they support the IPCC process which is directed at a common understanding of the dimensions of climate changes and its possible responses? If not, then these other efforts will not contribute to solving the problem for the long-term.

When President Bush, in his State of the Union Address, spoke of stewardship, he meant that we owe our children and our grandchildren a world well-cared for -- because the planet we inhabit is only borrowed, never owned.

Stewardship means just that. It means caretaking, remembering that our environment is fragile and we are temporary.

As Emerson said, "We do not inherit the Earth from our ancestors,
we borrow it from our children."

Thank you.

With the Compliments of the



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Reflections on Earth Day
By Robert M. White
President
National Academy of Engineering
Lindbergh Award
Explorers' Club, New York City
May 15, 1990

I am deeply honored to have been selected as the recipient of the Lindbergh Award for 1990. My distinguished predecessors have climbed the highest mountains, sailed the deepest oceans, and realized the dreams of Daedalus. Like Charles Lindbergh they tested the bounds of the human spirit, and each in his own way transformed the way we think of ourselves and our society.

Lindbergh's flight across the Atlantic was the conceptual analogue one half century ago of the modern landing on the moon. Europe was as distant in time then as the moon is today. The same electrified attention that attended Charles Lindbergh's approach to Le Bourget also attended the approach of Neil Armstrong and Buzz Aldrin to the moon, the one captured on radio, the other on television. The one achievement, just 63 years ago, opened the new age of global interdependence; the other, recognition of the unity and fragility of our planetary environment.

Humanity's concerns about the environment, its preservation and rational management are not new. In the United States the modern form of these concerns is more than a

century old, dating back to the 1860s when Yosemite Valley in California was designated as a national park and served as the forerunner of the present world system of national parks. Our concerns then were expressed by writers and naturalists like Emerson, Thoreau, Audubon, and Muir. Their view was simple but compelling---that it was an obligation of humanity to preserve the wilderness and the life within it for future generations.

Today in a world of diverse environmental concerns, this view is in many ways more cogent than ever. But these writers would have been staggered by the range and extent of environmental problems we now face. A century ago the causes of wilderness destruction were clear. They lay in the felling of forests, the hunting of wildlife, and the encroachment of humanity on the wilderness for agricultural and economic development. In these early views wilderness destruction could be arrested by setting aside preserves. The National Park System was the result. Our present concerns about biodiversity, habitat destruction, and species extinction are the modern manifestation of these continuing and ever more pressing problems.

One century later, writers have sounded a different environmental alarm---about the degradation of ecosystems and adverse effects on human health by more subtle and less obvious actions of humanity. The wastes, effluents and emissions of industrial society are loading the environment

beyond its restorative capacity and upsetting the natural balance and processes of nature. It was Rachel Carson who in her 1962 book Silent Spring crystallized the issue and marshalled public attention.

The past three decades have brought home to all the power of humanity, driven by needs for food, energy, and economic growth, to endanger the habitability of the planet and thus destroy the base of humanity's sustenance. Environmental degradation is clear and widespread---forests destroyed, wildlife decimated, streams contaminated, water supplies tainted, air polluted, fisheries destroyed, and even climate changed. The idea that the most fundamental functions of humanity might be in conflict with the sustainability of its habitat is a new and puzzling concept that we thought applied only to elephants or wildebeest. The dilemma of how we balance humanity's need for both environmental protection and economic growth is the central problem of our age. The habitability problem is both local and global, and no nation or region is immune. Love Canal and Times Beach at the local level are matched by the oil spill in Prince William Sound and destruction of tropical rain forests at the regional level and the decimation of great whales at the global level. And now some believe that the habitability of the planet itself is threatened by climate warming.

As the celebration of the twentieth anniversary of Earth Day a month ago amply demonstrated, environmental issues are

no longer concerns of a small elite. They have become concerns of the general public. The greening of governments in Europe is matched by a greening of government in the United States and the Soviet Union. It is now important politically to be or at least seem to be an environmentalist. President Bush seeks to be the "environmental President," and the Democrats and Republicans alike seek to "capture" the environmental issue. A far-reaching environmental initiative before California voters already has attracted broad public support. President Gorbachev sees ecological security as the driving issue among nations in the next century. Meetings of heads of state now focus on how to address environmental issues. International conventions are being negotiated to bring order out of growing environmental chaos. From trade in endangered species to protocols to protect stratospheric ozone, international movement has accelerated. By the end of this year we will see the opening of international negotiations on a Law of the Air to stabilize global climate.

A very thoughtful article recently published in The Washington Post by Virginia Postile sees a fundamental ideological reshuffling of our conventional ways of thinking about the political spectrum. Traditionally we have thought of the political spectrum as ranging from the left to right, relating to ideas about the centralization of power in the state versus the delegation of such power to the individual. Postile suggests that the political spectrum is now defined by

environmental protection at one end and economic development at the other. There is, I believe, much truth to this view. The green parties of Europe are in the vanguard. As yet, in the United States this separation has not taken place as both political parties color themselves pale green.

The greatly increased political strength of environmental movements within governments is a response to widespread public support and action by nongovernmental groups representing broad public interests. Their ability to change the pattern of politics in this country and abroad is a remarkable phenomenon of this age of environmental consciousness.

I can personally attest to the influence of such public pressure in shaping governmental positions and policies. I was deeply involved in leading the United States effort to save the great whales as the U.S. Commissioner to the International Whaling Commission. The task of this international commission is to regulate whaling. At the time I became Commissioner in 1971, the plight of the great whales was desperate. The population of blue whales, the largest creature ever to inhabit the earth, had been reduced through hunting from perhaps 200,000 to fewer than 5,000. All species of the eight great whales had been declared endangered. At that time the management of whaling was governed by the "blue whale unit." This unit of whaling intensity measured only the tonnage of whales killed and failed to recognize the different

species---tonnage being related to the weight of the blue whale. A Minke whale was worth only one-tenth of a blue whale unit and so on. Responding to public pressures for action, the United States called for a moratorium on world whaling. Over the years this objective has been achieved, but even after long years of protection, many of the species of great whales remain in perilous condition. It is vital that the international moratorium on whaling be continued.

Another incident illustrates my point. In the early 1970s porpoises were killed by the hundreds of thousands when they became trapped in tuna fishing nets. Public outrage forced Congress to require the use of special nets from which porpoises could escape and to place observers on U.S. tuna vessels. When, as Administrator of NOAA, I enacted regulations to implement the intent of the law, the U.S. tuna fleet went on strike. In San Diego Harbor, where the fleet was lodged, I was burned in effigy for the first and, I hope, only time in my career.

I now relish the fact that the three principal tuna packing corporations in the United States have announced that they will no longer purchase tuna from fishing vessels that take porpoises in their tuna nets. Results such as these are attributable in large part to the public's deep concern about the environment. Environmental activist groups have contributed greatly to our present environmental awareness.

I note, however, trends in the drive for improved environmental protection that as a scientist and engineer I find profoundly disturbing. I find great license taken with scientific facts and their interpretation in cases where scientific uncertainty prevents categorical answers. Such license is usually justified in the name of necessity to dramatize issues and gain political advantage. For some it is not necessary to have the whole truth on their side. It is sufficient to have only an element of truth that can be marketed. Perhaps environmental activists have merely learned the ways of modern public relations and political action. The television sound bite is the goal. What is true for presidential campaigns is equally true for environmental campaigns. Sometimes it results in painting environmental consequences at their apocalyptic worst. What may be good for fund raising or for gathering votes is bad for public policy.

I worry about the growing trivialization of environmental issues. Television ads present simplistic views of environmental consequences. Products are marketed for their environmental value---biodegradability and ozone safety---frequently without justification. A spate of popular books exhort the public to save the planet through actions that are disproportionate to that goal. Legitimate public concern for the environment is being distorted by the hoopla.

And modern technology has become everybody's favorite target and whipping boy to such an extent that

environmentalism runs the risk of becoming a modern Luddite movement. Technology may have much to answer for, but it has also been a boon to a better environment. For example, the sanitation systems of modern cities are herculean environmental achievements. Catalytic converters have radically reduced hydrocarbon and the oxides of nitrogen emissions, thus lessening the problems of urban air pollution.

I am equally disturbed that for too long corporate America has been so deeply concerned with the economic costs of environmental protection that it has failed to make environmental values an integral part of the planning and design of industrial systems. Much of corporate America has traditionally resisted legislation that would add to costs of production unless environmental consequences could be demonstrated with great certainty. While much environmental regulation has straitjacketed innovation and has had unintended consequences for U.S. corporate competitiveness resulting in legitimate objections, the net result is that some companies have painted themselves as black hats.

The lesson for all is that it is unwise to play footloose with either science or economics. We need to join our concerns for the environment with our concerns for economic growth and make them work together. Degradation of the environment solely for economic gain is as counterproductive as degradation of the economy for environmental gain.

Fortunately we are now beginning to recognize that these dual interests are not incompatible, that in many cases they are mutually reinforcing. There is a new realization in board rooms that long-term corporate welfare and profitability depend on the ability to harness science and technology in production systems in environmentally benign ways. I find it heartening that many corporate leaders in the United States today recognize that environmental responsibility is as central to business success as the quality and costs of their products. And we are beginning to witness new cooperative efforts between environmental groups and corporations seeking to find improved ways to address environmental problems. Witness the growing cooperation between power companies and environmental groups to reduce demand for energy.

We have now entered a period of transition in our thinking about environmental values, economic consequences and costs, and our use of science and technology to achieve our twin objectives of environmental protection and economic growth. Science is the key to our understanding of causes and effects; technology is the key to linking them and eliminating them as a problem. But how do we harness technology to achieve our environmental goals in a way compatible with those for economic growth? How do we develop environmentally advantageous technologies and move them into the marketplace so that they are widely used? That is the central challenge to industry, government, and the engineering community.

Technologies are the embodiment of the application of our knowledge about natural processes and man-made systems to produce the products and services that power the progress of society. Inevitably production is accompanied by wastes that degrade the environment. The degree to which we can produce the one without the other is a measure of the metabolism of industrial society. The more efficient and clever we are in producing our automobiles and aircraft, our chemicals and materials, and our energy and foods while minimizing wastes in the process, the healthier our industrial metabolism will be. The ways we transform raw materials into products, services, and residual wastes by industrial and agricultural processes need reexamination. We need to minimize industrial metabolic waste products---the noxious emissions, the contaminating effluents, the solid wastes and consumer products that contaminate the environment. But we need to do it by changing the design of our processes not by cleaning up the messes at the end of the pipe.

Industry is no stranger to the concept of waste minimization and alternative uses of wastes when it has been in their economic interest to do so. Industry has traditionally sought to transform wastes to useful products, and to substitute new materials for old. Natural gas, once flared as waste, is now a valuable energy resource, and cogeneration of power makes efficient use of waste gases.

Sometimes new approaches to environmental and economic issues encounter the law of unintended consequences.

Technological solutions adopted for economic, environmental, or health reasons are sometimes later revealed as threats to the environment or the public health. Although we can hope to reduce such unintended consequences, we can never eliminate them. Examples abound.

Tetraethyl lead was a great discovery. As an additive to gasoline for automobile fuel, it increased energy efficiency. It enabled the use of lower octane gasolines and reduced costs, to say nothing about quieting annoying engine knocks. Today lead in the environment is recognized as one of the most serious human health problems even in the smallest concentrations in the atmosphere, and lead-free gasoline is now a requirement for all new automobiles.

Polychlorinated biphenyls (PCBs) are another example. They are now banned in the United States as a persistent environmental and human health hazard. However, they were introduced commercially in the early 1930s as a solution to a clear threat to public safety at the time, namely, electrical equipment fires. Before the use of PCBs, only relatively unstable, flammable liquids were available for insulating and cooling equipment such as large transformers and capacitors. PCBs were valued for their stability and nonflammability, which made electric equipment safer. Long-term human health effects were only slowly recognized, and ecological damage was

linked to PCBs only later.

DDT is the classic case. Beginning in the 1940s, chlorinated hydrocarbon pesticides were introduced as safer, more effective alternatives to common agricultural pesticides based on such metals as lead, arsenic, mercury, and copper compounds, which were then known to be acutely toxic to humans. It was a wonder pesticide, suppressing insect-borne diseases such as typhus and malaria. DDT saved countless human lives. At the time of its introduction, it was shown to be almost nontoxic to humans. DDT was later found in trace amounts literally everywhere on earth---in water, air, plants, animals, and in the ice at both poles. Eventually the evidence of its accumulation in animal fat and the adverse ecological effects led to its ban in the United States in 1972. DDT illustrates the complexity of balancing risks and benefits. In Sri Lanka, for example, DDT applications had nearly eradicated malaria by the early 1950s. In 1968 a half million cases of malaria were reported following the cessation of DDT use there.

Chlorofluorocarbons (CFCs) were adopted as working fluids in air conditioners and refrigeration equipment and as solvents, because they were inert and nontoxic to humans. It is only in recent years that their effect on the stratosphere under the action of sunlight was shown to result in the destruction of the earth's protective shield of ozone.

The introduction of nuclear power as a source of cheap, environmentally benign energy raised the spectre of accidental releases of radioactive materials and the problem of disposal of radioactive wastes. Surface strip mining, which improved production of coal, introduced us to acidic wastes and contaminated streams. Tall stacks on coal-fired power plants were employed to eliminate acid deposition in the vicinity of power plants but only served to transfer and disperse the acidic pollutants, destroying freshwater ecosystems over broad areas. Irrigation systems to bring arid lands into production have destroyed productive farmland through soil salinization.

These technologies were introduced for sound social and economic reasons. They were applauded at the time of their introduction as great and useful developments. However, in all these cases scientific evidence of their adverse environmental and health effects led to the social decision to ban or restrict their use. But it has been technology that has produced the benign environmental alternatives. And so it will be in the future. Science and technology will document environmental and health problems, and technology will provide the principal means to address them. Society will shape technology and technology, will shape society.

It would be wrong, however, to ascribe to industry only altruistic environmental motives for these actions. Technologies traditionally are developed and adopted principally because they provide economic benefits through

increased productivity. Harnessing of technology is essential for corporate competitiveness. If we want to see new technologies to address environmental, health, and other human concerns, we need to link economic incentives to the development and use of these technologies. In the past we have sought to drive technology by government regulation. To a certain extent such governmental action has served our environment well. Urban air is cleaner, streams are less polluted, and carcinogens have been eliminated from food supplies. It is now recognized that such approaches have serious limitations.

Regulatory regimes require bureaucracies for defining, interpreting, and enforcing regulations---a costly and frequently interminable process. In many cases technological development is channeled to meet regulatory criteria rather than to provide fresh approaches to problems. Not the least of the concerns is that regulatory approaches sometimes have adverse effects on the location of industrial activities and the competitiveness of U.S. industry.

Consequently, economists and others concerned with environmental matters have increasingly questioned dependence on regulatory intervention as the sole means to address environmental problems. They recognized the inherent rigidity of regulatory approaches, which can be economically self-defeating and obstacles to technological or management innovations aimed at environmental improvement. They have

sought ways to harness the forces of the free market to provide incentives for addressing environmental issues. Such measures would be self-sustaining and self-reinforcing and in principle more powerful than regulatory measures.

We are now moving in this direction. The recent legislation governing the use of chlorofluorocarbons requires a tax of \$4.00 per ton on the production and use of CFCs. In the clean air legislation just adopted by Congress, the trading of pollution rights is a key element in reducing emissions.

Technological opportunities for ameliorating environmental degradation are literally unbounded. We have within our grasp the knowledge and the means to protect the global environment and continue the economic growth and increase standards of living for all. Almost all areas of present environmental concern are in prospect of technological amelioration. We know how to produce energy from nonfossil sources; even today photovoltaics have progressed to the point of wider utility. Ethanol, an example of energy from biomass, is in practical use. Nuclear power systems that are passively safe are under development. Yet, technological efficacy does not automatically guarantee public acceptance.

It is encouraging that some companies are beginning to respond by making common cause with environmental groups. We already witness power generating companies in many parts of the nation joining with environmental groups to adopt programs

to encourage energy efficiency and conservation using newly devised market incentives that benefit consumers, producers, and the environment. Leaders of the nation's foremost chemical companies have adopted policies to eliminate or drastically reduce toxic wastes from their chemical production. Petroleum companies in cooperation with the automotive industry are now producing alternative fuels to reduce emissions of pollutants. Automobile companies are redesigning engines for greater fuel efficiency, and electric cars are under experimentation.

To bring these technologies to the point of economic viability and into widespread use is the challenge we all face. The challenge to government is to establish the economic framework that will permit the private investment in these technologies and the incentives to bring them to market. Where the benefits of technology development cannot be easily captured by private companies, government must support the generic technologies that will be essential. Since many of our environmental ills are global and require action by all nations, an important role of government is to facilitate and encourage the global use of environmentally benign technologies. The challenge to industry is to incorporate environmental costs into the design and operation of systems to ensure the minimization of wastes. The challenge also is to bring together through consortia of companies the best scientific and technical talent to attack key problems.

The challenge to individuals is much the challenge enunciated during Earth Day---to be environmentally conscious, to take individual action, to see that our children are educated to protect their natural heritage.

Throughout history humanity has used the environment to advance its welfare, frequently at great environmental cost. While populations were small and technologies primitive, the restorative capacities of the earth could heal environmental wounds. As population has grown and technology has become sophisticated we have brought our planet to the brink of overstress.

Malthus in the seventeenth century predicted that population increases would outrun food supplies, bringing starvation and conflict. He failed to see the technological response in agriculture which has enabled the production of the necessary food. He failed also to see that birth rates and economic development were closely linked, and he failed to see that his prediction would more likely be true for other reasons. Population growth is outrunning not the food supply but the capacity of the environment to sustain that growth. With the advantage of such hindsight, we can thwart what some believe is an approaching environmental armageddon through the wise use of technology while still advancing the human condition.

Let me leave you with a thought. We are entering a new age of environmental consciousness. We are beginning to

recognize our dependence upon -- and our affection for -- this fragile blue planet. How daunting our environmental problems sometimes seem. How sobering to think that we often have no one to blame but ourselves.

But think of the obstacle that faced Charles Lindbergh when he left New York in his terribly vulnerable little craft. The modern technology of The Spirit of St. Louis made Lindbergh's flight physically possible. But it was the spirit of Charles Lindbergh -- his boldness, his vision, his belief in himself -- that carried him across the Atlantic and into history. Likewise, today's technology will carry us toward a solution to our environmental obstacles. We will have to find within ourselves the spirit to carry us across.

Thank you.

TECHNOLOGY POLICY IN AN INTERDEPENDENT WORLD
By Robert M. White
American Association for the Advancement of Science
April 13, 1990

The world is in political, economic, and technological upheaval unparalleled since World War II. We find ourselves in a new polycentric world in which political, economic and technological power is dispersed globally. Only the bipolarity of military power remains and this too is in the process of change. We are struggling to find our way in a new global system of nations - more tightly interdependent economically and technologically than ever before. Inevitable adjustments are under way and they are generating deep concerns in this country about their economic and technological impacts.

Why should we be concerned? The country is enjoying good economic conditions, which have persisted for the past seven years. Employment remains high with unemployment in the 5-5.5% range. Manufacturing as a percent of GNP has remained level at 20-21%. The absolute productivity level of U.S. labor in many manufacturing sectors continues to be the highest in the world. The U.S. share of OECD industrial output has grown to 39% of the total in 1986 from 36% in 1973. Our investments in research and development dwarf those of other nations, thereby ensuring our science and technology leadership in the future. Our higher education system is

preeminent in the world ensuring a continuing flow of essential talent.

On the other hand, much evidence suggests that we have failed, in both the government and the private sector, to contend effectively in many areas in the current world economic and technological arena. The evidence is all around us. U.S. companies have lost world market share in both mature and newer high-tech industries. To see this all you need do is walk through your local parking lot. The Honda Accord has now become the most popular car in the United States. Foreign firms now account for 30% of the domestic automobile market. Visit your local consumer electronics store and try to purchase an American-made VCR, compact disc player or camcorder. If you fly you are now more likely to find yourself on the European Air Bus than you were in the past. Some 50% of the world merchant market for semiconductor integrated memory chips is in Japanese hands.

This strange mix of good and bad news has been the fodder for much of the national technology policy debate. Over the last 15 years the problems of U.S. competitiveness and the role of technology have been studied by group after group. President Reagan's Commission on Industrial Competitiveness, the Council on Competitiveness, the National Academy of Engineering, the M.I.T. Commission on Manufacturing, and more recently the National Advisory Committee on Semiconductors and the Office of Technology Assessment, among others, have all

issued consistent findings and recommendations.

It was the commonality in most of these findings that led me to observe some months ago that a technology policy consensus was emerging. The common findings are by now a familiar litany: 1) the principal responsibility for harnessing technology for economic growth and remaining competitive in the global economy lies with industry; 2) there is a key role for government in providing the proper economic environment; 3) government at all levels must take a more prominent role in advancing education; and 4) there needs to be a stronger role for government participating with industry in the development of generic technologies when forces make it difficult for industry to capture the benefits of research and development.

The debate continues to shift, however, illustrating a U.S. technology policy in flux, especially on the government's role in research and development. Just consider the divergent views expressed in three recent government reports issued almost at the same time and in a very recent statement of President Bush. First, from the Economic Report of the President issued in February 1990:

Some have argued for a broad new Federal role: choosing specific civilian technologies and financing their development or commercialization by special tax treatment or direct subsidy--a so-called industrial policy. Such an expansion of the current Federal role is strongly opposed by this Administration.

Governments in the United States and elsewhere have shown themselves to be less able than private

businesses to pick specific technologies that will be commercially successful. They have often supported fashionable technologies with powerful advocates, rather than those that are economically productive.

Second, from the report issued by the chairman of the Congressional Joint Economic Committee in December 1989:

...we must acknowledge the fundamental changes that have occurred in the last forty years and adapt our approach accordingly....We must begin to support non-proprietary research in (civilian) engineering.... Federal policy should actively promote the diffusion and adoption of existing scientific and technological knowledge, not just the creation of new knowledge.... In funding R&D, we should reverse the systematic shift away from areas with the greatest potential for contributing to commercial innovations....

Third, from the recent Office of Technology Assessment report Making Things Better issued in February 1990 on the problems and prospects of U.S. manufacturing industries:

With few exceptions, the U.S. Government has been reluctant to adopt proactive policies to build competitiveness. For generations, most American academics and policymakers have been convinced that market mechanisms were better than government planners at identifying promising technologies. There are examples of failures of central planning that reinforce these beliefs, and for several decades, the economic performance of the American economy also justified that faith.

There are reasons to challenge this ideology now. First is the simple fact that many American industries are having great trouble in world competition, and some of the ablest international competitors assuredly do not have freer markets or lighter government involvement in supporting industrial technologies than the United States does.

This policy logjam may be breaking up. Just last month President Bush put his administration behind government support of generic technologies when individual companies

cannot bear the cost and risk of such investments alone given the diffuse nature of the benefits. In a speech to the American Electronics Association on March 7, President Bush said:

This Administration is committed to working with you in the critical precompetitive development stage where basic discoveries are converted into generic technologies that support both our economic competitiveness and our national security. Here again we can help to level the international playing field on which you compete.

Only future actions and budgets will tell the extent to which we are witnessing a real convergence of views. Clearly there is movement on the issue.

We have seen many responses with diverse and sometimes puzzling implications for technology policy. The Engineering Research Center system was established by the National Science Foundation to foster closer partnerships between universities, industry, and government on industrially relevant interdisciplinary engineering research and education. The government through the Department of Defense has undertaken to provide support for critical technologies in many ways. For example, it is providing a significant share of the funding of for SEMATECH to foster development of semiconductor manufacturing technology. More recently it has even moved to take an equity position in a corporation producing gallium arsenide chips.

On the educational front NSF has moved to increase significantly the number of graduate fellowships in science

and engineering, NASA is considering a major initiative in graduate education, and the President has committed his administration to strengthen education and training in K-12 levels.

On the economic front, our government has moved to make R&D tax credits permanent, has sought to lower the capital gains tax, and has taken prominent measures to open markets abroad.

Initial steps have also been taken to institutionalize a technology policy focus in the federal government. The Science and Technology Advisor has been elevated to the position of Assistant to the President and now participates broadly in deliberations of key policy arms of the White House. The last Congress established the National Institute of Standards and Technology (NIST) and the Under Secretary for Technology in the Department of Commerce. An Advanced Technology Program and a Manufacturing Technology Transfer Center Program have been initiated at NIST.

A more prominent government role in the support of technology development is underway. We need to ask, however, whether the remedies we formulate over the next several years will adequately address the technology issues that arise out of the continually changing nature of world production, trade, and markets? Let me explain my concerns.

It is a matter of fact, not ideology, that governments encourage, aid, monitor, oversee, regulate, and control the

workings of private industry in the international economy. They do this through tax policy, trade policy, industrial policy, and technology policy in various ways and to differing degrees. The U.S. economy, like the economies of other industrialized nations, is a product of both private decisions and government preferences, regulations, and controls.

The historical approach of U.S. policy is one that has largely downplayed attention to the structural composition of U.S. industry. In this view manufacturing paper cups and manufacturing semiconductors are equivalent. It has become increasingly clear that this traditional U.S. stance and the approach it engenders are virtually unique among the world's industrialized countries. Unlike Japan, France, the Federal Republic of Germany, or Sweden, the United States has eschewed a coordinated national economic development effort centered on technology development and diffusion, management of trade to enhance the comparative strengths of U.S.-based production, and government mechanisms to encourage development of an industrial structure that can yield high value-added jobs for its citizens.

Although most industrialized nations have gone much further in the direction of coordinating government-industry policies and activities to promote economic development than the United States has, the nature, form, and extent of this coordination differ considerably among these nations, and their efforts are by no means uniformly successful. In some

cases government involvement in particular industrial sectors goes well beyond support of R&D in generic technologies at the precompetitive stages and entails direct government subsidies to industrial production and marketing as well as government investments in commercial enterprises. Government involvement in development, production, and investment decisions along with direct and extensive intervention in import-export trade management have generally been regarded as the ultimate manifestations of what has come to be known as industrial policy.

As I have previously pointed out, however, there is a vast difference between this extreme form of industrial policy and a sound technology policy. The latter fosters cooperative and coordinated efforts of government, industry, and universities to sustain and advance industrial technological innovation, productivity growth, and economic growth. We should not let fear of lapsing into the extremes of government intervention into the private sector deter us from implementing a sound technology policy.

What are the global economic and technological realities that must shape our technology policy as we approach the year 2000? Let us start with some trends in both the domestic and global economies in the 1980s. Beginning in the early 1980s, the U.S. trade deficit grew practically unchecked to over \$150 billion a year -- though it has improved recently. The federal budget deficit has likewise ballooned. Borrowing from

abroad has fueled the prolonged economic expansion and has transformed the United States into the world's greatest debtor nation.

At the same time, the degree of interdependence among firms and nations has grown to unprecedented proportions. U.S. businesses now have more than \$1.2 trillion in assets abroad, and in 1988 a third of U.S. multinationals' earnings came from overseas operations. A recent complement to the expansion of U.S. direct investment abroad has been a virtual flood of foreign investment into the United States since the mid-1970s. Today, more than 3 million Americans work for foreign multinational corporations with affiliates in the United States, and countless others work for companies with sizable foreign interests. U.S.-owned operations abroad employ 6.2 million people and draw heavily on local production, technical, and management talent. In 1988, direct foreign investment in the United States totaled \$328 billion, compared with the \$326 billion in American direct investment abroad.

The ability to produce advanced goods in many nations, the trend toward globally operated engineering and production, and the homogenization of many previously national product markets have changed the nature of economic activity and dependence among industrialized nations. This change has occurred in such a way that very large volumes of capital, goods, services, components, people, data, and technological

know-how flow across national boundaries as part of everyday commerce.

Globalization has produced a movement to foreign countries of engineering and management activities traditionally associated with goods and services acquired in the United States. U.S.-based multinational companies -- long operated as a collection of financially linked national companies -- have begun to adjust to the idea of a global marketplace and to behave as truly international enterprises. In the past, U.S. companies established overseas subsidiaries almost exclusively for access to markets or low cost labor. The more advanced technical activities, such as R&D and product design and development stayed at home. Now more and more foreign subsidiaries of U.S. companies are part of a globally integrated production system in which all technical activities are increasingly globalized. As a result, decisions about location are being driven less by considerations of market access and labor costs more by the comparative advantages of foreign locations for global production efficiencies.

Not too long ago American multinationals provided R&D and engineering services to their foreign branches. With the growing excellence of engineering research and development overseas, more and more, U.S.-based multinationals are buying high-technology goods and services in place. The rapid transfer of technology across national boundaries has aided

this trend, as have the research and scholarly exchanges among U.S. universities and foreign companies and institutions.

Universities also are taking a new measure of their task in the unique challenge of the emerging global economy. Unlike companies that are established to pursue shareholder interests, universities are established to serve several ideals -- the education and training of young minds, and the pursuit and dissemination of knowledge. During the post World War II period, U.S. universities became global intellectual utilities driving development and education not just in the United States but worldwide.

With the recognition that harvesting the fruits of intellectual activity --- in fields like science, technology, economics and management --- is the key to economic growth, pressure has steadily increased for universities, especially scientific and technical research universities, to contribute to local, regional, national, and international economic development. At a regional level, every state wants a "Silicon Valley," a "Route 128," or a Research Triangle Park supported in part by local university-based technical talent. At a national level, government agencies increasingly expect research grants to contribute to national competitiveness, and there are congressional concerns about foreign firms' increasingly active use of U.S. university research as a means of accessing emerging technologies. In the future, U.S. universities are likely to face difficult questions about

their purpose as questions about who pays for and who benefits from university research and education are raised. This developing international integration of industries and research and educational institutions is the global context that must frame new approaches to our technology policies.

How do we chart our course in the face of the rapid globalization of technology that has blurred corporate nationalities and dissolved the once strong bond between corporate and national interests with regard to technology development and its commercial application. How do we chart a course in a world in which the redistribution of technical resources worldwide has been accompanied by a marked advance in the global integration of formerly relatively discrete national technology markets. These two trends have given rise to a global technical enterprise in which the technological capabilities of firms, entire industries, and other institutional actors have assumed a transnational base. In so doing, this globalization has provided a new compelling rationale for expanding the role of government in identifying and supporting national technology needs. At the same time it has also raised serious questions about some of the most fundamental assumptions that have guided debate about national technology policy in the past.

Private corporations or universities have traditionally assumed primary responsibility for the husbandry of U.S. national technology interests. Once they define their

interests in global or multinational terms, the need for effective public stewardship of national technology interests becomes glaringly apparent. Proposals for such institutionalization of this public stewardship abound---a Department of Industry and Technology, a Civilian Advanced Research Agency, and many others. It is urgent that we move to reshape our governmental institutions to provide this public stewardship of our technology interests and provide them with the necessary funding. Whatever the institutional form, it must be able to influence other related national policies. The new global realities will challenge the viability of any policy framework that segregates technology policy issues from related policy areas such as those concerned with economic policy, regulation, education, trade, or foreign investment.

Given the integration of the world economy we need to understand and agree on what it means to maintain a U.S. technological base for both our military and economic security. These words have a sonorous sound but we need to translate them into policies and programs. Certainly it must mean maintaining a full range of key technical competencies in the United States, including those associated with the actual production of goods and services, whether they are owned by domestic or foreign corporations.

If scientific and technological knowledge developed in the United States diffuses so that its benefits can be

acquired by others, then our policies must make if possible to capitalize more quickly on the immense output of our intellectual enterprise, a principal source of comparative advantage. Our problem is not in research but in our ability to commercialize the products of research.

If corporations will locate where the economic climate is favorable and the talent plentiful, then our policies must provide the economic incentives and the competitive talent so that they will locate in the United States.

Ultimately, the nation's ability to capture a fair share of the benefits of the global engineering enterprise will depend on whether its policymakers, private and public, recognize the vital interdependence of the broad range of domestic and international policies that influence technology development, diffusion, and commercialization. The technology policy challenge for the 1990s and beyond is to determine how the United States can capture the benefits of technological advance, no matter where in the world it originates. We must make this nation more attractive to individuals, companies, and other institutional actors, to practice the full spectrum of technical activities.

Only if our technology policies recognize these new realities and move to address them will the United States be able to prosper in an increasingly globally integrated economy. Thank you.

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Inventors, Invention and Innovation:
The Sources of Corporate Competitiveness
Inventors Day Address
Allied Signal Corporation
Morristown, New Jersey
By Robert M. White
April 18, 1990

I welcome this opportunity to join with you and the Allied Signal community to honor inventors and invention. Let me begin by saying that I believe invention -- and inventors -- are as critical to the advancement of our nation's economic growth in the 1990s as they were in what we sometimes think of as the Golden Age of Invention in the 1890s. In his book American Genesis, author Thomas Hughes states that "inventors, industrial scientists, engineers, and system builders have been the makers of modern America." Looking back over the past hundred years of American history, and looking around this room today, one has to agree with him.

In terms of invention, the past century has been like no other in history. In one century -- only a moment in historical time -- inventors have given the world the automobile, the airplane, the earth-orbiting satellite, the radio, the television, and countless other wonders. From noninvasive medical diagnostic systems to new pharmaceuticals to microchips and space shuttles, perhaps more progress has been made in the past century in raising the standard of living everywhere than has been made in all the preceding

centuries. Our inventions have even permitted man to reach beyond the earth to other extra-terrestrial bodies.

The productivity of some individual inventors during these years was awesome. Some became folk heroes, lionized and celebrated. The output of the giants of the early years of this century -- Edison, Bell, Tesla, Wright, Sperry -- was prodigious. A thousand patents for Edison, 350 for Sperry. This kind of productivity is hard to match. However, that kind of productivity can still be found. Indeed here at Allied Signal I'm told there are individuals who can chalk up as many as 300 patents to their credit.

But today, some point to the fact that the Japanese are now filing more U.S. patents than Americans---that American ingenuity is running out of steam. There's no question that the numbers have changed as other nations have recognized the central role of invention in economic success. But the number of patents awarded is not the sole measure of the health of the creative enterprise. Indeed scientific discovery and invention are not a problem in this country. We do very well. Discovery and invention now take place throughout the world as scientific and engineering capabilities grow in many countries. Despite recent progress, the problem in the United States has been in the rapid translation into quality products and services -- in short, the process of innovation.

Let us step back for a moment and examine the role of invention historically to give us some perspective on our

problems. In the landscape of human thought, inventions are the peaks. They support all social progress. Their roots lie deep in the subsoil of a fostering institutional, cultural, or social framework, without which they are as unlikely as an Everest without its foothills.

Invention is more than the development of useful and productive devices, although these are vital for material progress. Instead, it is a manifestation of the creativity in all human activities. The invention of the Gothic arch permitted the soaring cathedrals of the Middle Ages and the Renaissance. The paintings of Monet and Pissarro brought us the glories of impressionism. Our daily lives are uplifted by the songs of Irving Berlin and the symphonies of Beethoven.

In short, invention is where you find it. And so it is in industry. Whatever the function, whether in research and development, design, production, or distribution of goods and services, inventions are at the root of new products and processes and also the source of the economic success of companies. Inventions are the lifeblood coursing through the heart of industrial competitiveness.

One cannot overemphasize the importance of the context in which invention occurs. These contexts can be cultural, social, economic, or organizational and managerial. Civilizations and societies rise and fall in large measure on their ability to provide a context in which invention leads to innovation -- the process by which invention is translated

into useful building blocks for social development. Paper was a Chinese invention of the second century and the basis of a widely diffused culture of learning and social achievement that in turn translated to a civilization of the highest achievements. The compass and the quadrant, and later the chronometer and sextant, were great inventions of the age of global exploration, which led to the hegemony of the West over much of the world.

Great waves of economic progress have periodically changed the face of society related to the times of great outbursts of invention. The inventions are so sweeping that they completely transform the institutions of society, the general welfare of people, the economies of nations, and the fate of individual industries. These periods of innovation correspond to shifts in the locus of economic and political leadership among nations.

Those who have studied the process have identified three major cycles of invention leading to modern times. The first was associated with the development of textile manufacturing, the factory system, and steam power from about 1750 to the middle of the next century. The second embraced the development of railroads and iron and steel technology from about 1850 to about the turn of the century. The first half of this century has been characterized as the era of electrical power, the internal combustion engine, the automobile, and the growth of the chemical industry. We are

now in a fourth cycle, dominated by new technologies of electronics, computers, semiconductors, aerospace, pharmaceuticals, biotechnology, materials, and yes, nuclear power.

It is interesting to note that the full implications of inventions at the time of their development were frequently not understood either by the inventors or by companies or industries that were vitally affected. The steam engine was invented in Britain to pump water from coal mines. Only much later did steam power become the basis for railroad transportation systems, the generation of electricity, the powering of factories, and the social and economic revolution caused by them. In fact railroads when first put into operation were visualized only as overland ways to connect canal transportation systems.

It is also interesting to note that inventions that displace existing technologies are frequently developed outside the industry providing the services with the old technology. Carriage makers did not participate significantly in the development of the internal combustion engine and the automobile. Stagecoach companies did not participate in the development of the steam engine and modern railroads, that supplanted them. The makers of vacuum tubes, the principal elements of electronic systems until two decades ago, failed to participate significantly in semiconductor development, the backbone of modern electronic systems. John Mayo, executive

vice president of AT&T Bell Laboratories, calls these "killer" inventions.

The lesson for companies is that invention can make entire industries and companies obsolete. For this reason one of the central concerns of managers must be the potential of inventions to outflank their business and render it obsolete. Keeping abreast of inventions everywhere and their potential for affecting company futures becomes a sine qua non for management of all companies. And today when discovery and invention take place throughout the world as science and engineering knowledge diffuse globally, this becomes an even more important and more difficult task.

Invention is a many-splendored thing. It can be the logical extension of progress in basic science. Research in solid-state physics led to the invention of the transistor by Bardeen, Brattain, and Shockley. It can proceed from practical needs as did the invention of the integrated circuit by Kilby and Noyce, who were seeking a more efficient and productive system for the manufacture of solid-state circuits. It can occur serendipitously. Any of you who has seen the G.E. television commercial with the cat kicking over a beaker at night in a closed laboratory to create Lexan knows what I mean. Inventions can occur because of a management determination to achieve a specific objective. Quality control techniques in Japan flowed from the persistence of Deming and the determination of Japanese management to make

quality the hallmark of their production.

Inventors themselves are not very good at predicting the consequences of their work either. Marconi, the discoverer of radio communications, visualized it only as a means of communicating where it was difficult to put wires -- hence the term "wireless." He never visualized the broadcast industry. Bob Noyce, the coinventor of the integrated circuit recently commented that at the time of invention neither he nor Jack Kilby imagined the full implications of a new "information society." What the past tells us is that invention and its translation into products, processes, and services are the key to changing the rules of the game. And with ever-shortening product life cycles, the rapid conversion of scientific discovery and invention is the surest way to competitiveness for successful corporations.

It was inevitable that industry, recognizing the central value of invention and its translation into products and processes for the market, would move to systematize the process. The distinguishing mark of successful modern industry is its dedication to the process we now call technological innovation. The innovation process itself spans and integrates all of the functions of a modern corporation, from basic research to marketing. For the innovation process to work, all links in this process have to work together.

Hiroshi Inose, a Japanese Foreign Associate of the U.S. Academy of Engineering, currently Director General of the

Japan Center for Science and Information Systems, reflected on the essence of the process as seen in Japan. In a recently published paper, he wrote

...the necessary condition for a technological innovation to be accomplished successfully is that something new must be introduced to either one or more of the phases of the innovation process, namely, basic research, application research, development, design, production, marketing, distribution and consumption. However, this is not enough. The sufficient condition for successful innovation is that, responding to the introduction of the novel feature, all the links of the process are to function properly to control relevant phases so that the whole process can adjust itself organically and dynamically to provide better products or services.

I do not for a moment suggest that the United States is unsuccessful in the innovation process; many of our companies and industries continue as world leaders. It's just that in too many areas we are being bested by our competitors. We all now are well aware that the America that invented the transistor, the integrated circuit, color television, industrial robots, the video recorder, and plain paper copiers has seen great markets ceded to others who have made the innovation process work for them. To paraphrase something Roland Schmitt said at last year's Inventors' Day: "America gets the gold medal for invention, but others get the gold."

Because all companies operate in an increasingly integrated global economy, they have found that they can prosper only if their vision is global. The "not invented here" syndrome is a prescription for competitive failure in this new global economy. In a recent paper entitled "The

Quiet Path to Technological Preeminence" in the Scientific American Robert Reich caught the issue and the need well (and I quote):

This quiet path back to competitiveness depends less on ambitious government R&D projects aimed at specific technology areas such as supercomputers or high-temperature superconductors than on improving the process by which technological insights--wherever they may be discovered around the globe--are transformed by American workers into high-quality products.

The first step in rapid assimilation of new technologies is to discover what they are. American firms are often slow to learn of a new technological insight achieved elsewhere--whether it is a breakthrough invention, a more efficient method of fabricating and assembling products or a new way of organizing production and distribution. Some American researchers and engineers, whose formal education and early job experiences occurred when the U.S. was far ahead of other nations in developing and using technology, are simply skeptical of foreigners' abilities; anything "not invented here" is considered of little value.

The motivation and sources of innovation are numerous. Recently, the Academy of Engineering completed a major study, Profiting From Innovation, in which it examined various ways companies move ideas to the market.

The first type of innovation is "technology-driven" innovation. This is what many consider the "classic" case of a bright, new idea that grows into a major commercial success. While we all dream of such sudden success, it rarely happens overnight. This type of innovation, our study found, typically takes 15 to 20 years to go from initial idea to final product. The risk, of course, is that the market will change or evaporate.

The second kind of innovation is what we call "product or production driven." Through many quick, incremental improvements, one races to make an existing product better, cheaper, more reliable, or more attractive. The time frame here is not measured in years, but in weeks or months, and the greatest risk is that your competition will get there first. The Japanese have amply demonstrated their ability to move from sufficiency of design toward perfection of design -- while the product is on the market.

The third type of innovation we've identified is the "market-driven" innovation. Here, you perceive a need in the marketplace -- a gap -- and you work to find a technological fix. It requires close communication with, and a thorough understanding of, the market. The risk is that the technological fix you pursue will not be the right one, or that the competitor will find a better one before you do.

You may be wondering: in all of this talk of racing to the market and knowing the end user, where does the individual inventor fit in? It is simply that every idea starts in a single mind, which nurtures it and brings it to fruition. In fact, the need has never been greater for ideas and the ability to recognize their worth. While today's environment for independent inventors is not so easy as it was a hundred years ago, it is much easier for the corporate inventor.

In 1890, the state of the art -- levers, screws, and wedges -- was simple and inexpensive. Today, the complexity

and cost of instrumentation and other technological support for many devices and products has escalated beyond the means of the independent inventor. This intensive capitalization has created a formidable hurdle to the independent inventor and made it increasingly difficult to go it alone. People still do, of course -- the members of our own Academy include Wilson Greatbatch, Arnold Beckman, Bill Hewlett, and Dave Packard. It's not impossible -- but the corporation (or the university or the government) offers an advantage.

But too often our corporate inventors view their company's organizational structure as an obstacle to be overcome, instead of an asset to be employed. Where they should find support, they frequently find resistance -- to change, to new ideas, to the challenges that come with an increasingly global economy. Discouragement drives these potential innovators into "going along to get along," and finally into lethargy, their creative energy blocked by bureaucratic barriers.

And this is a challenge to our companies, our universities, and our government to provide the supporting technological and economic environment that will enable the creative juices to flow. We need to leverage the talent of our individual inventors. If innovation is to thrive, we will have to give the inventors a special place in our organizations. Instead of snarling the inventors in red tape, we must use the organizational structure to provide them the

freedom to dream. In February, we were pleased to have President Bush at The Academy's first Charles Stark Draper Prize ceremony. In his remarks, he commented that (and I quote): "only men who are free create the inventions and intellectual works which make life worthwhile."

Individual freedom can have enormous power when the support of the organization is behind it. There are dozens of examples of what is possible. Wallace Carothers of Du Pont was, as you all know, a brilliant but moody man who, left to himself, might well have lost his way. Under the aegis of a large, supportive organization, which looked after his needs and gave him the freedom necessary to pursue his vision, he gave the world moistureproof cellophane, neoprene, and nylon.

And while it may be immodest, I must return to the two recipients of our first Draper Prize. Jack Kilby and Bob Noyce, the inventors of the integrated circuit, must rank with the great inventors of a century ago if we consider the revolution that their chip touched off. What's more, they were working in large companies -- which understood their needs and worked with them to make the integrated circuit a commercial reality. Their work proves what can be done when the bureaucracy, if you will, frees inventors to pursue their vision.

A structured environment offers great advantages -- to relieve the day-to-day pressures of business and the law. It concentrates expertise from dozens of disciplines at the

inventor's fingertips. This is vital when the inventions of the day are space shuttles and automated manufacturing lines.

It's been said that lab specimens and humor perish when you dissect them. I think that we can add invention to that list -- the inventor's inner world is a private one. But innovation is a different story, and we may be able to renew it by taking the process apart and putting it back together again. The American system has worked wonders -- and can work wonders again. Our institutions can protect and nurture the spark of innovation. We have in the United States some of the best schools, some of the best companies, and some of the best workers in the world. What we need is not more creativity -- we need more freedom to be creative.

Product life cycles are shortening. Competition, as you well know, is intensifying. With the opening of new markets in Eastern Europe and in the Soviet Union, there will be great opportunities ahead for those who can capitalize on them. If we let our people go to work -- if we can get a product into the marketplace before we test and refine it to death, we will succeed.

All I have to do to confirm that invention and innovation are alive and well is to look around this room. Each of you who are recognized today for your contributions to invention should be very proud. But the very fact that you have succeeded and that you are here today means that many others have succeeded too, by providing the kind of supportive

environment in which your ideas could bear fruit.

The historical record suggests that the rush of technology will not slow. If you look at the Academy's recent list of the ten outstanding engineering achievements since 1964, you will see what I mean. In 1964, when our Academy was founded, there were no commercial applications of satellites, of lasers, of genetic engineering. No one had played a compact disc or flown in a jumbo jet.

It was our inventions and these institutions that made those things possible. As we look toward a new millennium, we will need to develop and incorporate new advances into the political and ethical foundations of a new world in which Berlin Walls and Cold Wars don't loom so large. We will need the creativity of our inventors -- people like you. And we will need our corporations and our universities and our government to turn your creations into applications.

Once again, I congratulate each of you. You are the advance scouts of technology, and your hard work, vision, and knowledge will become an even greater asset in the years to come. I urge each one of us to support you, to protect and nurture that creative spark of invention, and to work on turning invention into innovation. There are great challenges ahead; an inventive nation like our own has, in my opinion, the world's best chance for meeting them and advancing human welfare in the process.

Thank you for your kind attention.

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