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Briefing for Governor Sununu
Preparations for the First Framework Convention Negotiating Session
Washington, DC, February 4, 1991
November 7, 1990

Major Issues to Be Resolved by the White House

co-chairman State/NOAA Bolin/Krauss

1.— 1. Appointment of a head of delegation for the Framework Convention negotiations. This could be the same person as the "Special Ambassador", called for by the Carnegie Commission to be appointed to oversee the complex preparatory efforts leading up to the 1992 United Nations Conference on Environment and Development, to be held in Brazil (the "Brazil Conference). —2.

2. Background data and further details of positions on major issues to be addressed in the framework convention, including the comprehensive approach, economic aspects of emissions reductions, targets and timetables, the precautionary principle, the need for further scientific research, and financial assistance.

3. Beginning development or further development of any new policy initiatives that may be needed in conjunction with a framework convention. One initiative that may prove most useful is the National Energy Strategy.

4. Compilation of Administration accomplishments in the environmental area.

5. Timing of any new announcements on climate change policy. The beginning of the framework convention negotiating session may heighten public awareness of the issue. It coincides with the State of the Union address.

Logistics of February Meeting

RESPONSIBILITY FOR CONTRACTING WITH HOTEL FACILITIES

The Department of State/ Bureau of Oceans and International Environmental and Scientific Affairs will take the lead in securing the conference facilities. It is anticipated that they will do the same for conferenc participant hotel reservations and press arrangements.

HEAD OF DELEGATION

Buff Bolin, Assistant Secretary for Oceans, and International Environment and Scientific Affairs, has indicated and interest in heading the U.S. delegation.

COORDINATION OF DELEGATION

In the past, the Department of State has had the responsibility of delegation logistics. They will probably need guidance and backup from the DPC Global Change Working Group or Office of Cabinet Affairs if any limits are to be placed on delegation size or composition.

PREPARATION OF MATERIALS FOR MEETING

Department of State/Bureau of Oceans and International Environmental and Scientific Affairs has coordinated staff-level preparation of background materials. This needs to be closely coordinated with the outcome of the policy deliberations in the Domestic Policy Council.

November 6, 1990

Current USG Positions

1. Targets and timetables

We should not agree to specific targets and timetables. We should take a comprehensive approach that includes all sources and sinks of greenhouse gases and, in the short-term, take those actions which are justified for reasons other than climate change.

The Second World Climate Conference Ministerial Declaration lists a number of countries who have made some commitment to stabilize greenhouse gases. However, the Declaration also referred to options other than targets and recommended consideration of all gasses, sources and sinks in the most comprehensive manner possible.

2. Comprehensive Approach

The U.S. favors the comprehensive approach which includes all greenhouse gases.

The Second World Climate Conference Ministerial Declaration clearly preserves receptiveness to this approach. It recommends that "in the elaboration of response strategies over time, all greenhouse gases, sources and sinks be considered in the most comprehensive manner as possible and also that limitation and adaptation measures be addressed."

3. Financial Assistance

We will not commit to providing new and additional funding which increases the overall budget. We are already giving the environment a higher priority in our assistance funding, both bilateral and multilateral, and believe that existing resources and mechanisms must be fully utilized before new monies can be considered. It will also be necessary to quantify the costs associated with any actions in this area before consideration of new funds can be justified. We will also note that the provisions of the Montreal Protocol are not a precedent for other environmental issues.

* The Second World Climate Conference Ministerial Declaration is not limited to new funding. Instead, it recommends that "adequate and additional financial resources should be mobilized" This is compromise language that could be interpreted as acknowledging the potential for reprogramming of funds.

4. Statements Concerning the scientific understandings of climate change.

The statements must accurately describe the scientific context and uncertainties associated with potential climate change. The magnitude, timing, rate and regional distribution of predicted climate changes are uncertain because of limitations in our present scientific understanding of climate processes and in our ability to model behavior of climate systems and components. The human-caused emissions of greenhouse gases, while significant, are much smaller than the exchange between the atmosphere and natural systems.

5. Precautionary Principle

Where there are threats of serious of irreversible environmental damage, lack of full scientific certainty is no excuse to postpone actions which are justified in their own right. Environmental measures must anticipate, prevent, and attack the causes of environmental degradation. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation which are justified on their own right. These measures include: improved energy efficiency, use of lower greenhouse gas-emitting sources; improved forest management; development of comprehensive coastal management plans; use of practices to recycle and reuse CFC gases and their substitutes; and improved agricultural practices.

The SWCC Ministerial Declaration language reflects the U.S. position much better than previous, similar declarations. It specifies "cost-effective measures" to be taken where their is not full scientific certainty.

Timetable for First Negotiating Session in February

October 29	SWCC Science Meeting
November 6-7	SWCC Ministerial Portion of Meeting
November 7	Comprehensive Task Force directive transmitted asking for final materials needed to complete comprehensive approach plan.
November 8	Staff meeting to prepare for briefing on SWCC and forestry convention
November 9	Global Change Strategy Task Force Meeting Agenda items: (1) report on result of SWCC and implications for Framework convention; (2) forestry convention.
November 12	Veterans Day Celebration
November 14	PCC WGCC (DOS) meeting - Progress report on preparations for a framework convention by all subgroups.
November 16	Compilation of materials prepared for framework convention.
November 19	Staff meeting to organize materials on framework convention and comprehensive approach, determine outstanding materials and revise timetable as needed.
November 21	GC Strategy Task Force Meeting Agenda items: (1) Progress Report on Preparations for framework convention by PCC WGCC subgroups; (2) briefing on comprehensive approach EPA/DOJ; 3) Tasking out of additional information required and preparation of options paper on major, outstanding issues needing resolution.
November 22	Thanksgiving Day
November 26	Staff meeting to compile materials for options paper and develop draft structure of options paper.
November 28	GC Strategy Task Force Meeting Agenda items: (1) Discussion of framework convention preparation of options package for presentation at DPC GCWG meeting; (2) selection of a negotiator and head of delegation.

November 30	Deadline for all PCC WGCC Workgroup reports. Tentative deadline for Comprehensive Approach Task Force materials and Economics Task Force report.
December 1-7	Staff meetings to develop final options papers for presentation to full Global Change Working Group for approval.
* December 10	Full DPC GCWG to 1) review options paper, 2) review U.S. preparations for, and approaches to, negotiating a framework convention, 3) discussion of PCC WGCC Workgroup reports, and 4) tasking of additional work product.
December 11-19	Staff meeting as needed to compile and integrate additional information, put options paper into final draft form.
December 18	Strategy Task Force Meeting, if needed. Agenda items: (1) package options (based on all comments) for consideration by DPC GCWG.
December 20	Full DPC Global Change Working Group meeting. Agenda items: (1) Review Options Package to be presented to full DPC.
December 20- January 6	Staff meeting as needed to further refine options paper and compile additional information.
December 25	Christmas Day
January 7	Options package distributed to DPC members in preparation for meeting.
January 15	Full DPC meeting to consider Options package.
January 22	Full DPC meeting to consider Options package.

→ Dan Evans mid January

~~Paul Wagner~~

lunch w/ JHS invite

Negotiations on a Framework Convention on Climate Change
Proposed actions and Products:

1. PARAMETERS

1-1. Development of appropriate definitions **[Task Force on Climate Approaches]**

2. ECONOMICS

2-1. "The Economics of Long-Term Global Climate Change" report from the DPC GCWG Interagency Task Force on Economics. **[INTERAGENCY TASK FORCE ON ECONOMICS]**

2-2. Preliminary assessments of best available information on effectiveness and economic consequences of various response strategies **[DOE, EPA, OMB, CEA]**

2-3. Develop detailed analyses of the feasibility of meeting certain proposed targets in order to demonstrate the impracticability of these proposals. **[DOE, EPA, CEA]**

2-4. Calculate the impact on radiative forcing of emissions targets implemented by only a subset of countries (e.g., OECD members) **[DOE, EPA AND CEA]**

2-5. Evaluate the feasibility and economic consequences of emissions targets for the U.S. and other key countries. (Part of the effort will be to identify potential allies) **[EPA, CEA, OMB AND DOE]**

[SEE 10. ANNEXES AND PROTOCOLS FOR ECONOMICS IN THE CONVENTION]

3. NO REGRETS

3-1. Determine what could be listed under a "no regrets" heading. **[STATE IN COOPERATION WITH OTHER AGENCIES]**

4. COMPREHENSIVE APPROACH

4-1. Develop options regarding to what extent (i.e., how much detail) the framework convention should "tilt" the protocol in the direction of a comprehensive approach. **[STATE WORKING WITH THE TASK FORCE ON CLIMATE APPROACHES]**

4-2. The Task Force on Comprehensive and Incentives Approaches to Climate is specifically monitoring this set of products in preparation of the framework convention in relation to the comprehensive/incentives approach: **[STATE AND DOJ]**

4-2-1. Drafting a U.S. version of a possible framework convention. **[STATE AND DOJ]**

4-2-2. Develop an improved radiative forcing index. Sketch the design of a global change index. **[CEES, EPA (ALBRITTON AND TIRPAK, ET. AL.]**

4-2-3. Design an international GHG monitoring system. **[EPA, CES, DATA MANAGEMENT WORKGROUP, EPA, MARS]**

4-2-4. Development of talking points including quantitative demonstrations that piecemeal proposals would have little environmental benefit, or actually be counterproductive. **[DOJ]**

4-2-5. Conduct quantitative analysis of the comprehensive and economic incentives approaches, and its variations by gas, strategy, sector, nation. **[NORM HARTNESS, DOE]**

4-2-6. List of the net index-weighted emissions change wrought by relevant U.S. actions, including "no regrets" measures. Prepare a similar list for other countries. [EPA]

4-2-7. Develop language for the framework convention to address the vision of decisionmaking under uncertainty. **[CEES AD HOC ECONOMICS TASK FORCE]**

4-2-8. Assess other's proposals. [EPA, DOE, CEA]

5. FINANCIAL ASSISTANCE

5-1. Options paper on how to handle the possibility of differentiated treatment in the framework convention for developing countries with respect to both general and specific obligations. [STATE]

5-2. Catalogue existing U.S. financial assistance related to climate change. [STATE]

5-3. Assessment of existing institutions and mechanisms related to financial assistance for climate change. [STATE]

5-4. Develop positions regarding technology development issues. **[STATE, DOE, USDA, EPA'S INTERNATIONAL ENVIRONMENTAL TECHNOLOGY TRANSFER ADVISORY BOARD, DOC, USTR, AND OTHER RELEVANT AGENCIES]**

6. INSTITUTIONS

6-1. Consider surveillance/verification/compliance functions that might accompany comprehensive/economic mechanisms to be included in the framework convention. Determine whether they should be included in the convention or subsequent document. **[STATE AND THE TASK FORCE ON CLIMATE APPROACHES, in the long term: COMMERCE, USTR]**

6-2. Review and analysis of existing institutions, identifying gaps, and considering the provision for the establihsment of scientific or other bodies on a permanent or ad hoc basis to advise the parties on various technical matters. **[STATE, TASK FORCE ON CLIMATE APPROACHES AND OTHER AGENCIES AS APPROPRIATE]**

7. RESEARCH, SYSTEMATIC OBSERVATIONS AND ANALYSIS

7-1. Develop proposals it considers the U.S. should make with respect to research and monitoring. **[INTERAGENCY WORKING GROUP ON DATA MANAGEMENT FOR GLOBAL CHANGE]**

7-2. Develop an updated list of research areas to include in the convention, perhaps in an annex. The list should include areas in which further research is needed to determine an appropriate response strategy toward greenhouse gases. **[TASK GROUP ON CLIMATE APPROACHES]**

8. INFORMATION EXCHANGE AND REPORTING

8-1. Determine the kinds of scientific and economic information should be exchanged and under what conditions. **[STATE WITH APPROPRIATE AGENCIES]**

8-2. Consider the merits of a fund dedicated solely to climate change research and any institutional auspices under which it would operate. Also determine what kinds of scientific and economic information should be exchanged and under what conditions. **[STATE AND RELEVANT AGENCIES]**

8-3. Consider the need for the elaboration of a comprehensive international research program in order to facilitate cooperation in the exchange of scientific, ecnomic, and other information on climate change. **[CEES should provide its view]**

9. SETTLEMENT OF DISPUTES

9-1. Options paper discussing whether we should support stronger dispute settlement provisions. [STATE]

10. ANNEXES AND PROTOCOLS

10-1. Analyses to demonstrate the advantages of economic approaches and options for references in the convention to economic mechanisms. [TASK FORCE ON CLIMATE APPROACHES]

CARNEGIE COMMISSION ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

10 Waverly Place, New York, N.Y. 10003 (212) 998-2150 FAX (212) 995-3181

6 July 1990

The Honorable D. Allan Bromley
Assistant to the President for Science and Technology
The White House
Washington, D.C. 20506

Dear Allan,

As you are aware, the Carnegie Commission on Science, Technology, and Government was established in 1988 to seek ways in which the branches of the U.S. government can encourage and better use the contributions of the nation's scientists and engineers.

In early June the Commission convened a workshop to examine "International Environmental Organizations: The Science and Technology Dimensions." This meeting was designed to study, in depth, the institutional issues raised at the recent "White House Conference on Science and Economics Related to Global Change."

Workshop participants took particular note of the June 1992 United Nations ministerial Conference on Environment and Development to be held in Brazil. As a result, the co-chairs of the workshop have prepared a letter, attached here, which recommends three near-term actions by the U.S. government. These are:

1) appointment of a Special Ambassador for the 1992 Brazil Conference to oversee the complex U.S. efforts required to be successful at the meeting;
2) appointment of a Presidential Commission (or comparable body) for the Conference to synthesize data and concepts for the U.S. position; and
3) appointment of a Public Advisory Committee to the Special Ambassador to enhance dialogue among industry, universities, and citizens with the government on issues relating to the Conference.

The workshop participants believe that such actions could greatly facilitate the process of analysis and consultation needed to organize a unified U.S. position for this important meeting and to relay recommendations to the President for consideration. We understand that the Office of Science and Technology Policy is working with the Council on Environmental Quality, the Department of State, and other agencies in the preliminary preparation for Brazil. Thus, we bring the suggested actions to your attention. If the Workshop participants are correct, it would be desirable to take actions, in concert with the Congress, before the end of 1990, so that the mechanisms can be most effective.

Our Carnegie group would be pleased to meet with you and other officials to share detailed views relating to this matter.

Respectfully yours,

William T. Golden

William T. Golden   Joshua Lederberg

CARNEGIE COMMISSION ON SCIENCE, TECHNOLOGY, AND GOVERNMENT

6 July 1990

Mr. William T. Golden
Dr. Joshua Lederberg
Co-Chairmen, Carnegie Commission
on Science, Technology, and Government
10 Waverly Place
New York NY 10003

Dear Bill and Josh,

As co-chairmen of the meeting, we are pleased to report a successful Workshop of the Carnegie Commission on the subject of "International Environmental Organization: The Science & Technology Dimensions" at The Rockefeller University, June 4-6, 1990. The detailed findings of the Workshop will be conveyed to you later this summer.

During the course of our discussions, an important issue emerged that calls for early consideration. Our attention was drawn to the UN Conference on Environment and Development to be held in Brazil in June, 1992. Major recent studies have provided convincing evidence that the linkage between environment and development is now so compelling that the two very complex and important topics often need to be considered together. Decisions of lasting significance with regard to international institutions and decision-making processes bearing on both the quality of the global environment and the strategies for economic growth could be made in connection with the Conference.

The UN has appointed an outstanding Secretary General, Maurice Strong of Canada, for the Conference and established a Preparatory Committee to develop the agenda and supporting papers. A demanding schedule of international and regional meetings has been set by the Preparatory Committee for the next two years. Several scientific organizations in the United States (for example, the American Association for the Advancement of Science, American Association of Engineering Societies, Social Science Research Council, Consortium of Social Science Associations, the Council of Scientific Society Presidents, and Sigma Xi) have banded together to elicit and integrate the views of the scientific community in this country on these issues. There has been a call from the recent ministerial-level conference in Bergen, Norway, supported by influential scientists from many nations, for a "Science Summit" on environment and development that would be held only a few months before the 1992 Brazil Conference.

Our Workshop members agreed that it is a matter of prime importance that the United States be well prepared for the Brazil Conference. Several of the attendees were involved in similar preparatory work for other UN conferences, such as that on the Environment held in Stockholm in June, 1972, and on Science and Technology for Development held in Vienna during

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August 1979. The strong and persuasive national position developed by the United States was a factor in the success at Stockholm. An experienced delegation coped well with the contentious problems faced in Vienna. Our Workshop participants were unanimous in the conviction that lessons from the past show that more activity in regard to the Brazil Conference is desirable, both within the government and in its interactions with the outside community. Several actions should be considered, as a matter of urgency, to assure a dynamic and creative participation by our country. We recommend the following:

1) The President should appoint a Special Ambassador to work with the Secretary of State and other high level officials to oversee policy planning and development of a unified U.S. government position for the Conference on Environment and Development. This Special Ambassador should be provided with adequate funds and staff to support careful preparation of papers outlining options for the U.S. position. To be effective, the initial papers should be in hand no later than 1 September 1991. Accordingly, the Ambassador should be appointed by the fall of 1990, this year.

2) The President and the Congress should establish a Presidential Commission (or comparable body) on the UN 1992 Conference on Environment and Development to provide and help synthesize a wide range of data and views from governmental and nongovernmental sources in order to assist the State Department and other federal agencies involved in the planning process. To assure an appropriate diversity of perspectives, the President and Congress should appoint individuals from the Congress, the Executive Branch, industry, labor, environmental organizations, the scientific and engineering community, and other professionally expert and concerned groups to serve on the Commission. Selected members of the Commission would later serve as members of the U.S. delegation to the Conference and would thus be well-prepared to represent the U.S. position. For the 1972 Stockholm Conference, Senator Howard H. Baker, Jr. of Tennessee served as chairman of the comparable advisory group. Having a distinguished and knowledgeable sitting member of the Congress lead the group worked exceptionally well.

3) The Secretary of State in consultation with appropriate federal officials[1] should appoint a larger Public Advisory Committee to work with the Ambassador in preparing for the Conference. The Committee would serve to assure broad public dialogue in the U.S., through regional conferences and other means, on the issues the Conference will address.

* * * * * * * * * * * *

1 These include the Assistant to the President for Science and Technology, the Chairs of the Councils of Economic Advisors and Environmental Quality, the Secretary of Energy, the Secretary of the Treasury, the Administrator of the Environmental Protection Agency, the Administrator of the Agency for International Development, the Under Secretary of Commerce for Oceans and Atmosphere, and the Director of the National Science Foundation.

We urge you to bring these considered recommendations to the attention of the President, key White House officials, the Secretary of State, and such other individuals in the executive and legislative branches whom you feel must be informed now. We note that the steps recommended are ones that traditionally have been taken by the U.S. government in preparing itself for world conferences of major potential significance, such as the 1972 Stockholm Conference and the 1979 Vienna Conference.

As agreed at the Workshop, this letter has been prepared in consultation with Harvey Brooks, Rodney W. Nichols, Walter A. Rosenblith, and H. Guyford Stever, members of the Commission and its international steering group who participated in the Workshop, and has their full agreement. A list of all the Workshop participants is attached.

We join in commending you for your initiative in bringing the participants of our Workshop together and look forward to discussing with you our conclusions on a range of issues during the months ahead.

Sincerely yours,

Jesse H. Ausubel   Thomas F. Malone

cc. Workshop participants

"International Environmental Organization: The S&T Dimensions"
Workshop, The Rockefeller University, New York, NY
June 4-6, 1990

Participants:

John F. Ahearne, Sigma Xi
Jesse H. Ausubel, Carnegie Commission on Science, Technology, and Government
D. James Baker, Joint Oceanographic Institutions
Richard E. Benedick, World Wildlife Fund/ The Conservation Foundation
Harvey Brooks, John F. Kennedy School of Government, Harvard University
William C. Clark, John F. Kennedy School of Government, Harvard University
Richard E. Hallgren, American Meteorological Society
Philip W. Hemily, National Research Council
John A. Knauss, National Oceanic and Atmospheric Administration
J. W. M. La Riviere, Institute for Hydraulic & Environmental Engineering, Netherlands
Jeffrey Laurenti, UN Association of America
James R. Mahoney, National Acid Precipitation Assessment Program
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Peter S. Thacher, World Resources Institute
Mary Martha Treichel, National Research Council
Gilbert F. White, University of Colorado
Robert M. White, National Academy of Engineering
Anne V.T. Whyte, International Development Research Centre, Canada

APPENDIX I

Details of Issues Under Analysis

by State

Outline of Preparations for Negotiations on a Framework Convention on Climate Change

This outline is organized along the lines of the IPCC/RSWG Legal Measures Paper on "Possible Elements for Inclusion in a Framework Convention on Climate Change."

General

This paper assumes that a comprehensive approach leaves open what the ultimate response strategy or strategies will be (for example, controls on net emissions of greenhouse gases, technology R&D).

Preamble

-- Preambles, which explain the purpose of the agreement, generally contain hortatory language and declarative findings (such as "recognizing the need for further research and systematic monitoring to develop the scientific knowledge about the global climate").

-- Preambular language is customarily negotiated after the body of an agreement to ensure that it accurately reflects the agreement's content and to include items on which the parties were not able to reach substantive agreement in the text itself; given the range of extant proposals, it will be to our advantage to continue this practice. We will be able to draw from our positions on specific issues to develop appropriate preambular language when needed.

Definitions

-- Which terms need definition, and how any such terms should be defined, customarily follows elaboration of the body of the agreement, as they depend upon the purpose of the agreement and the language used by the negotiating parties.

-- Nonetheless, to enhance our ability to advocate a comprehensive approach, it might be useful to have definitions developed (in conceptual if not legal language) for certain terms connected with such an approach, e.g., greenhouse gases, net emissions, global warming potential index, sources, sinks.

Proposed Action: The Task Force on Climate Approaches should develop appropriate conceptual definitions for terms associated with a comprehensive approach.

General Obligations

-- Following the format of other framework conventions (for example, the Vienna Convention), general obligations are set out in a separate article and may or may not be followed up by more specific commitments later in the convention.

-- The following general obligations were largely accepted by IPCC/RSWG participants, including the United States:

-- taking "appropriate" (but unspecified) response measures to limit, reduce, adapt to, and, as far as possible, prevent climate change;

-- taking "no regrets" measures;

-- cooperating in research, monitoring, and information exchange;

-- encouraging the development and transfer of relevant technologies, as well as providing technical and financial assistance;

-- encouraging public education and awareness;

-- flexibility to fulfill the requirements of the agreement using bilateral, regional or multilateral agreements of arrangements;

-- cooperating with competent international organizations;

-- strengthening or modifying, if necessary, existing legal and institutional instruments and arrangements.

Although there may be differences concerning how to frame the general obligations, the main issues will relate to whether certain general obligations should be specifically elaborated elsewhere in the convention itself. The most controversial are likely to be: specificity of response measures; financial assistance; and technology transfer. Each of these is addressed below.

Specific Issues

1. Specificity of Response Measures

Issues:

-- Whether, apart from general obligations to take "appropriate" measures and "no regrets" measures, the convention should contain specific targets with respect to either levels of emissions or atmospheric concentrations?

U.S. Position to Date: The USG view has consistently been that it would be premature to include targets in the framework convention. Further, we have argued that response strategies should be chosen based on assessments regarding their effectiveness in averting potential impacts of climate change, as well as their economic consequences. We have also argued for a comprehensive approach that considers all greenhouse gases, their sources and sinks, together.

Proposed Actions: 1) DOE, EPA, OMB, and CEA should coordinate the following efforts: a) making **preliminary assessments of best available information on the effectiveness and economic consequences of** various response strategies; b) developing detailed analyses of the feasibility of meeting certain proposed targets; c) calculating the impact on radiative forcing of emissions targets implemented by only a subset of countries (e.g., OECD members); d) assessing the feasibility of response strategies contained in the Bergen and Noordwijk declarations. 2) To enhance our negotiating position in support of a comprehensive approach, the Task Force on Climate Approaches should develop an explanation setting out, in some detail, how such an approach would work and explaining its advantages over a piecemeal approach.

-- Should any such targets include stabilization by industrialized countries, as a first step, and later reduction of CO_2 emissions and emissions of other greenhouse gases?

U.S. Position to Date: Again, the USG view has been that the convention should not contain targets for either stabilization or reduction of greenhouse gas emissions.

Proposed Action: At a minimum for internal purposes, EPA, CEA, OMB, and DOE should, using best available information, evaluate the feasibility and economic consequences of emission targets for the U.S. and other key countries.

-- Should the convention spell out specific "no regrets" measures that the parties should take?

U.S. Position to Date: The USG has advocated taking "no regrets" measures in the face of scientific uncertainty. However, we have not taken a position on whether specific "no regrets" measures should be required by the framework convention.

Proposed Action: State should coordinate with relevant agencies to determine what could be identified under a "no regrets" heading.

-- Should the framework convention commit the parties to formulate appropriate specific measures (such as in a protocol)?

U.S. Position to Date: **The Vienna Convention provides for, but does not require, the formulation of further** specific measures. The USG view has been that the convention should not require the development of a subsequent instrument (i.e., a protocol) but should provide that any instrument that is developed must address greenhouse gases, their sources and sinks, comprehensively.

Proposed Action: State should work with the Task Force on Climate Approaches and other agencies, as appropriate, to develop options regarding to what extent (i.e., in how much detail) the framework convention should "tilt" any future protocol in the direction of a comprehensive approach. In addition, it should be considered to what extent (and from what baseline) a "credit" should be given in any protocol for current and past actions relevant to climate.

-- Should the convention provide that implementation of specific obligations may take place in different timeframes for different categories of countries? To what extent should the convention provide for differentiated treatment with respect to both general and specific obligations?

U.S. Position to Date: The USG view has been that all countries have a responsibility to protect the global environment. At the same time, we have recognized that certain differentiated treatment may be appropriate to reflect the more limited technical and financial situation of developing countries. The Vienna Convention requires the parties to undertake the general obligations "in accordance with the means at their disposal and their capabilities". The Montreal Protocol contains a ten-year grace period for certain developing countries (although such differentiated treatment was not required by the Vienna Convention). Both the Noordwijk and Bergen Declarations contain language recognizing the possible need of some countries to increase greenhouse gas emissions for development purposes.

Proposed Action: State should prepare an options paper for interagency review on how to handle the possibility of differentiated treatment in the framework convention.

2. Financial Assistance

Issues:

-- Whether, apart from a possible general obligation to promote financial assistance to developing countries to address climate change, there should be a specific commitment to provide new and additional financial resources?

U.S. Position to Date: We have opposed committing to new and additional funding which increases the overall budget. Although we did agree to "additional" funding in the Montreal Protocol amendments, those amendments explicitly provide that such funding and funding mechanism is without prejudice to other environmental issues. We have given the environment, and in particular climate change (Congressionally-mandated), a higher priority in our assistance programming, both bilaterally and multilaterally. The scope of resource needs and the costs and benefits of meeting possible obligations must be assessed and the adequacy of existing resources determined before increases could be considered.

Proposed Action: State should coordinate an effort with appropriate agencies to catalogue existing U.S. financial assistance related to climate change.

-- Whether, apart from a possible general obligation to promote financial assistance to developing countries to address climate change, there should be a specific funding mechanism to assist such countries in implementing the convention and presumably its protocol(s).

U.S. Position to Date: We have opposed the establishment of new mechanisms, insisting that there be assessments of whether existing institutions and mechanisms are adequate to meet needs.

Proposed Action: State should provide an assessment of existing institutions and mechanisms related to financial assistance for climate change.

3. Development and Transfer of Technology

-- Following other framework conventions, it would be usual for the convention to call upon the parties, generally, to promote the development and transfer of technology to assist developing countries to take measures to address climate change.

Issues:

-- Whether the convention should call for special terms to attach to climate-related transfers of technology (e.g., preferential, non-commercial), taking into account the protection of intellectual property rights.

U.S. Position to Date: Given that private industry, rather than the U.S. government, owns environmentally-related technologies, we have traditionally not been in a legal position to ensure any special terms of transfer. Thus, we have generally endorsed a rather weak commitment to "facilitate" such transfers. In the ozone context, where the substitutes and technologies are fairly discrete and EPA works closely with the relevant companies, we agreed "to take every practicable step...to ensure...that the best available, environmentally safe substitutes and related technologies are expeditiously transferred to [developing countries] and that [such] transfers occur under fair and most favorable conditions". However, our agreement was not to be taken as a precedent for other environmental areas. In this context, we would need to ensure that any such article did not preclude a subsequent emissions trading system as the means of satisfying technology transfer needs.

Proposed Action: State should work with DOE, DOC, NOAA, and USDA to develop positions regarding technology development issues. With respect to technology transfer issues, State should draw on the expertise of EPA's International Environmental Technology Transfer Advisory Board, as well as work with DOC, USTR, and other relevant agencies, to consider whether and, if so, how we could go beyond a general commitment to promote the development and transfer of environmentally-related technologies.

Institutions

-- It has been the general practice under international environmental agreements to establish various institutional mechanisms, including a secretariat (a standard administrative body) and a Conference of the Parties (not an independent organization but simply the mechanism through which the parties act, including taking decisions).

Issues:

-- Should any of the convention's institutions, through some kind of majority vote, have the authority to bind all the parties with respect to specific response measures?

U.S. Position to Date: Such an approach would be unacceptable in that we would not want to be bound by specific response obligations without our consent.

-- Should any international institution have powers with respect to surveillance, verification, and compliance?

Proposed Action: Initially, State should work with the Task Force on Climate Approaches and other agencies, as appropriate, to consider whether any surveillance/verification/compliance functions that might accompany comprehensive/economic mechanisms approaches need to appear in the framework convention (as opposed to a subsequent legal instrument). In the longer term, State should work with Commerce and USTR to review possible trade sanctions against parties in non-compliance (as well as non-parties) and their implications for the United States.

-- Should provision be made for the establishment of scientific or other bodies, on a permanent or ad hoc basis, to advise the parties on various technical matters?

U.S. Position to Date: We have supported the existence of subsidiary bodies on topics such as science and economics.

Proposed Action: State should prepare a review and analysis of existing institutions with a view to identifying possible gaps/overlaps and recommending how best to fill/eliminate them. Further, State should work with the Task Force on Climate Approaches and other agencies, as appropriate, to consider what bodies would be useful in connection with a comprehensive approach.

Research, Systematic Observations and Analysis

-- It would follow general practice for the convention to include provision for cooperation in research and monitoring. We have advocated strong research and monitoring provisions in the framework convention.

Proposed Action: The CEES and any other appropriate interagency group should develop proposals it considers the United States should make with respect to research and monitoring.

-- In terms of research, there appears to be consensus that each party might be called upon to undertake, initiate, and/or cooperate in, directly or through competent international bodies, the conduct of research in a variety of listed areas.

Proposed Action: We need to develop an updated list of research areas to include in the convention, perhaps in an annex (as was done in the Vienna Convention). In addition to any areas identified by the CEES, such a list should include areas in which further research is needed to determine an appropriate response strategy towards greenhouse gases. The Task Group on Climate Approaches should develop such a list.

-- General consensus also emerged on the need for monitoring and analysis of climate and cooperation in ensuring collection, validation and transmission of research, observational data and analysis through appropriate data centers.

Issues:

-- Whether there should be provision for open and non-discriminatory access to meteorological data developed by all countries?

U.S. Position to Date: We have strongly favored such a provision and will be promoting the concept at the Second World Climate Conference with respect to data and information for climate/global change research.

-- Whether a specific scientific research fund should be established?

U.S. Position to Date: Although not in the context of a convention, we are supporting the Climate Studies Fund, which is based on voluntary contributions, operated under WMO auspices, and designed to address climate change scientific research.

Proposed Action: State should work with relevant agencies to consider the merits of a fund dedicated solely to climate change research and any institutional auspices under which it would operate.

Information Exchange and Reporting

-- It would follow general practice for the convention to include provision for exchange of information on measures that parties had adopted in implementation of the convention and its protocol(s). In addition, as in the Vienna Convention, the parties could be called upon to exchange scientific, technical, socio-economic, commercial, and legal information related to climate change.

Proposed Action: State should work with relevant agencies to determine what kinds of scientific and economic information should be exchanged and under what conditions.

Issues:

-- Whether there is a need for the elaboration of a comprehensive international research program in order to facilitate cooperation in the exchange of scientific, economic, and other information on climate change?

Proposed Action: The CEES should provide its view on this issue.

-- Whether each party should be obligated to develop a national inventory of emissions, as well as strategies for addressing climate change?

U.S. Position to Date: We made this proposal in the IPCC Response Strategies Working Group.

Settlement of Disputes

-- It would be customary to include a provision on the settlement of disputes, should differences arise concerning the interpretation or implementation of the convention and/or any annex/protocol.

Issues:

-- Whether resort to binding dispute settlement should be voluntary or mandatory.

U.S. Position to Date: In the environmental context, we have generally favored voluntary resort to binding dispute settlement or mandatory resort to non-binding dispute settlement.

Proposed Action: State should prepare an options paper analyzing whether, in the climate change context, we should support stronger dispute settlement provisions.

Final Clauses (such as amendment, adoption of annexes, adoption of protocols, signature, ratification, right to vote, entry into force, reservations, withdrawal)

-- These provisions are generally non-controversial.

Annexes and Protocols

-- It would follow general practice for the framework convention to provide for the possibility of annexes and protocols.

Issues:

-- Assuming that the convention itself does not contain obligations for greenhouse gas emissions limitations, **whether the convention should provide how such obligations** are to be addressed in any protocol(s), e.g., that **greenhouse gases, their sources and sinks, are to be dealt** with individually, in groups, or comprehensively.

U.S. Position to Date: As mentioned above, the U.S. view has been that the convention should not require the development of a protocol but should provide that any protocol that is developed must address greenhouse gases comprehensively.

-- Whether specific response obligations should be negotiated simultaneously with the framework convention (either directly in the convention or in a protocol being negotiated at the same time).

U.S. Position to Date: We have taken the view that any specific response obligations should be contained in a protocol that should be negotiated subsequent to the framework convention.

Other

-- A remaining issue for the United States is the extent to which the convention should address economic mechanisms, such as emissions trading.

Proposed Action: The Task Force on Climate Approaches should develop the necessary analyses to demonstrate the advantages of economic approaches. Further, State should work with the Task Force to consider options for references in the convention to economic mechanisms, e.g.:

(a) the parties could be required to evaluate alternative administrative and enforcement mechanisms that could be used in connection with various reponse measures;

(b) the convention could require that any protocol developed to control emissions of greenhouse gases will provide for economically efficient and effective implementation mechanisms, including a system of international emissions trading; and/or

(c) the convention could require cooperation in research in issues related to emissions trading.

APPENDIX II

Specific Policy Analyses Identified by OMB

October 22, 1990

POLICY ANALYSES RELATING TO FRAMEWORK CONVENTION NEGOTIATIONS

GENERAL OBLIGATIONS

1. What are the advantages of a comprehensive approach for purposes other than implementing and monitoring emissions control commitments? Should the general obligations include the obligation to develop a strategy of "no regrets" and other "appropriate" measures using a comprehensive approach?

- The U. S. advocacy of a comprehensive approach may be taken by many to relate only to commitments to emission reduction targets and timetables.

- However, countries may wish to negotiate commitments other than control targets and timetables - such as to carry on various joint research programs. Shouldn't any such commitments be included in a comprehensive approach?

- Finally, individual country consideration of "no regrets" actions or voluntary actions ought to be done using a comprehensive approach.

- It may be advantageous to the U. S. to have a paper available which explicitly describes the uses and value of the comprehensive approach as a general way to consider and address climate change issues, as distinguished from a way to rationalize and minimize costs of emission reduction target and timetable commitments.

2. What "no regrets" actions has the U. S. already taken? What are the costs and estimated U. S. emissions reductions of these actions?

SPECIFICITY OF RESPONSE MEASURES: TARGETS AND TIMETABLES

3. What do we know and what are the uncertainties about the costs and effectiveness of partial and unilateral actions that have been proposed such as a 20% CO_2 reduction below 1990 levels achieved by the year 2005 and maintained indefinitely by the industrial countries alone?

- To what degree would economic activities in the industrial countries shift to modes emitting other GHGs?

- To what extent would high emission activities be transferred to developing countries and continue to emit at similar or higher rates? In general, what are likely to be the emissions implications of unilateral actions at various scales?

- What are the trade implications of unilateral actions at various scales?

- To what extent would the capital costs of such targets impact on the private and governmental capital available for environmentally sound economic growth in the developing countries.

- How quickly would the world-wide reduction in emissions from unilateral actions, after taking into account the likely shifts described above, be eliminated by emissions growth outside the industrial nations?

<u>4. What are the current knowledge and uncertainties about the costs and other implications to the U. S. of actions to reduce GHG emissions below the levels achievable by the "no regrets" actions already committed to?</u>

- How do U. S. costs of control vary with the magnitude of reduction, with the timing of reduction, and with the gases included?

- What do we know about the costs, effectiveness, and other implications of possible "no regrets" actions that we have not yet committed to implement, such as the potential "no regrets" actions under the National Energy Strategy?

- Can the U. S. show, in the negotiations, that it has done its homework in analyzing the issue of going beyond "no regrets": that the costs could be very high, that costs are strongly related to how fast emissions are reduced, that there are many remaining areas of uncertainty, and that premature and unilateral actions could well be counter-productive?

- The U. S. should also have information available to support a comprehensive approach by showing the degree to which the selection of the most cost effective GHG emissions reductions depends strongly on an appropriate greenhouse gas index as well as on the costs of eliminating or sequestering a unit of a specific greenhouse gas.

<u>5. What are the estimates of emissions and costs of reduction being made by other participants in the international discussion?</u>

- What information from the International Country Case Studies underway in the EIS of the IPCC would be useful to the U.S.?

- What do we know about global models being developed by the OECD, Japan, and others?

- Can we use what we know about these efforts to help us understand country positions and strategies and to support the positions we take?

6. How are the costs and benefits of mitigation measures likely to be related to the rapidity of implementation?

- Mitigation is likely to involve significant replacement of existing long-lived capital with new technology which has costs which decline as the time of initial investment is delayed. Investment in an early version of a technology means that the lower costs of the later version can not be obtained.

- To the extent that mitigation forces retirement of capital before its economic replacement time, costs are increased.

- On the other hand, delay in implementing mitigation increases the costs of any climate change that does occur or the costs of adapting to it.

- Can the U. S. describe these issues and make a credible case that they can not be ignored and thereby help support its positions in the negotiations?

7. What is the appropriate trade-off between addressing climate change by preventing it and by adapting to it?

- Analysis of the impacts of climate change has generally ignored adaptations to climate change that will occur for market driven reasons as well as governmentally sponsored adaptation.

- Given the costs of climate change, the costs of adaptation, and the costs of mitigation, it is almost certain that the least cost response will include accepting some change and responding with both adaptation and mitigation. The theological approach which many have taken to the climate change issue ignores this point.

- Is there advantage to the U. S. in trying to give this point more visibility in the discussion?

- What do we know and need to know about the kinds of market-driven adaptation that are likely to occur with various degrees of climate change? What are the costs of such various degrees of climate change, including the market-driven adaptations that would accompany them? What kinds of governmental actions or policies could be adopted to achieve additional adaptation at minimum cost?

8. What do we know and where are the uncertainties about the differing claims that (a) substantial emissions reductions can be obtained, not only without major costs, but with significant economic savings through energy conservation, or, alternatively, (b) that significant emissions reductions beyond the "no regrets" actions would be very costly because they would require major capital investments that would not otherwise be economic?

- Much of the pressure for large reductions may be based on the assumption that the energy conservation enthusiasts' more optimistic savings estimates are valid.

- Does the U. S. have sufficient information to reach conclusions as to the validity of each set of claims and as to the degree of uncertainty that remains?

- Can that information be used to support U. S. positions?

9. What do we need to know about the implications of various elements of target-and-timetable emissions control agreements?

- What are the implications of different approaches to setting baselines for such agreements: the highest historic value prior to 1990, a year in the next decade, a specified year or a year selected by the party from a specified range? What are the implications of different baseline years for different gases or groups of gases?

- What are the implications of different approaches to the timing of targets? Short term targets vs. those set for 10 years later or 25 years later? Targets set close together in time or at longer intervals? Initial targets set in the short term with less stringent levels or set at a later time with more stringent levels?

- What are the implications of various target formats? Successive phased targets set in advance at one time or a single target with later increments to be considered later? Considering changes in targets at short intervals or at longer intervals?

10. What are the implications of different types of targets for a control agreement?

- What are the implications of targets based on some absolute historic level? On emissions per capita? Emissions per unit of gross domestic product? Emissions per unit of energy use?

- What are the implications of targets based on some combination of bases, such as reducing from some absolute level until some per capita (or other per unit) level is reached?

- What are the implications of adjusting targets for local endowments of resources that produce emissions or are alternatives to emission-producing resources? For local characteristics or relative costs of emission-producing and alternative resources?

11. What considerations would have to be dealt with in implementing emissions control agreements?

- How would agreements be monitored? How would reported data be verified? Who would determine initial baseline conditions, if obligations are based on such conditions?

- What would be appropriate methods of sanction? For non-compliance by non-parties? For non-compliance by parties? What degree and length of time of time of non-compliance would trigger sanctions? Under what conditions would sanctions be raised? Could trade sanctions be designed as a means of enforcement?

- How would regional economic organizations be treated?

SPECIFICITY OF RESPONSE MEASURES: SPECIFIC NO REGRETS MEASURES

12. What "no regrets" measures should be considered by countries in developing a strategy of appropriate measures. Should the Convention identify such measures for consideration? Shouldn't the convention specify that, in order to encourage "no regrets" and other "appropriate" voluntary measures, countries should receive credit for such measures in the negotiation and implementation of any subsequent agreements to implement the Convention?

- Should the U. S. develop a list which identifies measures which are likely to be justified by non-climate benefits to be included in the convention as potential "no regrets" measures which should be considered by each country in the development of their own initial strategy?

SPECIFICITY OF RESPONSE MEASURES: REQUIREMENT THAT ANY INSTRUMENT BE COMPREHENSIVE

13. What kind of greenhouse climate change metric or greenhouse warming potential should be used? How sensitive is a greenhouse gas index likely to be to those factors that are highly uncertain?

- Is a set of greenhouse warming potential (GWP) indices based on the cumulative instantaneous radiative forcing of a given GHG release sufficient to compare different gases or should such indices reflect the relative discounted amounts of all future forcings from such releases? Are comparisons of forcings sufficient or should the relative present amounts of future climate changes be compared? Or the relative present values of future damages? Should gases that have indirect impacts on radiative forcing, etc. be included? If so, how should non-climate impacts of such gases, such as the polluting effects of SO_2, be treated? If discounting is not used, what time frame or time frames should be used? Should the indices include non-climate effects, such as CO_2 fertilization?

- An index based on cumulative radiative forcing neglects important economic aspects - the time path of realized climate changes resulting from radiative forcing, the time path of damages resulting from realized climate changes, the time path of benefits such as CO_2 fertilization, and the discounting of damages and benefits.

- Whether or not an index based on radiative forcing alone would be substantially different from one that included these economic aspects is unknown, nor is it known how differing assumptions about those aspects that are uncertain might change the relative index.

- The U. S. needs to understand what differences there might be in indices with different bases in order to determine its own position about alternatives indices and to be able to counter other country objections that a reasonably valid set of indices can't be supported by the present state of knowledge.

<u>14. What are the likely arguments that may be raised against a fully comprehensive approach to emissions controls?</u>

- What are the likely arguments for and against controlling GHGs in groups or as individual chemicals? Can we make a strong case to support our position?

<u>15. What are the likely arguments for and against international emissions trading?</u>

- What are the arguments relating to trading among countries with greatly different economic levels?

- How are schemes such as coal-by-wire to be dealt with?

- How are trading agreements to be monitored? How would sanctions be imposed upon countries which have entered into trading agreements?

SPECIFICITY OF RESPONSE MEASURES: DIFFERENTIATED TREATMENT

16. What are the characteristics of the major negotiating countries that are likely to affect their negotiating positions and rationales?

- What is the likely sensitivity of their economic structure to changes in climate? Are they likely to be clear losers, clear winners, or relatively unaffected? What is their capability for market-driven adaptation to changes, and at what costs?

- What are the economic and other constraints to the kinds of actions which they might take to limit or to adapt to climate change? Are certain kinds of action advantageous for them?

- What are the likely trade effects and effects on the relocation of economic activities that would be produced by actions to limit climate change, including actions that might be taken unilaterally elsewhere?

- How do these characteristics and sensitivities compare with those of the U. S.?

17. What proposals are other countries making in international fora, in their own domestic political and legislative processes, and what are the views of their governments and publics on the issues of climate change?

- Can the U. S. establish a systematic process for keeping an up-to-date summary of these matters with enough accuracy and timeliness to be useful to our decision-makers and negotiators?

18. What can we say about the reasons for differences in GHG emissions per unit of gross domestic product (GDP)?

- What explains the relatively high emissions per unit of GDP in the U.S. compared to some other countries with similar per capita incomes? Can we justify them on the basis that they reflect efficient decisions based on underlying real conditions in our economy or are they the result of market imperfections, institutional distortions, etc.?

- What do these considerations imply about the costs and difficulty of reducing GHG emissions in the U. S.?

19. What are the implications of various kinds of differential obligations and responsibilities for different countries or groups of countries to take into account differences in abilities to perform such obligations?

- What are the implications of differences in the times at which obligations become binding? Of differences such as exempting a country from a control obligation until per capita emissions reach some threshold level? Other kinds of differences?

- Would differences in obligations generate differences in incentives and in behavior that would not be desirable either from the point of view of achieving the objectives of the obligation agreements or from the point of view of taking differences in ability into account?

- How could differentials in obligations be kept from being a trade advantage or an offset to the results sought by the agreements to accept obligations?

FINANCIAL ASSISTANCE

20. What economic and other arguments can the U. S. marshall for an assistance regime which integrates the need for economic growth and for sustainable, environmentally sound approaches?

- Seperating the priorities, planning, and implementation of environmental projects from that of development projects is likely to produce different incentives and different results than if there is a single funding source to projects that integrate developmental and environmental considerations and objectives.

- If developing countries are only obligated to do "good" environmental things to the extent that industrial countries fund them through an environmental fund, is development likely to be sound and sustainable?

- If development projects can leave environmental considerations for seperate, and perhaps later, funding, will they adequately take such considerations into account? Will an environmental fund be used too often to correct, at higher cost, the environmental defects of development projects?

- Should not the U. S. have available materials that describe in detail the counter-productive aspects of an assistance regime which seperates environmental and development goals, funding, and implementation?

21. What are various countries seeking from a financial assistance regime? What kinds of arrangements or what kind of strategy are likely to produce a result that would be acceptable to the U. S.?

DEVELOPMENT AND TRANSFER OF TECHNOLOGY

22. What is the likelihood that R&D in alternatives to fossil fuels would pay off in terms of economically efficient replacement of fossil fuels in the near term?

- Claims for solar, wind, and other non-fossil alternatives are often made that their costs have declined in relation to fossil fuels and will cross the cost-time curves of the latter in just a few years.

- The economics of emissions reductions depends on whether cost reductions in non-fossil alternatives replace fossil fuels or simply drive down fossil fuel prices.

- Would it be advantageous to the U. S. to make these questions more visible?

23. What are the objectives of various countries with respect to transfer of technology? What kinds of arrangments or strategies would produce a result that is acceptable to the U. S.?

INSTITUTIONS

RESEARCH, SYSTEMATIC OBSERVATIONS AND ANALYSIS

24. What are the major scientific and socioeconomic uncertainties that might be resolved in a near-term time frame and which could significantly increase the effectiveness or reduce the costs of addressing climate change?

- What are the key uncertainties that affect decision-making? How are they related to other uncertainties? Where are investments in reducing uncertainty likely to have the most payoff in terms of improving the quality of decision-making, both in the short term and over longer periods? To what degree is international cooperation in monitoring and research needed?

- Can the U. S. provide a menu of areas of uncertainty which can be quickly reduced and which should be reduced before major commitments are made?

- For example, can the U. S. make a credible argument that we need to know how much all countries together are likely to achieve by "no regrets" actions before we can sensibly analyze the costs and benefits of additional actions, and that that can be done fairly quickly?

- In other words is there likely to be very high pay-off in terms of more effective response to global change from reducing the existing uncertainties about, for example, energy saving measures and other "no regrets" actions in the different socioeconomic circumstances of developing and industrial countries?

INFORMATION EXCHANGE AND REPORTING

SETTLEMENT OF DISPUTES

ANNEXES AND PROTOCOLS

OTHER

25. What are the defects of policies addressing only one or selected sectors, such as a transport-only policy?

- For example, how might emissions shift under a high CAFE statute due to changes in the economic life of existing vehicles, increases in miles driven, shifts to electric cars fueled by coal generated central power plants or to cars fueled by methanol or other alternative fuels?

26. What are the defects of command-and-control strategies which mandate specified technologies.

- To what extent does U. S. experience show that such approaches discourage the development and use of efficient technologies, leading to increased emissions in the longer run?

27. To what degree could ecological impacts be managed by adaptive actions?

- What are the possible management measures that might be taken? What would their costs and other implications be?

- What would be the likely ecological changes that would remain after management measures?

29. What, if any, role is there for international agreements on adaptation?

- Would agreements trade adaptation assistance for commitments to do such things as create or improve resource management and planning capabilities? Trade adaptation assistance for unused emission rights?

- Would agreements on adaptation be needed to avoid added regional disagreements, such as those over water use rights?

APPENDIX III

Prime Minister Margaret Thatcher's speech delivered to the SWCC

Maynard 11/6/90

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FOR: Dr. Bromley or Ken Yale

TEXT OF A SPEECH

MADE BY THE PRIME MINISTER

THE RT HON MARGARET THATCHER FRS MP

AT THE SECOND WORLD CLIMATE CONFERENCE

IN GENEVA

ON

TUESDAY 6 NOVEMBER 1990

PRIME MINISTER'S OFFICE
10 DOWNING STREET
WHITEHALL
LONDON
SW1A 2AA

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[Introduction]

Mr. Chairman, Your Majesty, President Koller, Distinguished Colleagues, Your Excellencies, Ladies and Gentlemen,

May I begin by thanking Heads of Agencies and Organisations for sponsoring this Second World Climate Conference, and indeed all those connected with it. It is a most important event for all our countries and I wish you success in your endeavours.

Mr. Chairman, since the last World War, our world has faced many challenges, none more vital than that of defending our liberty and keeping the peace. Gradually and painstakingly we have built up the habit of international cooperation, above all through the United Nations. The extent of our success can be seen in the Gulf, where the nations of the world have shown unprecedented unity in condemning Iraq's invasion and taking the measures necessary to reverse it.

But the threat to our world comes not only from tyrants and their tanks. It can be more insidious though less visible. The danger of global warming is as yet unseen, but real enough for us to make changes and sacrifices, so that we do not live at the expense of future generations.

Our ability to come together to stop or limit damage to the world's environment will be perhaps the greatest test of how far we can act as a world community. No-one should under-estimate the imagination that will be required, nor the scientific effort, nor the unprecedented co-operation. We shall have to show statesmanship of a rare order. It's because we know that, we are here today.

[Man and Nature: out of balance]

For two centuries, since the Age of Enlightenment, we assumed that whatever the advance of science, whatever the economic development, whatever the increase in human numbers, the world would go on much the same. It was progress. And that was what we wanted.

Now we know that this is no longer true.
We have become more and more aware of the growing imbalance between our species and other species, between population and resources, between humankind and the natural order of which we are part.

In recent years, we have been playing with the conditions of the life we know on the surface of our planet. We have cared too little for our seas, our forests and our land. We have treated the air and the oceans like a dustbin. We have come to realise that man's activities and numbers threaten to upset the biological balance which we have taken for granted and on which human life depends.

We must remember our duty to Nature before it is too late. That duty is constant. It is never completed. It lives on as we breathe. It endures as we eat and sleep, work and rest, as we are born and as we pass away. The duty to Nature will remain long after our own endeavours have brought peace to the Middle East. It will weigh on our shoulders for as long as we wish to dwell on a living and thriving planet, and hand it on to our children and theirs.

[The importance of research]
I want to pay tribute to the important work which the United Nations has done to advance our understanding of climate change, and in particular the risks of global warming. Dr. Tolba and Professor Obasi deserve our particular thanks for their far-sighted initiative in establishing the Intergovernmental Panel on Climate Change.

The IPCC report is a remarkable achievement. It is almost as difficult to get a large number of distinguished scientists to agree, as it is to get agreement from a group of politicians. As a scientist who became a politician, I am perhaps particularly qualified to make that observation!

Of course, much more research is needed. We do not yet know all the answers. Some major uncertainties and doubts remain. No-one can yet say with certainty that it is human activities which have caused the apparent increase in global average temperatures. The IPCC report is very careful on this point. For instance, the total amount of carbon dioxide reaching the atmosphere each year from natural sources is some 600 billion tonnes, while the figure resulting from human activities is only 26 billion tonnes. In relative terms that is not very significant. Equally we know that the increases of carbon dioxide in the atmosphere date from the start of the industrial revolution. And we know that those concentrations will continue to rise if we fail to act.

Nor do we know with any precision the extent of the likely warming in the next century, nor what the regional effects will be. We cannot be sure of the role of clouds.

There is a continuing mystery about how atmospheric carbon, including the small extra contribution from human sources, is being absorbed: is most of it going into the ocean, as used to be thought? Or is it being increasingly absorbed by trees or plants, or soils, especially in the northern hemisphere? These are questions that need answers, sooner rather than later.

Global climate change within limits need not by itself pose serious problems - our globe has after all seen a great deal of climate change over the centuries. It is notable that the blue-green algae which dominated the Precambrian period at the dawn of life are still major components of the marine phytoplankton today. Despite the climate changes of many millions of years, these microbes have persisted on earth virtually unchanged, pumping out life-giving oxygen into the atmosphere and mopping up carbon dioxide.

The real dangers arise because climate change is combined with other problems of our age: for instance the population explosion;
- the deterioration of soil fertility;
- increasing pollution of the sea;
- intensive use of fossil fuel;
- and destruction of the world's forests, particularly those in the tropics.

Britain will continue to play a leading role in trying to answer the remaining questions, and to advance our state of knowledge of climate change. This year, we have established in Britain the Hadley Centre for Climate Prediction and Research for this purpose. We need to improve in particular our understanding of the effect of the oceans on our weather, improve too our capability to model climate change. I have seen for myself the outstanding work being done on both these subjects at the National Center for Atmospheric Research in Boulder, Colorado.

We must also make sure that research is carefully targeted. Too many people can do the same thing, and at the same time vital problems can be neglected. The task of global observation is immense. It will require a coordinated effort more ambitious than any attempted before, as the meeting of scientists and experts last week recognised.

[The need for precautionary action]

But the need for more research should not be an excuse for delaying much needed action. There is already a clear case for precautionary action at an international level. The IPCC tells us that we cannot repair the effects of past behaviour on our atmosphere as quickly and as easily as we might cleanse a stream. It will take, for example, until the second half of the next century, until the old age of my grandson, to repair the damage to the ozone layer above the Antarctic. And some of the gases we are adding to the global heat trap will endure in the Earth's atmosphere for just as long.

The IPCC tells us that, on present trends, the earth will warm up faster than at any time since the last ice age. Weather patterns could change so that what is now wet would become dry, and what is now dry would become wet. Rising seas could threaten the livelihood of that substantial part of the world's population which lives on or near coasts. The character and behaviour of plants would change, some for the better, some for worse. Some species of animals and plants would migrate to different zones or disappear for ever. Forests would die or move. And deserts would advance as green fields retreated.

Many of the precautionary actions that we need to take would be sensible in any event. It is sensible to improve energy efficiency and use energy prudently; sensible to develop alternative and sustainable sources of supply; sensible to replant the forests which we consume; sensible to re-examine industrial processes; sensible to tackle the problem of waste. I understand that the latest vogue is to call them 'no regrets' policies. Certainly we should have none in putting them into effect.

And our uncertainties about climate change are not all in one direction. The IPCC report is very honest about the margins of error. Climate change may be less than predicted. But equally it may occur more quickly than the present computer models suggest. Should this happen it would be doubly disastrous were we to shirk the challenge now. I see the adoption of these policies as a sort of premium on insurance against fire, flood or

[The need for environmental diplomacy]
We are all aware of the immense challenge. The enormity of the task is not a matter for pessimism. The problems which science has created science can solve, provided we heed its lessons. Moreover, we have already established a structure of international co-operation on the environment to deal with ozone depletion. For the first time ever, rich and poor nations alike set out together to save our planet from a serious danger. This painstaking work culminated in the historic agreement reached in London this year. That agreement is a real beacon of hope for the future.

The main focus in London was on protecting the ozone layer. But the agreement will have other consequences. We should not forget that CFCs are 10,000 times more powerful, molecule for molecule, than carbon dioxide as agents of global warming. But of the other greenhouse gases, carbon dioxide is by far the most extensive and contributes around half the manmade greenhouse warming. All our countries produce it. The latest figures which I have seen show that 26 per cent comes from North America, 22 per cent from the rest of the OECD, 26 per cent from the Soviet Union and Eastern Europe and 26 per cent from the less developed countries.

These figures underline why a joint international effort to curb greenhouse gases in general and carbon dioxide in particular is so important. There is little point in action to reduce the amounts being put into the atmosphere in one part of the world, if they are promptly increased in another. Within this framework the United Kingdom is prepared, as part of an international effort including other leading countries, to set itself the demanding target of bringing carbon dioxide emissions back to this year's level by the year 2005. That will mean reversing a rising trend before that date.

The European Community has also reached a very good agreement to stabilise emissions. I hope that Europe's example will help the task of securing world-wide agreement.

Targets on their own are not enough. They have to be achievable. Promises are easy. Action is more difficult. For our part, we have worked out a strategy which sets us on the road to achieving the target. We propose ambitious programmes both to promote energy efficiency and to encourage the use of cleaner fuels.

We now require, by law, that a substantial proportion of our electricity comes from sources which emit little or no carbon dioxide. That includes a continuing important contribution from nuclear energy.

Such measures as these - which increasing numbers of countries are adopting - should be seen as part of the premium on that insurance policy which I mentioned. They buy us protection against the hazards of the future: but they also pay dividends even though the gloomier predictions about global warming are not fulfilled - dividends such as less air pollution, lowered acid rain, reduced energy costs.

Mr. Chairman, people may disagree about the effects of increased man-made carbon dioxide in the atmosphere. But everyone agrees that we should keep in healthy condition the forests and seas which absorb and utilise a large part of it here on earth. We would be wise to do that for other reasons too: for the beauty of the forests and the infinite variety of species which inhabit them, and to preserve the food chain and balance of nature in the sea.

That's why we want to contribute to conserving the world's forests, and to planting new ones. Trees help to reduce global warming. We intend to plant more at home: we have just announced our plans to replant one of the ancient forests of England - destroyed in an earlier phase of our history.

We shall offer our expertise and aid funds to help plant and manage forests elsewhere in the world, particularly in tropical countries. A year ago I told the United Nations General Assembly that the United Kingdom would aim to increase its funds for tropical forestry by £100m. We now have 150 projects underway in more than 30 countries.

Our aim is to give the people in those countries a better standard of living by conserving and using the forests than by cutting them down.

[The need for a Global Convention]
But our immediate task this week is to carry as many countries as possible with us, so that we can negotiate a successful framework convention on climate change in 1992. We must also begin work on the binding commitments that will be necessary to make the convention work.

To accomplish these tasks, we must not waste time and energy disputing the IPCC's report or debating the right machinery for making progress. The International Panel's work should be taken as our sign post: and the United Nations Environment Programme and the World Meteorological Organisation as the principal vehicles for reaching our destination.

We will not succeed if we are too inflexible. We will not succeed if we indulge in selfrighteous point-scoring for the benefit of audiences and voters at home. We have to work sympathetically together. We have to recognise the importance of economic growth of a kind that benefits future as well as present generations everywhere. We need it not only to raise living standards but to generate the wealth required to pay for protection of the environment.

It would be absurd to adopt polices which would bankrupt the industrial nations, or doom the poorer countries to increasing poverty. We have to recognise the widely different circumstances facing individual countries, with the better-off assisting the poorer ones as we agreed to do under the Montreal Protocol.

The differences can't be drafted away in that famous phrase so beloved of diplomats "a form of words". They need to be resolved by tolerant and sympathetic understanding of our various positions. Some of us use energy more efficiently than others. Some of us are less dependent on fossil fuels. And we each have our own economic characteristics, resources, plans and hopes for the future. These are the realities that we must face if we are to move forward towards a successful conclusion to our negotiations in 1992.

Just as philosophies, religions and ideals know no boundaries, so the protection of our planet itself involves rich and poor, North and South, East and West. All of us have to play our part if we are to succeed. And succeed we must for the sake of this and future generations.

One of our great poets, George Herbert, in his poem on "Man" wrote this:

> "Man is all symmetry,
> Full of proportions, one limb to another, And all to all the world besides;
> Each part may call the farthest, brother; For head with foot hath private amity,
> And both with moons and tides."

We are, in symmetry with nature. To keep that precious balance, we need to work together for our environment. The United Kingdom will work with all of you in this cause -to save our common inheritance for generations yet to come.

APPENDIX IV

"ECO" Reports published by the Non-Government Organizations during the SWCC

SECOND WORLD CLIMATE CONFERENCE NGO NEWSLETTE

eco

NOVEMBER
MINISTERIAL ISSUE

Eco has been published by Non-Governmental Environmental Groups at major international conferences since the Stockholm Environment Conference in 1972. This issue is produced cooperatively by groups attending the Second World Climate Conference 1990

US CLAIM BASED ON DOUBLE COUNTING CFCs

By ECO Staff

The United States' claim, made by Mr Allan Bromley, President Bush's Science Advisor, that US greenhouse gas emissions will be held "at 1987 levels until at least the year 2000" is three-quarters based on counting CFCs already to be controlled under the Montreal protocol, it emerged yesterday.

Bromley's assertion, made in a speech on October 23rd, is undermined by unpublicised EPA calculations, which show that the US programme relies far more on the CFCs than on the policies of tree-planting, landfill gas control, the new Clean Air Act, energy efficiency initiatives and other measures — which Bromley has emphasised. As Brooks Yeager, of the US Audubon Society points out: "In fact, the US 'stabilisation' programme assumes a 15% increase in CO_2 at the turn of the century." Yeager also questions other aspects of the programme. "The tree planting is not yet funded and discussion of the the 'global forestry convention' proposed at the Houston G7 summit that Bromley mentions, has now been deferred until March 1991."

According to the EPA study, the US calculation, that in terms of 100-year global warming potentials the year 2000 emissions should have no greater impact than those of today, is arrived at as follows:

Current Commitment

Millions of tonnes of carbon reduced (Carbon equivalents)	
Tree initiative	9
DOE Energy Efficiency Initiatives	28
DOE Appliance Standards	4
DOE Renewable Initiatives	4
Clean Air Act	68
Landfill Regulation	44
CFC Phaseout & Montreal Protocol	551
Total:	708

This projected reduction for year 2000 emissions compares to US expected total emissions of 3,040 million tonnes without CFC phaseout under the Montreal Protocol. Total US emissions in 1987 were 2,330 million tonnes.

— continued on back page, col 3

EFTA ANNOUNCES TALKS AIMED AT CO_2 STABILISATION

By ECO Reporter

Following a joint meeting with European Community countries yesterday, a statement released by EFTA and EC Ministers represented by Flavio Cotti of Switzerland and Giorgio Ruffolo of Italy announced that 'senior environmental officials' would 'undertake every effort towards the adoption of a concerted EC/EFTA position and as appropriate, common proposals to the extent possible on issues such as achieving stabilisation and subsequent reduction of CO2 and other greenhouse gas

Cotti and Ruffolo described the outcome of the meeting as a commitment by every country to stabilisation. Ruffolo described the meeting as "satisfactory and encouraging". Carlo Ripa di Meana, EC Environment Commissioner referred to "broad harmonisation" between EFTA and EC countries, and suggested that "the 18 countries of Europe are convinced and commited to stabilise CO_2 emissions by the end of this century". Ruffolo added "there is no possibility for delaying or postponing action".

Swedish Position Unknown

Former US Negotiator Damn American Positio

"The US position is not only irresponsible, unnecessary," said William A Nitze, Presid of The Alliance To Save Energy said yesterc Commenting on the US policy at the Sec World Climate Conference, Nitze, a forr State Department negotiator on environmer issues, added, "The US has greater opportuni for reducing its CO_2 emissions through gre energy efficiency and use of renewables t most other industrialised countries. An inter EPA study shows US CO_2 emissions increas by less than 13% between 1987 and 2000 e without counting the full benefits of the Cl Air Act amendments. Use of a 1990 basel and modest policy changes to exploit lower negative cost energy efficiency improveme would eliminate any growth in US C

— continued on back page, cc

CONTENTS

CONFERENCE REPORT

OECD STABILISATION PROPOSAL

How should the SWCC Science Report be translated into policy? That is the main question now facing politicians in the Ministerial conference. Here David McRobert interviews Bunli Yang, Policy Adviser in the Cabinet Office of the Ontario government about a way forward for the OECD.

The scientific report of the Second World Climate Change Conference has confirmed an even stronger consensus for immediate actions to reduce the risks posed to the climate by the "Business-as-Usual" approach in the industrialized countries. However, possible next steps for policy-makers are under intense dispute as the Ministerial portion of the SWCC gets underway.

To explore what some of the next steps might be, ECO interviewed Dr. Bunli Yang, a policy advisor to the Cabinet Office of the Government of Ontario, Canada about his views on how to achieve even a small breakthrough in negotiations for an international convention on climate change.

ECO *What implications for policy-makers do you draw from the scientific and technical report of the SWCC?*

Yang The wide agreement expressed here at SWCC on the need for actions leads me to think that the ball is in the policy-makers' court to propose some practical things for the industrialized nations to do.

ECO *Given the arguments being made about uncertainty of regional impacts and the need for flexible response, what kinds of measures can industrialized nations take on a collective basis before an overall international convention is negotiated?*

Yang Well, I think that collective action by the industrialized nations is both possible and needed. If we have learned anything from the process that led up to the 1987 Montreal Protocol, and its stronger revamping in London this summer, it's that fairness to developing countries is essential. For example, in trying to get the developing countries to take part in an overall agreement on greenhouse gas emissions, there should be an assurance of financial resources for them.

ECO *The notion of a fund for technology transfer has been raised before, what's different now?*

Yang The problem has been how to allocate the responsibility for paying the funds. There might be a straightforward way: on the basis of current use of fossil fuels. So, for example, think of a fund for technology transfer for energy conservation of $250 million per year. That's only 10 cents per tonne of carbon in the fossil fuels used by OECD countries. So the OECD countries, in proportion to their existing energy use, would help improve energy efficiency in the developing countries. That strikes a fairness chord in me.

ECO *The SWCC scientific report refers to cost-effective measures in the industrialized countries themselves, yet we hear that the draft Ministerial Statement does not even refer to the Toronto 20% target. And many countries, led by the US, seem to be avoiding even stabilization of emissions. Are the industrialized countries ready to reduce emissions?*

Yang I think the targets are useful to focus attention on the size of commitments needed. But they can't be applied to the developing world on a country-by-country basis. And even for the OECD, it's the emissions in total that need reducing now, not just country-by-country. So the next step would be to make contributions by OECD governments (say at 10 cents per tonne) tradeable, with a higher charge for fossil fuels used above the overall OECD 1990 cap.

ECO *That sounds complex and hard to administer. How would it work?*

Yang Well, the OECD use of fossil fuels in 1990 ends up in 2.5 billion tonnes of carbon. The US part is about 1.1 billion tonnes, so the US contribution to the transfer fund would be $110 million for its 1990 use of fossil fuels. Set an OECD cap at 1990 levels for 1990-2000. This is 'stabilization of emissions'. So if in 1995 the US emits 1.3 billion tonnes, it would pay into the technology fund $110 million, having bought (or traded with) other OECD countries the permits for the additional 200 million tonnes. They would probably cost the US more than 10 cents per tonne. But there might not be enough permits for these contributions because the OECD countries together might be exceeding their cap of 1990 levels. Then the higher charge, essentially a penalty surcharge, of say $5 per tonne would kick-in. So if there were no more permits available under the OECD 1990 cap, the US would pay into the fund for tonne, or another $1 billion. That wou[ld] would be a very powerful economic incenti[ve] for the country to reduce fossil fuel use, a[nd] yet the money would be going into ve[ry] worthwhile efforts.

ECO *Is this a practical possibility for [the] Ministers to commit to? And besides, the wa[y] you've described it, the stabilization target c[an] be exceeded, so maybe it isn't a cap at all.*

Yang I think your earlier question [on] administration is important. No kind of ca[p] or reduction target is going to be enforce[d] internationally by the threat of death o[r] criminal penalties! There will have to b[e] economic measures that will provide strong self-interest incentives. What better wa[y] than to use the existing abilities of the OECD and the IEA (International Energy Agency) to track fossil fuels use, and to have th[e] OECD collect the contributions on that basis. The tradeable nature of the permits mean[s] that each country can have a flexible strateg[y] but still have a strong incentive to go below 1990 levels of fossil fuel use.

ECO *Are the Ministers ready for this?*

Yang I think this approach addresses severa[l] issues at once: how to get funds today for the developing countries, how to allocate the funding fairly, how to get a meaningfu[l] OECD cap, and how to be flexible fo[r] individual countries. The Ministeria[l] delegations are probably looking fo[r] constructive things to do, following the pretty solid scientific consensus from las[t] week.

Quotes of the Week

"Reilly didn't feel it requires his time. It is largely a conference on climatology"
Bill Reilly's Press Secretary to Reuters, David Cohen, explaining why the US Chief Administrator to the EPA was absent from the SWCC

"As a scientist, I have no view or opinion as regards the position of the United States"
Professor Dooge, Chairman of the Organizing Committee, at the SWCC Press Conference

"It's like asking a parent how you treat your children — not that I'm trying to be paternalistic"
Professor Dooge, Chairman of the Organizing Committee, at the SWCC Press Conference

"I think we should say the Conference concludes that reductions are technically achievable"
Dr Al Gain of Saudi Arabia, in the last Science Plenary

"I think the Energy Working Group can live with that"

日本政府の皆様へ

日本政府の方々は、"ひとり当りの二酸化炭素(CO_2)排出量について2000年以後、概ね1990年レベルでの安定化"という目標を示したことで、第2回世界気象会議での任務は終ったと思っているようですね。

でも世界40数団体からジュネーブに集ったNGOの人々は、そうは甘く見てはくれませんよ。

環境庁が示した積極案を、産業界をバックにして省庁間で強い発言力を持つ通産省がつぶしにかかったあたりのことや、アメリカに歩調を合わせて環境庁長官を意図的にジュネーブに送って来ないことなどが、二本立てで内容に乏しい日本の行動計画とともにVilla Rigotで、盛んに話題になっているのですから。

技術力、経済力ともに指導的立場に立つ日本が、この2日間の閣僚会議でアメリカの顔色をうかがうことなく、私たち日本国民の声を反映させ、CO_2削減に向けて積極的に行動することを、世界のNGOとともに監視していますよ。

地球の友より

Keiko Ishikawa, FoE Japan

A Message to the Japanese Delegation

You seem to be quite pleased with yourselves and feel that your job is over at the Second World Climate conference because you have announced a target of stabilising "per capita" CO_2 emissions at the 1990 level after the year 2000. However, the more than 40 non-governmental organisations (NGOs) attending the conference do not share the same feeling with you in this respect. Recent talk among NGOs at the Villa Rigot has been focusing on the way in which the Ministry of International Trade and Industry (MITI), one of the most powerful Japanese ministries which has strong backing from Japanese industry, has crushed the very positive proposal put forward by the Environment Agency (EA), as well as the fact the Director General of EA has decided not to come to Geneva in order that Japan will appear to be sending a low level delegation like the US. The NGOs will be scrutinising your position very closely at the ministerial conference over the next 2 days to determine whether you listen to the voice of the Japanese people rather than keeping your eyes cast on the actions of the US, and if you will take a step forward towards reducing CO_2 emissions.

Friends of the Earth, Japan

Japan's Plan for Centralised, Nuclear Action

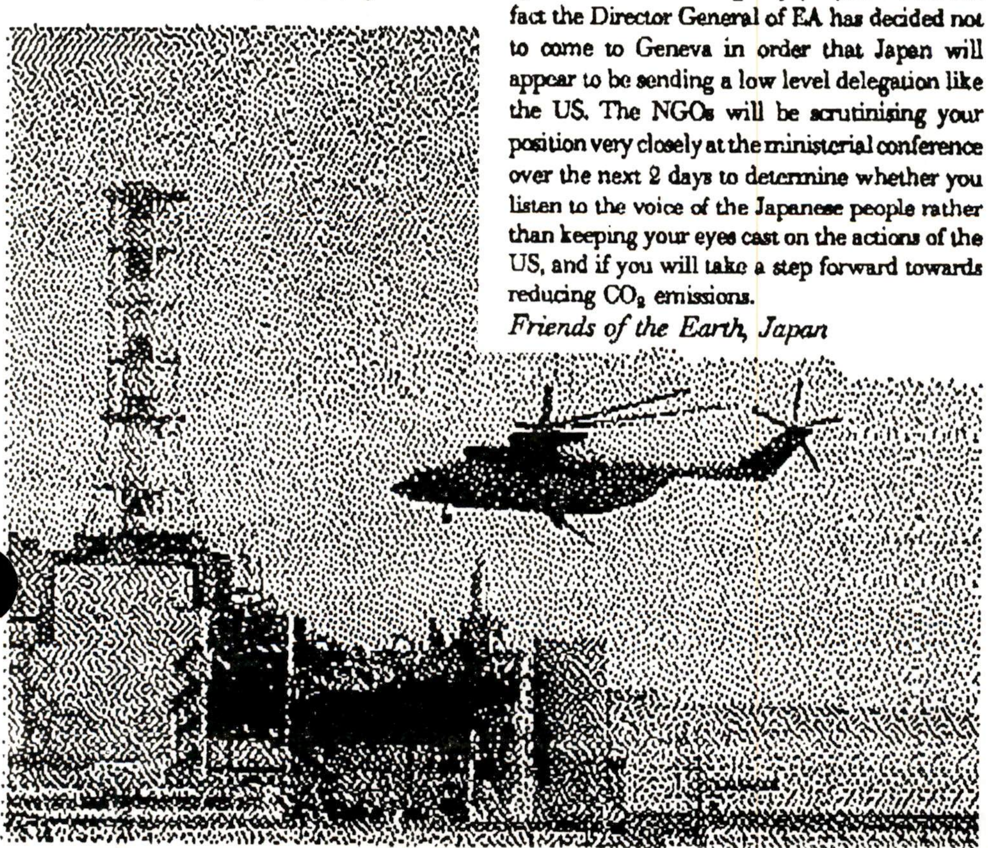
By Dwight Van Winkle, CASA Japan

On page 7 of its Action Plan to Arrest Global Warming, the Japanese government informs us that nuclear power is "an energy with no CO_2 emission." Perhaps Japan could share with the rest of the world their secret of materialising out of thin air completed nuclear power plants and fuel to drive them. Outside of Japan, people still have to expend a tremendous amount of energy, mostly provided with fossil fuels, to mine and transport nuclear fuels, to build and maintain the plants, to store radioactive wastes for the necessary thousands of years, and to decommission these plants at the end of their short life spans.

Japanese power companies plan to build 40 nuclear power plants within the next 20 years, doubling their number. In Japan, nuclear power is being billed by its supporters as a "clean energy" which will provide a solution to the problem of global warming. They obviously have not talked to the leukemia victims of Chernobyl, who probably feel differently about the cleanliness of radioactivity.

The recommendations of Task Group 4 (Energy) include nuclear power among energy technologies that reduce greenhouse gas emissions. The Japanese government must be happy with this inclusion. I suggest they read on, however. The Task Group continues, "new methods are required to identify the least-cost mix" of energy sources. "Such methods must reflect the full economic, environmental, and public health cost of energy supply and use." Face it, Japan. Even if your electrical utilities were able to overcome the strong public opposition to nuclear power in Japan and find sites for 40 new plants, nuclear power fails to meet each of these very clear criteria for least-cost planning, and should be rejected both as a source of further power and as a means of alleviating solution to global warming.

Also on page 7 of the Action Plan, Japan states that "the introduction of dispersed power generation, such as fuel cells and photovoltaic cells, should be encouraged." They had better focus their encouragement on the Japanese Energy Utility Industry Council, who announced in June in their long-term forecast of electrical power supply composition that dispersed power sources will account for only 0.5% of total electrical power sources in 2000, and 2% in 2010. Not a very optimistic forecast, and one which is likely to be self-fulfilling.



Left: Chernobyl — It couldn't happen in Japan?

Will Norway Increase Emissions of CO_2?

By Gunnar Bolstad

Norway plans to increase its emissions of CO_2 by 6%. The increased emissions will come from a gas powerplant located in the North-West of the country, near the city of Kristiansund. Environmentalists hope that Gro Harlem Brundtland now returned as Prime Minister, will stop the plan.

The Norwegian emission of CO_2 is 8.5% tonnes per capita. This is 4.5 tonnes more than the world average, despite the fact that 45% of Norway's energy comes from hydroelectric power.

In June of last year the Norwegian National Assembly decided that emissions of CO_2 are to be stabilised at the 1989 level by the year 2000. The State Pollution Control Authority has presented a cost-benefit analysis of CO_2 reductions, but at the moment there is no government plan as to how emissions will be stabilised at the 1989 level.

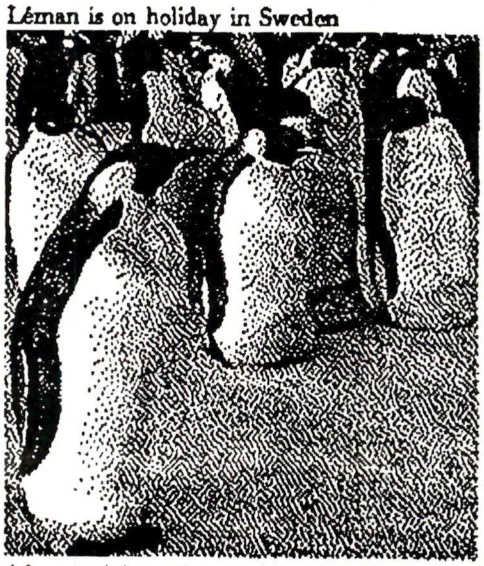
There are, however, plans to increase the emissions of CO_2 by 6%. A gas powerplant will emit more than 2 million tonnes of CO_2. The powerplant is supposed to provide energy for the metal industry, including the giant industrial company Norsk Hydro, which is partly state-owned.

Environment groups believe a much better environmental solution would be to export the gas as a substitute for oil and coal in the UK, or on the continent, where a gas power plant also can be utilised as a central heating plant, thus using the gas more efficiently.

Today there is an energy surplus in Norway and profitable saving potential of 20%, according to official estimates.

Léman

Léman is on holiday in Sweden



EFTA – continued from front page

Conclusions' does not amount to a binding or specific commitment. When asked at a press conference whether individual EFTA countries such as Sweden, Iceland and Finland had commited themselves to stabilisation of CO_2 emissions at present levels by 2000, Cotti was unable to answer. When asked if the net emissions of EFTA countries would stabilise, Cotti replied that "EFTA countries had no agreement together" and added that EFTA had no environmental remit, "environment does not belong in EFTA" he said.

Switzerland and Austria are publicly committed to CO_2 reductions but it is understood that neither Finland or Sweden are.

The EFTA/EC position invites 'all industrialised countries to take actions similar to those decided by the EC/EFTA countries and by certain other industrialised countries aimed at stabilising CO_2 emissions by the year 2000'. Following 'feasibility studies' programmes, strategies or targets for non-CO_2 greenhouse gases should be developed, adds the statement.

Eastern and Central Europe

The EFTA/EC Ministers also propose environmental cooperation in developing the European Economic Area covering both blocs, with 'policies based on the precautionary principle' in order to achieve 'sustainable development'. The Convention on Climate Change and 'legal instruments related to it, should be signed at the United Nations Conference on Environment and Development in 1992', while there needs to be closer cooperation with Central and Eastern Europe, says the statement.

The EFTA/EC position introduces the idea of applying the definition 'best available technology not entailing excessive cost' to development in East and Central Europe. It also calls for more use of 'economic and fiscal instruments' including pollution fees, noting that the next opportunity to discuss these at Ministerial level will be at the OECD Environment Committee in January 1991.

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US Claim – continued from front

Environmentalists accept that the C Air Act will bring real benefits but contras with briefings given by the Administratic US press, criticising other countries for ma similar claims about future work. Alden M of the Union of Concerned Scientists comme yesterday "The National Energy Strategy w Allan Bromley refers to appears likely t heavily weighted in favour of increased dom fossil fuel production and to largely over the tremendous potential for cost-effec energy efficiency improvements. He a "Allan Bromley claims that 'No other nat can make the claim that it will hold greenhouse impact at 1987 levels by the en the century but this is just not true. Europ countries and others that have committed stabilise their CO_2 emissions while also phas out CFCs will obviously realise signific reductions in overall greenhouse gas emissic The US, by contrast, will make no progress o the next decade in overall emissions reductior

Observers also contrasted the US cla which involves the so-called 'comprehensive 'basket of gases' approach, with the recen agreed Australian policy which specific excludes CFCs from a pledge to stabilise greenhouse impact in 2000 and cut it 20% 2005 (see SWCC ECO 1).

The EPA document acknowledges that CFCs are not included in the total greenho gas budget, total emissions in the year 2000 v exceed 1987 levels by approximately million metric tonnes of carbon equivalen Actual CO_2 emissions it notes, will be 1: above 1987 levels.

ECO's Who's Who: Guide to Environment NGOs present at the Conference – Adden

The Alliance To Save Energy, US – Bill Nit Greenpeace, Austria – M. Johann; Greenpea UK – Steve Elsworth; Norwegian Society Conservation of Nature – Gunnar Bolstad; U Association Youth, UK – David Allen.

Nitze – continued from front pa

emissions. Therefore the US refusal to acce CO_2 stabilisation must be based more ideology than on rational economic analysi

Split With Allies

"The White House has no appreciation of t international dimensions of this issue," Nit continued. "Continued US refusal acknowledge the seriousness of greenhou warming and the need for immediate action the face of growing scientific and politic consensus is driving a wedge between the U and its closest allies. Key developing countri have made it clear that they will not tal further action until the world's largest C emitter commits to reduce its own emissions. the US does not change its position soon," Nit concluded, "it will lose its credibility as a wor leader on the most important internation

INTERVIEW

with Giorgio Ruffolo, Italian Minister of the Environment

As Chair of the European Community Environment Council Giorgio Ruffolo steered Europe to its recent decision to stabilise carbon dioxide emissions. An Economist who wrote a book 'Social Quality' advocating a link between Ecological and Economic thinking over ten years ago, Ruffolo is now engaged in helping restructure Italy's policies to integrate energy with environment.

ECO How do you evaluate the recent European Community decision to stabilize net emissions?

Ruffolo Winning the commitment of the twelve countries of the European Community was really a success: I hope that it is a good basis for a wider approach at tomorrow's conference. I'd underline the importance of the fact that it was a joint European Community Council of Energy and Environment Ministers that took the decision — that was the first such meeting.

The principal commitment is to stabilise CO_2 emissions at 1990 levels by 2000. The important principle of burden-sharing was also introduced: those countries with large emissions and more advanced industrial development are to make greater reductions so that those with very small emissions and rapidly developing economies can increase somewhat. They have a less strict target.

ECO What about the UK position — does that disappoint you?

Ruffolo The UK stressed its 2005 date. That is included in the deal — implicitly. We insisted that the Community as a whole stabilise by 2000. A further important factor is that the European Commission must now present a Report before the 1992 Conference in Rio de Janiero, with proposals for reductions in 2005 and 2010. This is in line with the decisions taken at Bergen and Noordwijk.

ECO When will the Commission come forward with its proposals?

Commission to Make CO_2 Reduction Proposals to 2005 and 2010 'Next Year'

Ruffolo It will be next year: 1991. Another important part of the Luxembourg decision is the acknowledgement that fiscal instruments are very important. The Council of Ministers has taken note of that and the Commission will present particular proposals on a carbon tax before the end of 1990. That has been approved by a Resolution.

ECO How long will it be before Europe has a

Giorgio Ruffolo

Ruffolo That's impossible to say but while certain things are discussed for decades, these days we live in times when an issue suddenly changes within weeks or months and decisions are taken very suddenly, particularly on these environmental subjects.

In Italy particularly, within the past three years we have seen 'an acceleration of history' in this subject. Advances have been made in policies on National Parks, urban cities, rivers and seas. We started with the normative changes — laws, directives, and now we have concrete programmes of action. Now we are linking ecology and environment with industrial and economic policy: that is essential. The only successful approach will be to involve environment in economics and economic theory in environment policy.

ECO Do you think the EFTA countries will follow suit?

Ruffolo I think they substantially agree on the position adopted by the Community.

ECO There is an inter Ministerial Commission linking environment and energy in Italy, but the ten year energy plan which is to be reviewed annually, forecasts an 11% increase in Italy's CO_2 emissions by 2000. Is that to be changed?

Ruffolo Yes, we must eliminate this trend. For this reason the Italian Government is studying proposals from the Ministries of Environment, Energy and Industry, to revise the economics of the Energy Plan. This means more efficiency and curbs on emissions. We plan to introduce a tax on CO_2 emissions in 1990: a carbon tax. We must eliminate that 11% in order to stabilise in line with the European position. That means energy saving measures.

If I can put it this way, our train is heading towards the 'Cassandra Crossing': we must make a U turn, reverse the trend to avoid catastrophe.

ECO We featured the massive 600,000 petition recently handed to you by Lega per l'Ambiente asking for a 20% carbon dioxide cut. You said that was unrealistic, do you still feel that, even 20% cut is technically feasible and immedi[ate] action should be taken?

Ruffolo I haven't yet seen the Science Rep[ort] but I know there are other studies showi[ng] that a potential of at least 30% exists [in] carbon emission reductions in OECD countr[ies] — which are cost effective.

ECO I know you are interested in the issue [of] technology transfer: will you be putting forwa[rd] a specific plan on this at the Minister[ial] Conference?

Ruffolo Not a detailed plan but an approach whi[ch] I hope will be included: we must have [a] instrument, a Protocol which allows the transf[er] of technology and assistance from the develope[d] to the developing countries, in the Clima[te] Convention. It could be along the lines of t[he] provisions in the revised Montreal Protocol.

LETTER

Geneva, November 6th 1990

Dear Mr Cotti

You as chair person of the ministerial part o[f] the SWCC will have a most important role. Th[e] World is looking to the outcome of this conferenc[e] and we are very worried about its result[s]. Ministers will adopt a Declaration, which w[e] hope will call for immediate action, CO_2 reduction by industrialised countries and a strong globa[l] convention on climate change. The Scientists o[f] SWCC clearly concluded that there is a scientifi[c] consensus on global climate change, on th[e] necessity to act now, notwithstanding existin[g] uncertainties, because impacts on ecosystems an[d] societies are considered to be unprecedente[d]. They also concluded, that CO_2 emission reduction of 20% by the year 2005 are not only feasible bu[t] also cost-effective foremost of the industrialise[d] countries. Your job is not an easy one — becaus[e] you will not only have to chair all the statement[s] of heads of State, ministers and delegates, but you will probably also have to chair the discussion o[n] the Ministerial Declaration. This Declaratio[n] looks to us more like a non-declaration as all the crucial points on CO_2 reduction targets, dates and the urgent call for immediate action have been removed from the original draft by the negotiators over the weekend. It has to be made sure that the ministers and negotiators really take note of the recommendations of the scientific community and take their responsibility to reduce CO_2 emissions in all industrialised countries. The EFTA and EC countries have to fulfil their commitment to keep these crucial points in and do their best. There are also still problems with square brackets... You see — there is still a lot to do. But we are positive that you, as the Swiss Minister for the Environment and chairman of this conference will do your best. We wish you good luck and all the best — the people of all over the World are looking to this conference and to the ministers to take active steps to solve this global problem. Let's try to give them hope.

Very sincerely yours

.eco

Daylight Robbery

A strange thing happened to the SWCC scientific statement on the way to the Palais. It disappeared. Ministers will not have it to hand.

The draft ministerial statement makes no reference whatsoever to the scientific statement. At the end of the Sunday night — Monday morning marathon session, the political representatives could not even agree to it going before the ministers as an appendix to their report. The civil servants seem happy to let their politicians work in a scientific vacuum.

This means that the politicians will not know that when they argue over action to *stabilise emissions*, the scientists talk of the need to drastically reduce emissions to *stabilise* atmospheric *concentrations*. Politicians are minimising action while the scientists call for minimising risk.

Politicians will talk of "no regrets" policies; unaware that the Science Report states that the risks of climate change justify reductions in emissions. Politicians will not know that the conference concluded that technically-feasible cost-effective measures exist to reduce carbon dioxide emissions in all countries.

Push Comes To Shove

For years environment groups have criticised the retrograde positions of countries such as the US and UK. At this conference, together with its oil allies, the United States has disgraced itself once again. The UK has been able to hide cuts under the European Community's CO_2 umbrella. But none of these 'villains' are feeling any real pressure. Why? Because, with the honourable exceptions of a few countries such as Australia, New Zealand, Austria and the Netherlands, supposed environmental leaders have backed away from commitments.

It is difficult to get used to the idea that Germany has got 'sticker shock' and dropped its highly moral commitment to tropical forest conservation, now that it sees it will cost real money. Hence the German delegation sat silent as mention of a forest protocol was cut from the draft declaration. And Sweden, host of the 1972 Stockholm Environment Conference, will not commit itself to stabilise CO_2 by 2000. Sweden's name only creeps into the draft list of 'committed' countries by the insertion of the weasel phrase 'aimed at' stabilisation. Hence too, the bizarre twists and turns of the EFTA/EC statement which does not amount to a commitment to stabilise, only a vague wish to do so.

Carlo Ripa di Meana claims that '18 countries of Europe' now lead the world, and that a battle is about to start. But Europe isn't shooting. The Swedes and Germans have prepared a white flag. When push has come to shove, these so-called environmental leaders have let domestic political pressures (Sweden's problems restructuring its energy policy, and Germany's need to finance the old east), push the planet's interests aside.

Fortunately for today the Ministerial Declaration remains a draft. By tomorrow we will know if the Europeans have let the US and others off the hook by agreeing a document with no firm CO_2 target, no energy protocol, and hence (as Brazil then objected), no forest protocol. If this is the future greenhouse realpolitik, then Europe is throwing away its influence as well as its reputation.

OPINION AND ANALYSIS — JAPAN

CO_2 and Japan: A Freeze is Not Enough

by Stewart Boyle, Energy and Environment Programme Director, Association for the Conservation of Energy

Japan is the most energy-efficient nation in the world, has half the per capita carbon emissions of the USA, and "the development and diffusion of energy-saving technology has already run its course". Well, at least this is the case promoted by the Ministry of International Trade and Industry (MITI) in Japan. The truth is somewhat different. Faced with pressure from its Environment Agency and international public opinion, MITI has brought down the country's proposed CO_2 stabilisation target from 16%, to 9% and finally to something between zero and 6% (such is the ambiguity of their recent target announcement - see Léman, ECO no. 6, 5 Nov). Though a welcome first move, there in fact remains a significant energy and CO_2 savings potential throughout the economy.

In the electricity sector, huge forecasts requiring nearly 100GW of new coal, gas and nuclear plant by 2010 largely ignore the potential for demand side efficiency improvements in electrical appliances, lighting and drive motors. Unlike more progressive US utilities, least-cost planning techniques which allow utilities to sell energy conservation and hold or reduce demand, are nowhere present.

In the transport sector, fuel efficiency improvements have reversed since 1983, aided in part by a repeal of the tax system which encouraged smaller, more efficient vehicles. In the face of rising car ownership and congestion levels, new initiatives on fuel efficiency standards, gas guzzler taxes and further investment in mass transit, are needed.

In other sectors, there has been a stalling of efficiency standards, and the building stock has low efficiency levels in lighting, air conditioning, and insulation. There has also been a significant falling away of public awareness and industrial priority on efficiency due to lower oil prices since 1985.

The recent Gulf Crisis is a reminder to Japan (and the US) that energy efficiency programmes have to be sustained, and directed at sectors other than just industry. Importing 99.6% of its oil, half of which comes from the Gulf of Hormuz, it is a nation which is highly vulnerable to external events such as fuel wars. Between 1973 and 1986, Japan reduced the amount of energy needed to produce a unit of economic output by 34%, better than any other nation. Japan could increase the energy services available to its people significantly in future, without reducing CO_2 emissions. A recently published study by the Royal Institute of International Affairs in London demonstrates that, with more realistic 'business-as-usual' energy forecasts, a greater emphasis of energy efficiency, fuel switching to gas and renewables, CO_2 could be reduced 7% by 2000, 10–20% by 2010, and 25–40% by 2030. The attainment of such reductions would keep Japan at the forefront of technological development. They would also reflect a more honest appraisal of the technical and cost-effective potentials than the current near-freeze in CO_2 target suggests.

FOCUS on Eastern Europe

Introduction

by Reinhold Pape

Hundreds of delegates from Western governments, aid agencies and environmental groups have visited Eastern Europe countries during the last months, yet experts in Poland say that only 5–10% of these visits have resulted in concrete assistance. 'Help' to Eastern Europe has become a 'big business', with big promises but very little real assistance. So far, the millions of US$ given to the Bush-Center in Hungary has mainly been spent on expensive renovations and Italian furniture.

From the 2 million SEK raised in Sweden for a so-called Wistula Project, not a single crown reached Poland. It stayed in the pockets of Western consultants. Big promises concerning the so-called 'Debt for Nature' also failed. But now there is news about hazardous waste sent from the west to the east.

It really is time for Western organisations to start listening to the real needs of Eastern Europe and to respect the opinions of Eastern Europe's new NGOs. Below are some examples of what the environment movement in Eastern Europe is aiming at to do on the environment policy level: A second part of this special focus appears in tomorrow's ECO.

Position Statement of Central and Eastern European NGOs present at the SWCC, November 5, 1990

Due to recent political changes Central and Eastern European NGOs are the first time present in the joint work of representatives of science, policy making, industry, governments and NGOs working together.

Having attended SWCC we support the recommendation of the Conference that "nations should now take steps towards reducing sources and increasing sinks of greenhouse gases through national actions and negotiation of a global convention on climate change" to minimise "risks to society and natural ecosystems".

We want to have "accurate public information" on climate issues as well as "to participate fully in the free exchange and flow of information necessary for the devolopment and technical input" of any convention which coincides with the interest of this region.

On this basis the newly liberated Central and Eastern European nations should be ready to cooperate with those already working on both the assessment of global warming and the strategies for addressing it.

However, for policy implications there is a need to realise that these countries have a special stance. Speaking of the special needs of developing countries and of differentiated responsibility of the industrialised and the developing countries the conference statement points out that "the problem is largely the consequence of past patterns of economic growth in the industrialised countries". But this is not the case with the countries in Central and Eastern Europe.

Devastation of the environment, and, among other problems, accumulation of greenhouse gases in this region, had causes other than economic growth. These nations were blocked by force into a counterproductive economic system by now bankrupted. Central and Eastern European countries, notwithstanding their cultural and political potential, may suffer from a double burden: after the social and natural resources have been misused by totalitarian regimes for decades, these countries are now facing a possible environmental colonialisation by industrial firms seeking an extra profit both from cheap labour and from the inadequate environmental legislation.

Central and Eastern European nations should be given special attention as we are not industrialised, neither do they share most of the problems of the developing countries.

It is true that we have suffered from the lack of financial resources, an overused infrastructure and a fragmented flow of information. But we have neither a population nor a food problem.

These countries have a hidden potential:

- a — somewhat limited — tradition of parliamentary democracies;
- that of a liberal economy;
- a homogeneously distributed school achievement;
- a legacy of universities and learned societies at least 600 hundred years old;
- and the remnants of a civil society still existing in collective memory

These capacities are there. They need no establishment, only revitalisation. This hidden potential, if properly managed and supported, means these nations will soon be able to catch up with industrialised countries with a better environmental performance — therefore they may contribute to tackling global problems, too.

It should be noted by the ministerial session, that according to the NGO statement to SWCC, November 1, 1990 "The economic restructuring currently occurring in Eastern Europe presents a critical opportunity to introduce energy-efficient technologies that will benefit both the environment and the economies of these countries."

Work on energy conservation in this region will fulfil the recommendation of the SWCC that "Many of the actions that ... risk are also desirable on other grounds."

The community of environmentall[y] responsible countries should help these newl[y] and freely elected, still vulnerable government[s] to find environmentally sound ways of managin[g] their economies. This kind of investment ma[y] bring short-term returns both nationallly a[s] well as on a globally.

The support should come in the form o[f] special policies, conventions, codes of industria[l] behaviour to stop environmental exploitation and a transfer of know-how to rationalise, or swaps of nature-for-debt. Any differentiated policies should meet the ambition and the efforts of these nations to cope with their difficulties, to re-enter into the European community as well as to run a less polluted economy and work on a healthy and effective society.

Jadwiga Taylor Rusworth,
Social Ecological Institute, Poland
Dr Judit Vàsàrhelyi,
Independent Ecological Centre, Hungary
Igor Halama,
Green Circle, Czechoslovakia

Black Triangle – Time for Action

by Reinhold Pape

Alarming news has reached the public in recent years about the degradation of the environment in Central Europe in the border region of Czechoslovakia, Poland and East-Germany. Here the effects of heavy pollution have not only become obvious by destroyed forests and landscape but also by its direct influence on human health. Life expectancy is in some parts of the region 4-5 years lower than the average and scientists believe that the causes are the polluted living-environment. The region is called the 'Black Triangle' because here the basis for the energy production of the 3 countries is abundant - brown coal, which is burned in large coal power stations, heavy industrial plants and in communal heating without any cleaning of the exhausted gases and dust.

The region is also typical of a very old and insufficient heavy-industry structure without any environmental protection measures and which have caused strong local environmental protection measures and which have caused strong contamination of soils, vegetation and food products. Environmental groups from the three countries are now preparing for a campaign to get national and international attention in order to solve the problems of this region. This month they issued a 'Black Triangle Declaration'

SECOND WORLD CLIMATE CONFERENCE NGO NEWSLETTER

eco

5 NOVEMBER

NEGOTIATIONS ISSUE

Eco has been published by Non-Governmental Environmental Groups at major international conferences since the Stockholm Environment Conference in 1972. This issue is produced cooperatively by groups attending the Second World Climate Conference 1990

TAKE IMMEDIATE ACTION SAY SWCC SCIENTISTS

By ECO Staff

More than 700 scientists from 120 countries yesterday released the strongest warning of its kind yet delivered to the world's politicians, when the Second World Climate Conference reported on its scientific and technical sessions at Geneva.

The scientific Report which is presented to Ministers meeting this week, goes much further than the Intergovernmental Panel on Climate Change which is in effect its predecessor, in calling for countries to take 'immediate action' to reduce risks of climate change, 'concluding' that 'technically and cost-effective opportunities' exist to reduce CO_2 emissions from many industrialised countries, and that 'remaining uncertainties must not be the basis for deferring societal response'.

The report reflects an even stronger scientific consensus than the IPCC that action on the greenhouse effect is justified, stating: 'a clear scientific consensus has emerged on estimates of the range of global warming which can be expected during the 21st Century. If the increase of greenhouse gas concentrations is not limited, the predicted climate change would place stresses on natural and social systems unprecedented in the past 10,000 years'.

It adds: 'This conference concludes that, notwithstanding scientific and economic uncertainties, nations should now take steps towards reducing sources and increasing sinks of greenhouse gases... with the long term goal of halting the build-up of greenhouse gases at a level that minimizes risks to society and natural ecosystems'.

It also warns that because natural feedbacks which will increase global warming have been

– continued on back page, col 3

Pacific Summit: Bush 'Rejects' IPCC On Sea Level Rise

Sea-level rise is so uncertain that it poses minimal concern, President George Bush is understood to have told leaders of Pacific Island states last week. Bush addressed 10 Heads of State at an environment summit called to discuss global warming and the US facility to incinerate chemical weapons on Johnston Atoll.

The leaders pointed to the findings of the IPCC on sea level rise, and were perplexed when Bush rejected them, saying "My scientists are telling me something different to that".

News of the Bush statement has sent a wave of dismay through members of the US scientific community who were involved in the IPCC process. At the Second World Climate Conference Mr Jim Bruce of the Coordinating Committee

– continued on back page, col 1

US, USSR, SAUDIS GUT MINISTERIAL STATEMENT

By ECO Reporter

On the eve of the Ministerial portion of the Second World Climate Conference, the US, USSR and Saudi Arabian delegations led successful moves to gut a draft of the statement to be adopted by politicians who start a [illegible] day meeting today, Monday.

Yesterday, at the same time as their scientists delivered a report saying immediate action should be taken on climate change, the major oil producers proposed deleting key sections on targets and dates for reducing greenhouse gases, from the draft Ministerial Statement. In negotiations taking place in the United Nations

USA, supported by Canada, succeeded in removing reference to the 'Toronto Target' of a 20% cut in CO_2 emissions by 2005, adopted by a major conference in Canada in 1988.

"Speaking as a Canadian, I am ashamed at the complicity in helping the US water down the Ministerial declaration" said David McRobert of the Toronto-based Pollution Probe group. "The United States has turned its back on science — including its own researchers — and is working with the fossil fuel industries to block any meaningful action by the Ministers" said Alden Meyer of the US Union of Concerned Scientists. "It's appalling that the US has taken

CONTENTS

Two Views on Science and Policy

Today, ECO carries two interviews with two of the major scientific figures involved with climate change issues, Professor Bert Bolin, Chairman of the IPCC, and Dr Stephen Schneider of the National Center for Atmospheric Research, who has worked on analysing the significance of climate models for some 15 years.

INTERVIEW

with Stephen Schneider

of the National Center for Atmospheric Research in Boulder Colorado

"We've detected about an 0.5°C rise during the twentieth century record. That's certainly not a normal fluctuation — you might expect a century like that once in a millenium but it's certainly far less than even odds — a 50% probability — that it would occur by chance.

So we can already argue that something unusual has occurred."

"It's not a 'scientific certainty' in [the] sense of a traditional 99% probability — but what makes 99% appropriate for policy making?"

"Corporations spend trillions of dollars on the basis of economic estimates with no more than a 50% probability. Why should the science community demand a 95% or 99% probability before their findings can be used to inform decisions? It's elitism of the worst kind."

"I like to say if there is a coin flip probability — 50:50 — of unprecedented global climatic change actually occurring, and that there is a 1 in 10 chance — Russian Roulette odds — of it turning out to have catastrophic impacts, then that's more than adequate to say we should slow down."

"...when you treat the environment as a sewer, something eventually stinks."

***ECO** What is the most important scientific development being reported at the Second World Climate Conference*

Schneider I don't want to be cynical but in truth there's very little that's scientifically new. Three main 'scientific' events have caught world imagination in the last decade. The discovery of the ozone hole — though not directly related to global warming served as a symbol of the fact that when you treat the environment as a sewer, something eventually stinks.

Secondly, there was the rising temperature trend — the record warm years in the 1980s. Of course, one record warm decade does not a greenhouse prove but the momentum of public opinion would have been much the less without it.

Thirdly, for the last 10 years the modelling community has worked its tail off trying to disprove the predictions of warming caused by greenhouse pollution, and has failed to do so. Nothing has really shaken the prediction of a 1.5–4.5°C rise with doubling of CO_2 or equivalent. More recent models suggest 1.9–5.2°C. Without feedbacks they suggest 1.5°C.

***ECO** You published a table showing the time probably needed to resolve uncertainties. Do decision-makers understand the scientific process?*

"Smoking Gun"

Schneider Consensus on the magnitude of the temperature effect is not only based on the models, it also depends on the temperature record, as Tom Wigley showed in the only original piece of climate science I saw presented at the meeting. We've detected about an 0.5°C rise during the twentieth

fluctuation — you might expect a centu[ry] like that once in a millenium but [it's] certainly far less than even odds — a 50 probability — that it would occur [by] chance.

So we can already argue that somethi[ng] unusual has occurred. It's not proof of cau[se] and effect, but certainly the fact that it h[as] coincided with increasing greenhouse g[as] emissions and is within the expected rang[e] of the models, is suggestive. Intuitively, [to] me, it's close to a smoking gun.

The 99% certainty that scientists lik[e] before having high confidence will indee[d] take a decade or two more to achieve.

"Elitism of the Worst Kind"

***ECO** Do you think the generally understoo[d] 'criteria' of scientific proof are really ver[y] useful in dealing with such an issue?*

Schneider It's not a 'scientific certainty' in the sense of a traditional 99% probability — but what makes 99% appropriate for policy making? People make decisions to get medical treatment or to buy health insurance for potential problems that are not established beyond doubt. Why should science be any different?

Corporations spend trillions of dollars on the basis of economic estimates with no more than a 50% probability. Why should the science community demand a 95% or 99% probability before their findings can be used to inform decisions? It's elitism of the worst kind.

I'm not saying we should exaggerate probabilities. What I do believe is that scientists should not claim they cannot talk to the public until there is a 95% probability — especially not as they rely on public funds.

***ECO** Is the scientific community getting its message reported properly?*

Schneider Scientists are human beings. They hold world views. Mine is that we must take global collective action to help the world survive. Uncertainty by itself is no excuse for inaction. Others shed their scepticism at a higher degree of certainty than I do. I like to say if there is a coin flip probability — 50:50 — of unprecedented global climatic change actually occurring, and that there is a 1 in 10 chance — Russian Roulette odds — of it turning out to have catastrophic impacts, then that's more than adequate to say we should slow down.

Some others view 'world survival' as an abstract entity and regard their 'scientific purity' as most important. They fear society will resent them crying wolf if they turn out to be wrong. So they say nothing. Many scientists in fact make this decision without realising it is a value judgement.

Unlike journalists who lead with a headline, scientists lead with their caveats.

while others take the 'world citizen' view, and describe dangerous possibilities.

But I think we don't require proof of scary scenarios to convince the world to take action. We need to attach odds to the various possibilities. I believe that suppressing a dangerous or scary possibility is as irresponsible as putting out a scary scenario without odds. If I'm only 10% certain that there's botulism in tonight's soup, that's enough to stop me from trying it. I don't need 99% probability.

Some lobbies or governments are parading an unrepresentative series of people with extreme views to mislead the public. They claim that the science is totally uncertain, but they never give any probabilities. That's misrepresentation.

"Does it really matter if there is a 10% or 50% chance of catastrophe?"

ECO How do environmental groups perform?

Schneider Unfortunately, some are like Sununu: they take things out of context or forget to mention odds. Everybody should tell the story probabilistically. The truth is bad enough. Does it really matter if there is a 10% chance of catastrophe? or 50%? We're not talking asteroid-collision-with-the earth odds here — its not as if there's only a thousandth or a millionth of a percent chance that a climate catastrophe will occur. We don't need to claim certainty for the evidence. That's only an invitation to discredit us.

Some in industry have been spreading confusion since the events of 1988. In the US some have used full page newspaper adverts to do so, making it no longer politically safe for most politicians to talk about the need for carbon taxes. They are raising what appear to be fundamental new questions about greenhouse science, but in fact they largely flaunt well known uncertainties. They are beating us with our own caveats and pretending they invented them.

The public often falls for it because they misunderstand the nature of the scientific process, debate and doubt. The media enjoys polarised debate because they like a conflict. Politicians can use the debate as they like.

ECO Would you comment on President Bush's position?

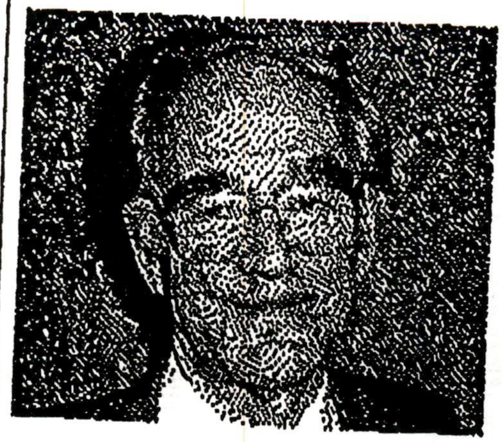
Schneider I suspect that his Chief of Staff John Sununu doesn't let a representative spectrum of climate scientists get near the Oval Office. The President apparently only hears unknowledgeable or extreme people. Neither Bolin nor Hansen nor myself have spoken with him. I doubt he gets balanced information on global warming or he'd join the Margaret Thatcher, and other 'conservative' leaders, who counsel at least some immediate action to counter the greenhouse effect.

● *Dr Schneider is author of Global Wa...*

INTERVIEW

with Professor Bert Bolin

Chairman of the IPCC



"We don't understand the carbon cycle adequately today. We can only account for where about 80% of the emissions go.

How can we be sure that the same fraction will stay in the atmosphere? If 50 or 60% stays in the atmosphere of a warmer world, that will mean concentrations rising at twice the present rate. I think it is most likely that accumulation will go more quickly in future than less quickly."

ECO You have received a prize for your work during this Conference, and have become an international public figure as a result of your work with the IPCC: what do you feel about that?

Bolin It's unimportant what I feel as an individual — I do feel very engaged in the issue. Engaged in trying to steer a way between extremes on either side of the argument in this business.

ECO The science-policy interaction seems a very difficult area: Working Group I's report was very well received, II and III less so, do you think there is now a problem with communicating the nature of uncertainty to people?

Bolin All three Reports were well received. There is naturally a tendency among researchers to talk about their own research and to interpret it in terms of policies. That is a major step and many don't recognize it. A single scientific voice is not very important. It may even be counter-productive.

I'm not saying that scientists should keep quiet but it is important to sift out what we really are able to say with certainty, with...

"Journalist Problem"

ECO Is there a problem with journalists wanting to hear about what we don't k... even though that may in itself be impor... scientifically?

Bolin Journalists are a major problem. V... major. I recently gave a long interview t... daily newspaper in Sweden and the journa... then talked with Professor Budeko, who s... that he thought a warmer world would b... better world. She wrote that, and it is corre... he does think that. But that was all she wro... which was very misleading. They take a sm... point and make that seem to be 'the issue...

Journalists put about wild exaggeratio... which naturally scare people. There may b... an utterly small chance that things turn o... in such a way. We don't need to scare peopl... instead we must bring home to them that w... face a serious issue in the future developmen... of our world, and set in train a process c... collaborative action, involving those wh... have influence.

"30–40 Years"

ECO what about environment groups, what do you think of their work?

Bolin Generally they do a good job but there are a lot of battles going on over issues that are not of central importance. From the 'green' side there are many — and I admire the engagement of those people — who create such battles. How would one go about convincing people to take real action to reduce their CO_2 emissions for example. That is a practical question, and one which extreme green groups do not want to address.

Drive the car less, economise on heating but what else can you do? Very little: we have built a society which depends on cheap energy — you can't change that in less than 30–40 years.

If you ask 100 people in the US if they would do the things really required to achieve the reductions described in Working Group I, 90% would say no.

No single country would accept those things in the next 10 years.

Severe measures would also create unrest and conflict: then what has been achieved? Politicians who advocate such measures will get kicked out of office. Greens ignore that aspect of the problem.

ECO The conference has heard a lot about feedbacks: which do you think is likely to be the most important?

Bolin The most important is water vapour. That is crucial and work on it is reasonably well in hand.

The surprises I referred to earlier this week involve CO_2. Concentrations in the atmosphere ...

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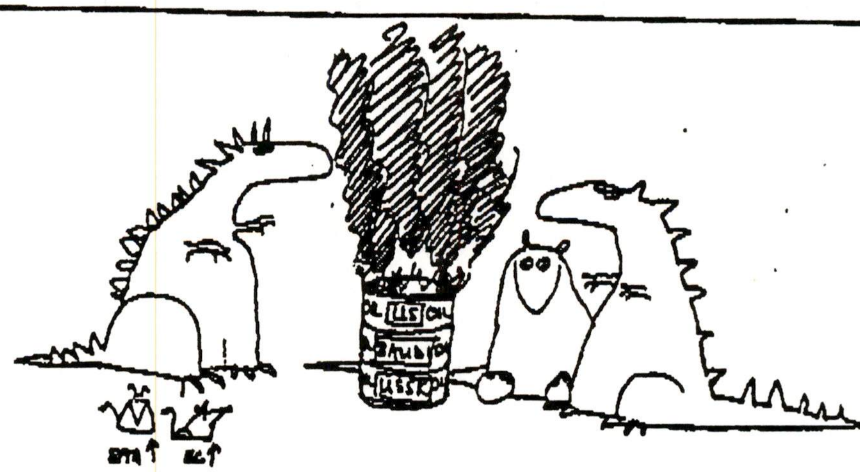
SEE NO LIMITS, HEAR NO SCIENCE, TAKE NO ACTION

The 747 scientists who penned the Science Report of the Second World Climate Conference have left politicians with little choice. They have called for immediate action. They have concluded that carbon dioxide reductions are technically (and economically) feasible, and proposed a cut of 1-2% a year. They have, most significantly, ruled out uncertainty as a justification for 'societal delay'.

The SWCC Science Report is a highly significant document. Twice as many scientists contributed to it as to the IPCC, and it reaches firmer, stronger conclusions, after taking on board the IPCC itself. It introduces the important priority of taking action to limit greenhouse pollution at levels which will prevent serious damage to human society and to ecosystems. For making that link we must thank the scientists who contributed to the Stockholm Environment Institute Report.

SWCC scientists may think there is no longer justification for delay but 'societal' means societies and although the people may share the scientist's concern, in practice it is governments who must act. Yet before the ink was dry on the science report we witnessed the unedifying spectacle of negotiators ignoring the science and preparing to do nothing, by gutting the draft Ministerial Declaration to remove talk of targets and dates. The US even enlisted Canada's help to try and trick the world into double-counting CFCs already controlled under the Montreal Protocol.

The US, USSR and Saudi Arabia, are



AS THE SECOND WORLD CLIMATE CONFERENCE DRAWS TO A CLOSE, DINOSAURS WARM THEIR PAWS AROUND THE SUNUNU CAMPFIRE

coal interests. All the computer models in the world will not make a Swiss Franc of difference to governments who simply want to sell all the oil the world can be persuaded to buy. Simple greed is now coming out in the open.

When science provided what sounded like convenient uncertainties, Mr Bush and his camp followers demanded more science. Now science is just being ignored. Other excuses will be cooked up on Mr Sununu's ca[mp] fire. The US, USSR and Saudi Arabia [are] like the three monkeys: see no lim[its,] hear no science, take no action.

The oil nations are industr[ial] dinasours that the world cannot affo[rd.] Environment groups only half jokin[gly] refer to them as the 'forces of darkne[ss'.] If they are allowed to succeed, it co[uld] be the midnight oil that they [are] burning.

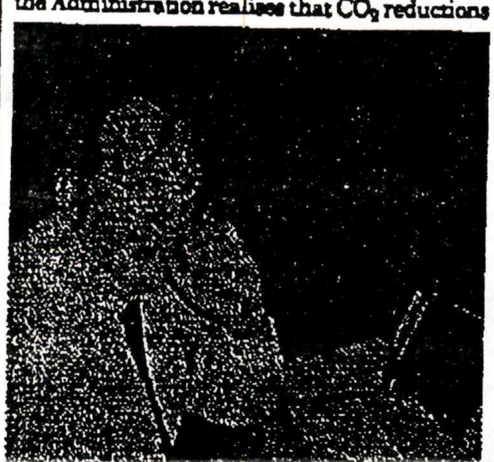
OPINION AND ANALYSIS

CO_2 Stabilisation Would Serve the US National Interest

By Brooks B. Yeager, Legislative Director, Audubon Society

The actions that would be required to stabilise US CO_2 emissions would have considerable economic benefits which could help overcome the nation's serious economic problems. It would improve American oil security, help reduce the deficit, and strengthen the economy in world trade.

Yet as I write these words, there is no sign the Administration realises that CO_2 reductions



are an opportunity not a problem. True, the [US] has real problems.

200,000 American soldiers are now encamp[ed] in the sands of Saudi Arabia, readying themsel[ves] for a conflict over the stability of a maj[or] portion of oil supply. The US economy [is] grinding to a halt, with analysts predicting th[at] a severe recession may now be underway. T[he] dollar seems to be in a chronic fall in curren[cy] markets, reflecting the declining position of t[he] US in world trade. The Congress has on[ly] recently returned home for the November General Election, and although Democrat[ic] leaders and the President managed to patc[h] together a precarious budget deal, nobod[y] believes the compromise will actually cure th[e] long-term Federal deficit.

Meanwhile, the White House is steadfastl[y] refusing to commit to any date by which it wi[ll] stabilize CO_2 emissions, and US negotiators a[t] the Second World Climate Conference Ministeria[l] talks are blocking international calls for CO_2 action. The White House derides stabilization implying it will be difficult to implement and that the cost impossible to support.

rejecting the only long-term economic strategy that could really contribute to the gradual improvement of the economy?

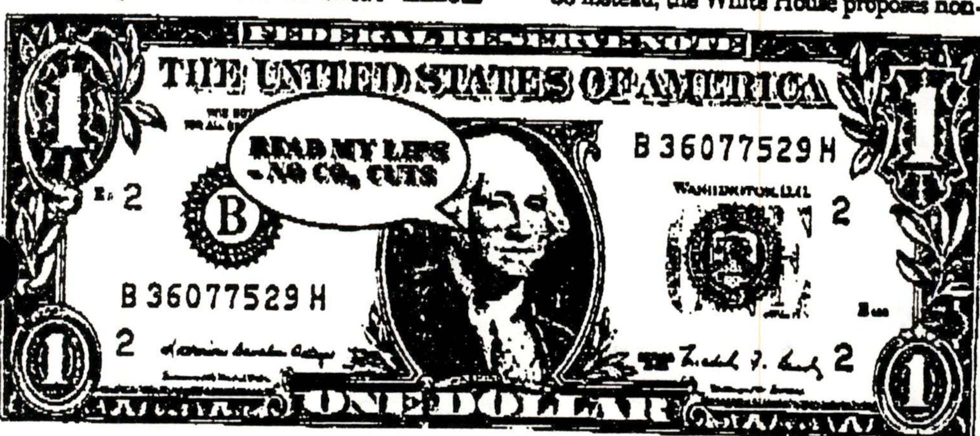
A multitude of national economic studies, some of them funded by the US Government, now demonstrate the achievability of stabilization of CO_2 emissions at 1990 levels, at no economic cost. Such a program, which would, for instance, involve encouraging industry to achieve new process efficiencies, require greater automobile fuel economy, and facilitate the introduction of energy efficient appliances in the marketplace, would actually result in consumer savings totalling billions of dollars.

Because many of the savings would occur in the oil-greedy transportation sector, they would also contribute to the nation's long-term oil security, and lessen America's anxious dependence on the Persian Gulf. Incentives for corporate investment in energy efficiency, such as conservation investment credits, could help the wasteful US industrial sector regain some of the efficiency ground lost in Japan and Germany, both of whom seem to have concluded that meeting the challenge of climate change can be economically beneficial. A phased-in carbon tax, could encourage a more realistic market response for renewable sources of energy, perhaps even reviving the failing US solar industry, making another substantial dent in the deficit.

Non-Solutions

For the current resident of the White House, these multiple opportunities apparently look like threats. To support fuel economy, Mr. Bush would have to part ways with General Motors, Ford, and Chrysler. To impose a carbon tax, he would have to take on the coal industry, still licking its wounds from the Clean Air Act. To approve new regulatory standards, he would have to run against the traditional Republican abhorrence of government interference with the "free market."

So instead, the White House proposes non-solutions. For oil security, drill the Arctic National Wildlife Refuge. For the deficit, raise taxes on beer, wine, and gasoline (but only five cents, mind you), and income taxes on the middle class. For our trade position... well, there simply aren't a lot of good ideas there. And for the climate? Do nothing, and hope the weather doesn't bite back.



NOT JUST A HORSE RACE

On Tuesday 6 November, up to 100,000 people are expected to gather, discuss and speculate on the outcome of an event of great uncertainty. Those gathering will be representing millions of their countrymen and women also interested in the outcome of the vent. The focus of speculation is the annual Melbourne Cup, a rich Australian horse race, run over 3,200 metres and with 21 starters.

Despite scientific assessment of power, carrying capacity and endurance, etc., the outcome cannot be predicted with confidence. In spite of claims of divine guidance or extrasensory perception by some, all who speculate are, in truth gamblers attempting to reduce the odds using a mixture of crude calculation, perception and the advice of spivs and touts of the horse-racing fraternity. At the end of the day there will have few winners and ...

of the global community will also be assembling. Their charter will be to speculate on the Race for Life. Without divine guidance, extrasensory, expertise in the physical dimensions of the problem they will be relying on the spiv and touts of the scientific community.

As with any horse race, the Race for Life is altered by human intervention. The stewards in Geneva will be meeting to find a common objective and to develop strategies that might be adopted to meet that objective.

Although idealism would have us hope that the stewards would alter the course of events such that we would all be winners, this is an impossible dream. However, if as the Race for Life unfolds human intervention directed by the stewards, perchance, produces an increasing proportion of winners, then the gathering in Geneva will be

THE VIEW FROM TUVALU

AN ARCHIPELAGO HAUNTED BY SEA LEVEL RISE, THE MALDIVES

By Abdullahi Majeed, Maldives Director of Meterology

The Republic of Maldives lies in the equatorial calm of the northern Indian Ocean. The Maldives is an archipelago of 1190 small coral islands, most of which barely rise more than two metres above mean sea level. The country has a population of a little over 200,000. Two hundred islands are inhabited, with a total land area of 298 square kilometres strung over 90,000 square km of sea.

The Maldives had its first experience of global warming and sea level rise when almost one third of the country was hit by a tidal wave in April 1987. Malé, the capital island, which houses a quarter of the nation's population, suffered the worst of the ordeal. One fourth of the urban land was inundated by the salt water and 30% of the land reclaimed during the last seven years was completed washed away. The nation's sole international airport sustained extensive damage to its physical infrastructure and installations.

President Maumoon Abdul Gayoom of the Maldives brought the issue of the rising sea levels to the Commonwealth Summit in Vancouver 1987 and to the United Nations Conference on Environment and Development in 1987.

In November 1989, the Maldives hosted a conference on sea level rise among the small states of the world which are the most vulnerable to the phenomenon. The country is also mounting a campaign of public awareness among its citizens.

For a country like the Maldives, the IPCC projected sea level rise of one metre will be disastrous, if not fatal. We, like some other small island states would like to see all the countries of the world, especially the developed, stabilise the emissions of carbon dioxide and arrest the sea level rise. For a country, which emits very little carbon dioxide certainly does not wish to become a dinosaur of the 21st century nor be wiped out from the face of the earth due almost entirely to the actions of richer countries.

THE VIEW FROM

ECO GUIDE TO US POLICY

With the Ministerial Conference approaching, ECO introduces a short guide to US policy, in case delegates have trouble with lip reading.

The following is the official White House 'Talking Points' brief which was inadvertently released through NGOs at the Bergen Conference, where the US wanted to avoid even discussing carbon cuts. US policy has not changed much but ECO has added some new points the help policy development along.

TALKING POINTS
APRIL 17, 1990

* The U.S. is taking environmentally responsible actions that make sense on their own merits that also help deal with global change issues.
* The U.S. Conference is working in complement to the IPCC.
* The world community is making great strides towards understanding the science of global change, but many fundamental questions remain unanswered.
* The economic impacts of potential global changes and possible responses are not well understood--more work is needed.
* Science, economics and policy formulation need to be integrated, so we can deal responsibly with global change.

DEBATES TO AVOID

* NOT BENEFICIAL TO DISCUSS WHETHER THERE IS OR IS NOT WARMING, OR HOW MUCH OR HOW LITTLE WARMING. IN THE EYES OF THE PUBLIC WE WILL LOSE THIS DEBATE. A BETTER APPROACH IS TO RAISE THE MANY UNCERTAINTIES THAT NEED TO BE BETTER UNDERSTOOD ON THIS ISSUE.
* DON'T GET INTO AN ADVOCACY POSITION OF THE MERITS OF VARIOUS POLICY PROPOSALS.
* DON'T LET REPORTERS POSITION THIS CONFERENCE AS AN ATTEMPT TO DELAY SERIOUS DECISIONS ON THIS ISSUE.
* THIS CONFERENCE IS ACCELERATING THE INTERNATIONAL DISCUSSION AND UNDERSTANDING OF THESE ISSUES. (DON'T USE SPECIFIC NUMBERS IE., DEGREES, DOLLARS, RATES ETC.)

The 'Talking Points' brief from Bergen

Eco's extra points for the US:

Avoid the use of the words 'climate', 'change', 'disaster', 'US' and 'responsibility', especially in that order.

- Remember, your mother might like a warmer climate — cheaper vacations at home. Everyone has a mother, even 'Third World' delegates.
- Most of the countries that will drown aren't worth invadin
- The right to have a big car is contained in the US Constitution (somewhere).
- Only wimps like forests.
- Who needs glaciers anyway? (Remember that all the ice used to be water in any case, and that melting is a natural process)
- It took hundreds of years to prove that the earth wasn't flat: we've only been looking at this greenhouse thing for a decade or so (this will convince most scientists).
- Although rats and bugs may prosper in a warmer climate more than elephants and rhinos, this will cut zoo feeding bills.
- Don't use the phrase 'global warming', instead always refer to 'so-called measurements of a claimed variation in certain atm kinetic phenomena usually taken earth's surface but as yet still understood'.
- Don't talk to the press, fore environmentalists, dogs or othe (especially parrots) who may be w hostile powers (avoid speaking close telephones, house plants, light fittings anyone with facial hair (including delegation).
- Always remember, the Saudis are th guys, the Ruskies used to be bad b coming along, the Europeans can't be t and the rest of the world doesn't cour

90-11-01 13:20 WHITEHOUSE BULLETIN TEL=

THE WHITE HOUSE **BULLETIN**

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compromise on agriculture, enabling the other things to go through. I would guess probability of this is around 60-40."

- **A U.S. delegation led by NOAA Administrator John Knauss will take the message "let's get serious in February" to the Second World Climate Conference in Genev**

according to a number of involved Administration officials. The international conference - which will begin with scientific discussions this Monday, with the ministerial session scheduled for November 6 and 7 -- will address the issue commonly referred to as global warming. During the Geneva meeting, the U.S. expects a number of Western European governments along with Japan to push strenuously for targets and timetables for greenhouse gas reductions "as they have been doing at every international meeting in the last year." Japan will unveil its target to stabilize carbon dioxide emissions on a per-capita basis, in the year 2000 and beyond at about the same level as 1990. These expected pronouncements from other nations were criticized this morning by an involved Administration official: "While the Japanese position looks like stabilization at 1990, it is not. It is an 18% increase over 1988, steadily increasing as the population grows. Australia wants to reduce emissions of greenhouse gases by 20% by the year 2005, but this declaration is really no more than a feasibility study and has no legal significance unless adopted by the territories. France has set a stabilization target which is actually above its current emission level. The U.S. is not in favor of continued political statements in the form of declarations. This is all a shell game with these countries and they are not making legal commitments. Even the UK, which says it is going to stabilize to 1990 levels by 2005, seals its lips when you ask how long after 2005 they will hold at that level." While these nations are expected to push strongly at the end of the meeting for a declaration which includes targets, the U.S. negotiating position will be that the opening round of negotiations on a framework convention (scheduled for early February in Washington, D.C.) is the right time and setting for such discussions. The President's Science Advisor Allan Bromley recently chaired a meeting at which the instructions for the Knauss delegation were provided. The U.S. will issue a statement to the conference restating Secretary Baker's "no regrets policy." The statement will highlight progress that the U.S. has already made on the issue -- CFC reductions, the clean air act, the President's tree-planting initiative, energy-efficiency initiatives, as well as the leading role provided by the U.S in providing climate-change research. According to one U.S. official, "these actions will bring the U.S. to 1987 levels of net greenhouse gas emissions by the year 2000, which is really better than the other nations are doing."

- While reserving judgement, the White House is optimistic that the final language of the clean air bill will allow the President to sign it into law. According to one Administration official, "We haven't seen the fine print yet on that is a request, but we are optimistic. The

The White House Bulletin

Bolin – continued from page 3

today. We can only account for where about 80% of the emissions go.

"More Quickly"

How can we be sure that the same fraction will stay in the atmosphere? If 50 or 60% stays in the atmosphere of a warmer world, that will mean concentrations rising at twice the present rate. I think it is most likely that accumulation will go more quickly in future than less quickly.

Another feedback question concerns the delays between emissions and temperature response. Delays are considerable but I think it is most likely that they will get shorter in future.

ECO You spoke this week of the northern carbon sink and its potential role in positive feedbacks: if a change does occur there, when will we know?

Bolin Nobody knows how to monitor it. It would be interesting to know what has happened to the tundra-taiga border over the past 50–100 years for example. That is an interesting point.

The progress of science is steady but if a major surprise occurs (such as the ozone hole), then we suddenly get a lot of new information.

ECO Are you disappointed by the position of countries such as the US and the UK, which have not even talked much about the statement of IPCC 1 which said that 60% reduction in CO_2 emissions is required to reach stabilisation. Do they accept the IPCC estimates concerning sea level rise and temperature?

Bolin The UK has now joined the Europeans. The US is another matter. I agree fully — on the other hand, in no other country has anyone looked completely into what the difficulties for taking action in a free market. I am disappointed by the recent US decision concerning cars (a decision in Senate not to raise the fuel efficiency of cars).

There is a tendency for politicians to view the practical problems most seriously with respect to their own country. It is important to broaden views more. In the United States Bill Reilley (in the US Administration) is well aware of what all this is about. As is Alan Bromly. It is obvious that the President may be looking at the next elections. He may not be fully aware of all the implications of this. Information is always sifted, and he does have a major responsibility to the Republicans, he can't change policy overnight. Perhaps it can change if he is re-elected.

ECO Has your faith in governments as a means of getting action on this issue increased or decreased as a result of your experiences in the IPCC process?

Bolin If information is brought f...

impact on governments. Governments have not changed as a result of the IPCC process but the IPCC has made it possible for them to do their job better than before. It is a job the scientific community could retain.

ECO As a Swede do you feel there is a parallel with the acid rain debate, after all that started over twenty years ago and is still not resolved?

Bolin Action on CO_2 is being taken. The Netherlands and Germany are ahead of Sweden in fact: the nuclear issue complicates that one. Many new investments (in technology and so on) involve CO_2 reductions that are economically beneficial. But to have a crash programme would be a terrible waste of money. One would have to scrap things that would have worked for decades.

ECO What would your message be to people outside this Conference?

Bolin Resolving the question about what needs to be done implies judgements about the well-being of populations: we need to find optimal ways of proceeding nationally and internationally. It is a ten year job and we are about a year into it. The (Ministerial) Conference this week will confirm some of these things — such as through the European initiative. That is a signal to the negotiators.

Now we need a cost benefit analysis to bring home to people the costs and benefits of taking action or not: one which brings in wider costs too, that is externalities.

We also need more scientists who are ready

NGO PROFILE

The FORUM of Brazilian NGOs

Over 200 independent organizations have joined together to create the "FORUM of Brazilian non-governmental organizations for preparation for the United Nations Conference on Environment and Development (UNCED)" in 1992 in Rio de Janeiro.

In addition to bringing together these various groups within Brazil, the FORUM also serves as a point of contact for the UNCED secretariat, other UN bodies, and NGO networks outside Brazil. Its aim is to stimulate and coordinate NGO activities in Brazil before and during the conference, including the formulation of positions on the substantive issues under discussion. By presenting a united front, the FORUM can pressure the Brazilian government to adopt the UN recommendation for NGO participation in the official decision-making process and in the elaboration of national reports. It is important that the representatives of these 200 NGOs have a vehicle through the FORUM to ensure that environmental, social, cultural, and ethical issues be heard in the UNCED process.

Programs to deal with climate change mu address the issues of developing countries, s that effective development models can b implemented there. The FORUM and i members suggest the following measures:

1) Promote the development of huma capacity on issues related to climate chang within developing countries: in the government the universities, and the public.

2) Provide funding to deal with climate change. First, for environmental and other studies of specific regional eco-systems. Second, to assist in implementing necessary changes.

3) Promote effective mechanisms of industrial technology transfer in order to reduce the environmental degradation process which is usually related with industrialization in developing countries.

4) Stimulate the study of urban development and land-use to create effective planning methods in developing countries.

Delcio Rodrigues and Magda Lombardo
CEDI, Av. Higienopolis, 983 Tel. 55 11 825 5544 01238 Sao Paulo SP, Brazil, Fax. 55 11 825 7861

NEW PUBLICATION

Global Warming and the Third World: A New Newsletter

So far, Third World countries have not been closely involved in either the scientific or political discussions relating to global warming. "Insufficient information" and "insufficient communication" have been identified, by the IPCC, as two factors seriously inhibiting the involvement of Third World nations.

If these countries are to play their part in international negotiations on climate change, and guarantee that the terms of any agreement are not to their disadvantage, an adequate flow of information is is essential. A newsletter due to be published from early 1991 aims to address this problem.

The newsletter has the support of the Swedish International Development Agency (SIDA). It will be published on a regular basis from early 1991 by the International Institute for Environment and Development (London-UK), in partnership with the Climate Research Unit (University of East Anglia, Norwich -UK) and the Climate Action Network (London-UK). Additional partners from Third World research and other organisations are currently being agreed.

If you would like to receive a copy of thi...

WORLD CLIMATE CONFERENCE NEWSLETT

EFTA Countries Fall Out Over Stabilisation

by ECO Reporter

European Free Trade Association seemed likely to split over a proposal to stabilise CO_2 emissions in 2000 on 1990 levels Sunday night, as officials met to prepare for the Ministerial section of the Second World Climate Conference. Today Monday November 5 EFTA ministers are due to agree a joint strategy.

Yesterday evening negotiations between the EFTA group, normally at the front of environmental reform, was deadlocked over an Austrian proposal to limit each country's emission's to present levels, from the end of the century. Sweden and Finland opposed the Austrian move, which was initially backed by Switzerland and Norway. The controversial EFTA draft also called for negotiation of protocols in parallel with those for a climate convention. Observers believe Sweden's embarrassing position is explained by its commitment to also phase out nuclear power.

Environment groups of the EFTA countries attending the SWCC urged the EFTA group to promote 'as a first step, stabilisation at the 1988 level'. They also called for a 20% reduction by 2000 as a 'minimum intermediate target', pointing out that IPCC 1 concluded a 60% cut was needed to stabilise CO_2 levels at today's concentrations.

The groups also appealed to the EFTA bloc to 'strongly promote international agreements on forest conservation, and additional financial and technical aid to developing countries'. The environmentalists noted that 'great attention' would focus on the EFTA group as well as the EC at the Conference, because they are widely expected to give a world lead on greenhouse gas reductions.

Sea Level – continued from front page

commented "I don't know who the President's scientists are: the IPCC and SWCC estimates are a firm scientific consensus based on the work over hundreds of scientists". A senior official from an OECD country commented that the President could 'only have been talking about one scientist', John Sununu who is his Chief of Staff and an engineer. Delegates pointed out that as the US has accepted the final report of the IPCC, the President has in fact accepted the sea level rise estimates which he now rejects, although he may not be aware of that. "This insults science and the whole Pacific region — it's no less than outrageous hypocrisy," said Bill ...e of the Australian Conservation Federation.

Aid Offer

Bush offered an aid package believed worth hundreds of millions of dollars to the leaders, from the Solomons, Tuvalu, Fiji, the Cook Islands, Papua New Guinea, Tonga, Western Samoa, Marshalls, Kiribati and the Federated States of Micronesia, as an inducement to rethink their opposition to the ...

Léman

Léman was interested to hear Japanese delegates from MITI explain their country's new carbon dioxide target. Keichi Yokobori, who chaired the forceful Energy and Industry sub-group of IPCC confessed with pride in the wording of his country's recent declaration. "I received much praise for the per capita wording of our target which is very suitable for our needs", he told others. But Léman is told that the Japanese population is increasing. Léman understands that this will allow a 6% increase in CO_2 emissions, which seems to have been ignored by Mr Yokobori. So is this a real freeze or not? Léman feels the SWCC should be told.

Léman understands that unusual conditions of near hysteria broke out during the negotiations to agree the draft Ministerial Declaration in the early hours of Sunday morning. Tired delegates were reduced to gales of laughter as the United States, upset at being left off the list of countries which had done something to reduce CO_2 emissions [as they have not], repeatedly tried to get their country mentioned. Other nations which had not committed to stabilisation or cuts began to ask why, if the US were to be included, their paltry efforts might not qualify them for inclusion in the roll of honour. Mexico pointed out that something - not much admittedly — but something, had been done in Mexico City. The Indians remembered things underway in India which seemed just as relevant as the US not yet enacted Clean Air bill.

After some minutes, with the list growing ever longer, the US mention was consigned to square brackets. With the laughter of weary delegates echoing in Léman's ears, your correspondent retired to bed.

ECO's Who's Who: Guide to Environmental NGOs present at the Conference – Addendum

Friends of the Earth, USA – Liz Cook; Friends of the Earth, Luxembourg – Claude Turmes; Stichting Natuur en Milieu, Netherlands – Ralph Hallo; WWF, UK – Jane Bevan;

eco

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Statement gutted – cont from fro...

Late Sunday night, the drafting gro... adopted a long section on forests which ... away from commitments made at the ... and Noordwijk Conferences to call for a Pr... to protect forests, linked to a Climate C... Convention. "This is a chopper's charter - ... nothing useful" said Adam Markham of W... "it will end up in the hands of the FAO w... has shown itself unable to conserve the w... tropical forests". Environment groups ... alarmed at the failure of German delegat... oppose such weak wording. All references t... rights of indigenous peoples were also dele...

USA, USSR and Saudi Arabia also overc... weak opposition from European count... which had proposed the call for a 20% cu... at least stabilisation and won wording wh... merely states that 'establish targets and feasible national programmes or strategi... The draft also allows countries to 'anal... feasibility' of these options before the Ju... 1992 Brasil Sustainable Developme... conference. "This waffle lets the US off t... hook: it means 18 months of doing nothin... Needless to say, the US is delighted", sa... Stewart Boyle, of the Climate Action Networ...

SWCC Scientists – continued from front pa...

left out of models for simplicity, and others wi... increase as warming takes hold, 'it appea... likely' that, 'as climate warms, these feedback will lead to an overall increase... in greenhous... gas concentrations'. In other words, climat... change is even now probably under-estimated.

On the key gas carbon dioxide it states that: 'In order to stabilize atmospheric carbon dioxide concentrations... at about 50% above pre-industrial concentrations [today's levels being c. 25% above], a continuous world-wide reduction of net carbon dioxide emissions by 1 to 2% per year, starting now, would be required'.

As to countries of the 'third world' whose future emissions will determine the success of any climate agreement, it notes: 'it is clear that developing countries must... "leapfrog" ahead directly from a status of under-development through to efficient, environmentally benign, technologies presently found only in the most advanced industrial economies...' and calls for: 'a massive and sustained flow of scientific and technological expertise towards the development of the intellectual resources, technical and institutional capacity of the developing countries.

'Mechanisms for the transfer of technology' says the report, ... 'should take into account... the need for preferential and assured access, intellectual property rights, the environmental soundness of such technology and the financial implications....Additional financial resources will have to be channelled to developing countries... both to [limit] greenhouse gas ...

APPENDIX V

International Participation in SWCC

INTERNATIONAL PARTICIPATION IN THE SECOND WORLD CLIMATE CONFERENCE
October 29 - November 7, 1990
Geneva

140	Countries attending
2	Heads of State
4	Prime Ministers
134	Knauss-level representatives

NOTE: Had the U.S. not mentioned very early on that we would be sending a lower-level official, the SWCC would likely have been attended by 30 or more heads of state.

48 hrs / 6/25

THE WHITE HOUSE

WASHINGTON

June 21, 1990

AC HAS SEEN 6/25

MEMORANDUM FOR JOHN H. SUNUNU

FROM: D. ALLAN BROMLEY Allan

SUBJECT: THE NATIONAL CRITICAL TECHNOLOGIES PANEL

The FY90 Defense Authorization Act, amending the National Science and Technology Policy, Organization and Priorities Act of 1976 required OSTP to establish a National Critical Technologies Panel that in turn will produce its first report to the Congress by October 1, 1990 and biennially thereafter until the Panel expires on December 31, 2000.

The legislation authorizes a 13-person panel, 9 of whom are to be appointed by the OSTP Director (3 federal officials--one of whom will be designated as chairman and 6 persons from the private sector and academia) and 4 by Defense, Energy, Commerce and NASA respectively.

Our primary task is to merge and analyze the critical technology lists produced by Defense and Commerce to identify up to 30 "critical" product and process technologies, to report on their current status in the U.S. as compared to that in other countries and to formulate recommendations for Federal and state, private sector and academic actions and milestones where appropriate.

The Panel is to be supported administratively by OSTP and in FY90 is to be reimbursed by DOD for related expenses up to $500,000; in subsequent years the funding is to come from OSTP appropriations although no such provision is in our current FY91 budget request.

Bureaucratic obstacles associated with establishing any new Federal Advisory Committee have already resulted in substantial delay in getting this work underway but if we can move expeditiously, we can still meet the Congressional deadline for the first report.

I am now, subject to completion of conflict of interest reviews, in a position to appoint the 9 members to be named by OSTP and the four agencies involved are similarly prepared to move forward. We have assembled what I believe to be an excellent list of broadly qualified potential panel members.

If I follow normal White House procedures and clear these panel members through Chase Untermeyer's and Boyden Gray's offices I am informed that the process will take at least 10 weeks.

This leaves me with an unhappy set of options:

a) Follow normal procedure and miss the statutory due date for our report.

b) Appoint the panel as authorized by the legislation and comply with the statutory requirement but at the cost of by-passing the normal procedures.

The problem is exacerbated by the fact that OSTP in recent years had established an unfortunate reputation for missing due dates for Congressionally mandated reports and I have thus far managed to get all those required by OSTP since my arrival to the Congress on time. I would hate to miss this coming October 1 date for the Critical Technologies Report by a large amount and thus revive the old reputation.

I need your advice. Do I follow option

______a)

or

______b)

as outlined above.

I enclose the pertinent section of the legislation and the suggested membership of the Panel herewith.

Enclosures

(1) the contractor has negotiated a comprehensive subcontracting plan under the test program that includes the matters specified in section 8(d)(6) of the Small Business Act (15 U.S.C. 637(d)(6));

(2) such matters have been determined acceptable by the Secretary of the military department or head of a Defense Agency negotiating such comprehensive subcontracting plan; and

(3) the comprehensive subcontracting plan applies to the contract.

(d) FAILURE TO MAKE A GOOD FAITH EFFORT TO COMPLY WITH A COMPANY-WIDE SUBCONTRACTING PLAN.—A contractor that has negotiated a comprehensive subcontracting plan under the test program shall be subject to section 8(d)(4)(F) of the Small Business Act (15 U.S.C. 637(d)(4)(F)) regarding the assessment of liquidated damages for failure to make a good faith effort to comply with its company-wide plan and the goals specified in that plan.

(e) TEST PROGRAM PERIOD.—The test program authorized by subsection (a) shall begin on October 1, 1990, unless Congress adopts a resolution disapproving the test program. The test program shall terminate on September 30, 1993.

(f) REPORT.—(1) Not later than March 1, 1994, the Secretary of Defense shall submit a report on the results of the test program to the Committees on Armed Services and on Small Business of the Senate and the House of Representatives.

(2) Before submitting such report to the committees referred to in paragraph (1), the Secretary shall transmit the proposed report to the Administrator of the Small Business Administration. The report submitted to the committees shall include any comments and recommendations relating to the report that are transmitted to the Secretary by the Administrator before the date specified in such paragraph.

(g) DEFINITIONS.—As used in this section:

(1) The term "small business concern" shall have the same meaning as is provided in section 8(d)(3)(C) of the Small Business Act (15 U.S.C. 637(d)(3)(C)), and includes a small business concern owned and controlled by socially and economically disadvantaged individuals.

(2) The term "small business concern owned and controlled by socially and economically disadvantaged individuals" shall have the same meaning as is provided in section 8(d)(3)(C) of the Small Business Act (15 U.S.C. 637(d)(3)(C)).

PART E—DEFENSE INDUSTRIAL AND TECHNOLOGY BASE

SEC. 841. CRITICAL TECHNOLOGIES PLANNING

(a) NATIONAL CRITICAL TECHNOLOGIES PANEL.—(1) The National Science and Technology Policy, Organization, and Priorities Act of 1976 (42 U.S.C. 6601 et seq.) is amended by adding at the end the following new title:

"TITLE VI—NATIONAL CRITICAL TECHNOLOGIES PANEL

"ESTABLISHMENT

"SEC. 601. The Director of the Office of Science and Technology Policy shall establish within that office a National Critical Technologies Panel (hereinafter in this title referred to as the 'panel'). The panel shall prepare the biennial national critical technologies report required by section 603.

"MEMBERSHIP

"SEC. 602. (a) The panel shall consist of 13 members appointed from among persons who are experts in science and engineering as follows:

"(1) The Director of the Office of Science and Technology Policy shall appoint nine members, of whom—

"(A) three shall be Federal Government officials; and

"(B) six shall be appointed from persons in private industry and higher education.

"(3) The Secretary of Defense shall appoint one member, who shall be an official of the Department of Defense.

"(4) The Secretary of Energy shall appoint one member, who shall be an official of the Department of Energy.

"(5) The Secretary of Commerce shall appoint one member, who shall be an official of the Department of Commerce.

"(6) The Administrator of the National Aeronautics and Space Administration shall appoint one member, who shall be an official of that agency.

"(b)(1) Members appointed under subsection (a)(1)(B) shall serve for a term of two years.

"(2) Any vacancy in the membership of the panel shall be filled in the same manner as the original appointment.

"(c) The Director shall designate one of the members appointed under subsection (a)(1)(A) as chairman of the panel.

"BIENNIAL NATIONAL CRITICAL TECHNOLOGIES REPORT

"SEC. 603. (a) The panel shall submit to the President a biennial report on national critical technologies. Each such report shall identify those product technologies and process technologies that the panel considers to be national critical technologies. The number of the such technologies identified in any such report may not exceed 30. The reports shall be submitted not later than October 1 of even-numbered years.

"(b) For purposes of subsection (a), a product or process technology may be considered to be a national critical technology if the panel determines it to be a technology that it is essential for the United States to develop to further the long-term national security and economic prosperity of the United States.

"(c) Each such report shall include, with respect to each technology identified in the report, the following information:

"(1) The reasons for the panel's selection of that technology.

"(2) The state of the development of that technology in the United States and in other countries.

"(3) An estimate of the current and anticipated level of research and development effort in the United States, including anticipated milestones for specific accomplishments, by—

"(A) the Federal Government;

"(B) State and local governments;

"(C) private industry; and

"(D) colleges and universities.

"(d) Not later than 30 days after the date on which a report is submitted to the President under this section, the President shall transmit the report, together with any comments that the President considers appropriate, to Congress.

"ADMINISTRATION AND FUNDING OF PANEL

"SEC. 604. The Director of the Office of Science and Technology Policy shall provide administrative support for the panel. Funds for necessary expenses of the panel shall be provided for fiscal years after fiscal year 1990 from funds appropriated for that Office.

"EXPIRATION

"SEC. 605. The provisions of this title shall cease to be effective on December 31, 2000, and the panel shall terminate on that date.".

(2) The Secretary of Defense shall reimburse the Director of the Office of Science and Technology Policy for the reasonable expenses, not to exceed $500,000, incurred by the National Critical Technologies Panel during fiscal year 1990.

(b) ANNUAL DEFENSE CRITICAL TECHNOLOGIES PLAN.—(1) Chapter 148 of title 10, United States Code, is amended by adding at the end the following new section:

"§ 2508. Annual defense critical technologies plan

"(a) ANNUAL PLAN.—(1) The Secretary of Defense shall submit to the Committees on Armed Services of the Senate and House of Representatives an annual plan for developing the technologies considered by the Secretary of Defense and the Secretary of Energy to be the technologies most critical to ensuring the long-term qualitative superiority of United States weapon systems. The number of such technologies identified in any plan may not exceed 20. Each such plan shall be developed in consultation with the Secretary of Energy.

"(2) In selecting the technologies to be included in the plan for any year, the Secretary of Defense and the Secretary of Energy shall consider both product technologies and process technologies, including the technologies identified in the most recent biennial report submitted to the President by the National Critical Technologies Panel under title VI of the National Science and Technology Policy, Organization, and Priorities Act of 1976.

"(3) Each such plan shall cover the 15 fiscal years following the year in which the plan is submitted.

"(4) Such plan shall be submitted not later than March 15 of each year and shall be submitted in both classified and unclassified form.

"(b) PRIORITIES AND FUNDING.—Each plan submitted under subsection (a) shall—

"(1) designate priorities for development of the technologies identified in the plan; and

"(2) specify the funding requirements of the Department of Defense, the Department of Energy, and other appropriate departments and agencies of the Federal Government for the development of the technologies identified in the plan for the five fiscal years following the year in which the plan is submitted.

"(c) CONTENT OF PLAN.—Each plan submitted under subsection (a) shall include, with respect to each technology identified in the plan, the following:

"(1) The reasons for the selection of that technology, including—

"(A) a discussion of the consideration given to the most recent biennial report submitted to the President under title VI of the National Science and Technology Policy, Organization, and Priorities Act of 1976; and

"(B) the relationship of the technology to the overall science and technology program of the Department of Defense and the long-term funding strategy associated with that program.

"(2) A designation of the lead organization within the Department of Defense or the Department of Energy responsible for the development of the technology.

"(3) A summary description of the lead organization's plan for the development of the technology, including the milestone goals.

"(4) The amounts contained in the budgets of the Department of Defense, the Department of Energy, and other departments and agencies for the support of the development of such technology for—

"(A) the five preceding fiscal years; and

"(B) the fiscal year beginning in the year in which the plan is submitted; and

"(C) each fiscal year thereafter for which the Secretary of Defense, with respect to the Department of Defense, and the Secretary of Energy, with respect to the Department of Energy, has prepared a budget.

GOVERNMENT OFFICIALS

Mr. Arnold D. Aldrich Associate Administrator Office of Aeronautics, Exploration & Technology National Aeronautics and Space Administration 600 Independence Avenue S.W. Washington, D.C. 20546	Known as: Arnie Phone: (202) 453-2693 Fax: (202) 755-3283 Secretary: Gaile Eastman
Dr. Frederick M. Bernthal Deputy Director National Science Foundation 1800 G Street, N.W. Washington, D.C. 20550	Known as: Fred Phone: (202) 357-9427 Fax: Secretary:
Dr. James F. Decker Director for Office of Energy Research (Acting) Department of Energy ER-1 1000 Independence Avenue S.W. Washington, D.C. 20585	Known as: Jim Phone: (202) 586-5434 Fax: (202) 586-4102 Secretary: Barbara Chambers
Dr. Charles Herzfeld Director, Defense Research & Engineering Department of Defense Room 3E 1014 Pentagon Washington, D.C. 20301-3100	Known as: Charlie Phone: (202) 697-5776 Fax: (202) 693-7167 Secretary: Maggie Souleyret
Dr. Ruth Kirchstein Director National Institute of General Medical Sciences 5333 Westbard Ave Westwood Building Room 926 Bethesda, Maryland 20892	Known as: Ruth Phone: (301) 496-7891 Fax: Secretary:
Dr. William Phillips Associate Director for Industrial Technology Office of Science and Technology Policy Executive Office of the President Washington, D.C. 20506	Known as: Bill Phone: (202) 395-3125 Fax: (202) 395-3719
Dr. Robert White Undersecretary for Technology U.S. Department of Commerce Room 4822 14th and Constitution Avenue N.W. Washington, D.C. 20230	Known as: Bob Phone: (202) 377-1575 Fax: Secretary:

PRIVATE SECTOR AND HIGHER EDUCATION

Dr. Robert W. Lucky
Executive Director of Research
Communications Sciences Division
ATT Bell Laboratories
Crawfords Corner Road
Room 4E 605
Holmdel, New Jersey 07733-1988

Known as: Bob
Phone: (201) 949-4477
Fax: (201) 949-5353
Secretary: Marlene Gannon

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Vice President, Research & Development
and Chief Technical Officer
Cincinnati Milacron, Inc.
4701 Marburg Avenue
Cincinnati, Ohio 45209

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Fax: (513) 841-8584
Secretary: Lori Chowning

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Sedgewich Professor of Biophysics
Massachusetts Institute of Technology
77 Massachusetts Avenue
Cambridge, Massachusetts 02139

Known as: Alex
Phone: (617) 253-4715
Fax: (617) 253-8699
Secretary: Alice Colby

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Director
Lawrence Berkeley Laboratory
Building 50A Room 4133
1 Cyclotron Road
Berkeley, California 94720

Known as: Chuck
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Fax: (415) 486-6720
Secretary: Mrs. Mardel Carnahan

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Vice President, Science
Martin Marietta Corporation
6801 Rockledge Drive
Bethesda, Maryland 20817

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Fax: (301) 897-6800
Secretary: Mona Moore

Mr. James Worsham
Chairman
GPA Asia Pacific
Pacific Corporate Towers
222 N. Sepulveda
El Segundo, CA 90245
(213) 322-2210

Known as: Jim
Phone: (213) 322-2577
Fax: Diane DeSilva
Secretary:

check w/ Chas

THE WHITE HOUSE

WASHINGTON

June 21, 1990

AC HAS SEEN 6/25

MEMORANDUM FOR JOHN H. SUNUNU

FROM: D. ALLAN BROMLEY

SUBJECT: NSF DIRECTORSHIP

As you know, Erich Bloch is coming to the end of his six year appointment as Director of the National Science Foundation. In my opinion, he has done an outstanding job but in the course of doing so he has managed to antagonize a significant fraction of the research community and we both have agreed that it would not be in Erich's--or the President's best interests--for a reappointment to be considered.

That concluded, in April I asked Dr. Mary Good, Senior Vice President for Technology of Allied Signal, and Chairman of the National Science Board, to chair a search committee for Erich's replacement. This approach is in accordance with the National Science Foundation's Organic Act, (42 U.S.C. 1864), Section 5(a) which states that "The Director of the Foundation (referred to in this Act as the "Director") shall be appointed by the President by and with the advice and consent of the Senate. Before any person is appointed as Director, the President shall afford the Board an opportunity to make recommendations to him with respect to such appointment.

As part of the search the NAS, NAE, and AAAS were asked to provide recommendations. Recommendations were also received from a number of the major scientific societies and from a wide spectrum of individual scientists and engineers.

From this input the search committee has winnowed the list to four persons. They are the following:

Neal F. Lane	Provost, Rice University Houston, Texas
Peter W. Likins	President, Lehigh University Bethlehem, Pennsylvania
Walter E. Massey	Vice President University of Chicago
Homer A. Neal	Professor and Chairman Physics Department University of Chicago

I have known all four of these candidates for many years and would note that two of them, Likins and Massey, are currently members of the President's Council of Advisers on Science and Technology.

My recommendation is that the President nominate Walter E. Massey to the NSF Director with Neal F. Lane as the alternate, if one should be required. I am enclosing their curriculum vitae herewith. Lane is an atomic physicist while Massey's field is condensed matter physics.

While I have a high regard for Likins and Neal, I do not believe that either would be as successful in leading the NSF in the critical years ahead as would Lane or Massey.

Massey did his graduate work in condensed matter physics and from 1958 through 1979 pursued an outstanding academic career in this area ending as Professor of Physics and Dean of the College at Brown University. From there he was recruited to be the Director of the Argonne National Laboratory and to an adjunct appointment as Professor of Physics at the University of Chicago. In 1982 he relinquished the Directorship of the Argonne Laboratory to take over as Vice President for Research of the University of Chicago and as the University of Chicago officer responsible for exercising the University's management of the Argonne Laboratory under contract with the U.S. Department of Energy. Concurrently he serves as Chairman of the Board of the Argonne National Laboratory/University of Chicago Development Corporation.

Walter Massey has also played a very active role in U.S. science policy. He served as a member of the National Science Board from 1978 through 1984; he was President and then Chairman of the Board of the American Association for the Advancement of Science in 1988-1990 and has recently been named as President-elect of the American Physical Society.

As his curriculum vita indicates he has had broad experience in a variety of state, national and international activities and serves on a number of major corporate Boards of Directors.

He is widely considered to be the Nation's most distinguished black scientist.

Enclosures

CURRICULUM VITAE -- WALTER E. MASSEY

May 1990

Born:	Hattiesburg, Mississippi, April 5, 1938
Marital Status:	Married -- Shirley Ann Streeter Children -- Keith and Eric
Address:	4950 Chicago Beach Drive Chicago, Illinois 60615
Telephone:	Offices -- 312/702-6021 or 708/972-5330
Present Position:	Vice President for Research and for Argonne National Laboratory and Professor of Physics The University of Chicago 5801 Ellis Avenue Chicago, Illinois 60637

Education:

Institution	Inclusive Dates	Degree and Date
Royal Street High School Hattiesburg, Mississippi	1952-1954	(Did not graduate; entered college from 10th grade.)
Morehouse College Atlanta, Georgia	1954-1958	B.S., Physics and Math, 1958
Columbia University New York, New York	Summer 1958	None
Howard University Washington, D.C.	1959-1960	None
Washington University St. Louis, Missouri	Sept. 1960-Jan. 1966	M.A., Ph.D., January 1966

Ph. D. Research:

Development of a theory and the calculations of the ground state properties of liquid helium.

Thesis Title:

"Ground State of Liquid Helium: Boson Solutions for Mass 3 and 4." Available at Olin Library, Washington University, St. Louis, Missouri.

Research Supervisor: Dr. Eugene Feenberg
Washington University
St. Louis, Missouri

Fellowships and Scholarships:

1. Ford Foundation Early Admission Scholarship: Morehouse College, 1954
2. National Defense Act Fellowship: Howard University, 1959
3. National Science Foundation Fellowship: Washington University, 1961
4. Academic Administration Fellow: American Council on Education, 1975

Professional Organizations:

1. American Association for the Advancement of Science
2. American Association of Physics Teachers
3. American Nuclear Society
4. American Physical Society
5. New York Academy of Sciences
6. Society of Sigma Xi

Honors and Awards:

1. "Outstanding Educator of America" Award, 1974
2. "Distinguished Service Citation" of the American Association of Physics Teachers (AAPT) for "Exceptional Contributions to the Teaching of Physics," 1975
3. University of Illinois College of Engineering Alumni Honor Award for "Distinguished Service in Engineering," 1988
4. Honorary Fellow Award, Society for Technical Communication, 1989
5. Listed: Who's Who in the East and Who's Who in America
6. Doctor of Science Honorary Degree, Lake Forest College, Lake Forest, Illinois, 1981
7. Doctor of Science Honorary Degree, Williams College, Williamston, Massachusetts, 1981
8. Doctor of Science Honorary Degree, Elmhurst College, Elmhurst, Illinois, 1982
9. Doctor of Science Honorary Degree, Atlanta University, Atlanta, Georgia, 1982
10. Doctor of Science Honorary Degree, Rutgers University, New Brunswick, New Jersey, 1984
11. Doctor of Science Honorary Degree, Morehouse College, Atlanta, Georgia, 1984
12. Doctor of Science Honorary Degree, Marquette University, Milwaukee, Wisconsin, 1987
13. Doctor of Science Honorary Degree, Boston College, Boston, Massachusetts, 1987
14. Doctor of Science Honorary Degree, Northern Illinois University, DeKalb, Illinois, 1989
15. Doctor of Science Honorary Degree, Rensselaer Polytechnic Institute, Troy, New York, 1989

Employment History:

1. *Morehouse College*
   1958-1959 — Instructor of Physics

2. *Atlanta University*
   Summer 1959 — Instructor of Physics

3. *Howard University*
   Summer 1960 — Instructor of Physics

4. *Washington University*
   1960-1961 — Teaching Assistant
   January 1966-July 1966 — Postdoctoral Research Associate

5. *Argonne National Laboratory*
   July 1966-June 1968 — Postdoctoral Fellow
   June 1968-September 1968 — Staff Physicist

6. *University of Illinois*
   September 1968-January 1970 — Assistant Professor of Physics

Employment History (contd.):

7. *Brown University*
   1970-1975 — Associate Professor
   1975-July 1979 — Professor of Physics and Dean of the College

8. *Argonne National Laboratory*
   July 1979-1984 — Laboratory Director

9. *The University of Chicago*
   July 1979- — Professor of Physics

10. *The University of Chicago*
    1982-1984 — Vice President for Research and Laboratory Director, Argonne National Laboratory

11. *The University of Chicago*
    1984- — Vice President for Research and for Argonne National Laboratory

12. *Argonne National Laboratory/ University of Chicago Development Corporation* — Chairman of the Board
    August 1986-

Other Relevant Experience:

A. National Science and Science Policy Experience:

1. *Commission on College Physics*
   Member of study group to develop proposals for the improvement of the teaching of physics in high schools and colleges, 1971, 1972

2. *American Physical Society*
   Executive Committee, New England Section, 1971, 1972;
   Councillor-at-Large, 1980-1983; Vice President, 1990

3. *American Institute of Physics*
   Executive Committee on "Physics in the Predominately Black Colleges," 1971, 1972

4. *Aspen Center for Physics*
   Participant, 1971, 1976, 1979

5. *National Academy of Sciences -- National Research Council*
   Member, Physics Review Committee, 1972-1975

6. *National Academy of Sciences*
   Advisory Committee on Eastern Europe and the USSR, 1973-1976

7. *American Association of Physics Teachers*
   Committee on Physics in Higher Education, 1974-1977

8. *National Science Foundation*
   Advisory Panel, Division of Physics, 1975-1977
   Advisory Committee Directorate for Science and Engineering Education, 1985-1989

National Science and Science Policy Experience (contd.):

9. *National Science Board*, 1978-1984

10. *American Association for the Advancement of Science*
Fellow, 1962; Board of Directors, 1981-1985; President-Elect, 1987-1988; President, 1988-1989; Chairman, 1989-1990

11. *Scientists' Institute for Public Information*
Board of Trustees, 1989-

12. *President's Council of Advisers on Science and Technology*
Member, 1990-

B. Other Academic and Educational Experience:

1. *Graduate Records Examination Board*
Advanced Physics Examination Committee, 1974, 1975

2. *United States Department of Health, Education and Welfare*
Fund for the Improvement of Postsecondary Education
Board of Advisors, 1976-1979

3. *Association of American Universities*
Energy Advisory Committtee, 1979-1980

4. *American Association of Colleges*
Commission on Institutional Development and National Affairs
1979-1981

5. *Science Research Institute, Atlanta University Center*
Advisory Board, 1979-1981

6. *Washington University*
Board of Trustees, 1980-1981

7. *Brown University*
Board of Trustees, 1980-

8. *Northwestern University*
Visiting Committee of the College of Arts and Sciences, 1982-1985

9. *Massachusetts Institute of Technology*
Department of Physics Corporation Visiting Committee, 1982-

10. *Harvard University*
Committee to Visit the Department of Physics, 1985-1989

C. Civic, Cultural and Community Affairs:

1. *Urban League of Rhode Island*
Board of Directors, 1973-1975

2. *KQED Television, Inc., San Francisco*
Project Advisory Committee, 1977-1980

Civic, Cultural and Community Affairs (contd.):

3. *World Book-Childcraft International, Inc.*
   Advisory Board, 1979-1982

4. *Chicago Museum of Science and Industry*
   Board of Trustees, 1980-1989

5. *Mayor's Task Force on High Technology Development, City of Chicago*
   Chairman, 1981-1982

6. *Governor's Commission on Science and Technology, State of Illinois*, 1982-1989

7. *Chicago High Tech Association*
   Chairman, Board of Directors, 1984-

8. *Chicago Symphony Orchestra*
   Board of Trustees, 1984-1989

9. *Illinois Mathematics and Science Academy* (high school)
   Board of Trustees, 1985-88

10. *United Way of Chicago*
    Board of Directors, 1985-88

11. *Chicago Council on Foreign Relations*
    Board of Directors, 1985-

12. *Institute for Illinois*
    Board of Directors and Treasurer, 1986-

13. *Governor's Science Advisory Committee, State of Illinois,*
    Executive Committee, 1989-

14. *Illinois Coalition*
    Board of Directors, 1989-

D. International Experiences:

1. American Nuclear Society, Scientific Exchange to the People's Republic of China, September/October 1980

2. United States-South African Leadership Exchange Program, Study of South African Universities, Republic of South Africa, August/September 1981

3. Conference on Physics in Latin America, Rio de Janiero, Brazil -- Planning Committee, July/August 1983

4. United States-South African Leadership Exchange Program -- Council Member, 1983-1989

5. American Association for the Advancement of Science, African Regional Symposium on the Role of Scientific and Engineering Sciences in Development -- Co-chairman, Mbanne, Swaziland, March 1984, and Grand Bassam, Ivory Coast, December 1984

6. American Association for the Advancement of Science, Project to Strengthen Scientific and Engineering Infrastructure in Sub-Saharan Africa -- Co-chairman, 1984-

International Experiences (contd.):

7. National Science Foundation -- Advisory Committee on International Programs, 1985-88

8. American Association for the Advancement of Science, Annual Meeting of the Continuing Committee on the Role of Scientific and Engineering Societies in Development, Finland, 1989

9. American Association for the Advancement of Science, Board Planning Meeting for Cooperative Programs Between Soviet Academy of Sciences and the AAAS, USSR, 1989

E. Corporate and Not-for-Profit Organizations:

1. *Analytic Services, Inc.*
   Trustee, 1980-1981

2. *Corporation of Woods Hole Oceanographic Institution*
   1980-1983; 1986-1989

3. *Research-Cottrell, Inc.*
   Board of Directors, 1982-1987

4. *Amoco Corporation*
   Board of Directors, 1982-

5. *Continental Materials, Inc.*
   Board of Directors, 1982-1990

6. *The First National Bank of Chicago*
   Board of Directors, 1983-

7. *Rand Corporation*
   Board of Trustees, 1983-

8. *Motorola, Inc.*
   Board of Directors, 1984-

9. *Chicago Tribune Company*
   Board of Directors, 1987-

10. *MacArthur Foundation*
    Board of Directors, 1990-

Neal F. Lane, Provost
Rice University

Date and Place of Birth:

August 22, 1938
Oklahoma City, Oklahoma

Education:	B.S.	University of Oklahoma, 1960
	M.A.	University of Oklahoma, 1962
	Ph.D.	University of Oklahoma, 1964
Fellowships:	1964-65	NSF Postdoctoral Fellow (Queen's University of Belfast, Northern Ireland
	1965-66	JILA Visiting Fellow (Joint Institute for Laboratory Astrophysics, Boulder, CO)
	1967-71	Alfred P. Sloan Foundation Fellow
	1975-76	JILA Visiting Fellow (Joint Institute for Laboratory Astrophysics, Boulder, Co)
	1984-present	JILA Non-Resident Fellow

Professional Appointments:

1966-69	Assistant Professor of Physics (Rice University)
1969-72	Associate Professor of Physics (Rice University)
1972---	Professor of Physics* (Rice University)
1979-80	Director, Division of Physics, National Science Foundation (on leave from Rice University)
1984-86	Chancellor, University of Colorado at Colorado Springs
1986---	Provost, Rice University

Teaching Honors (Rice University):

1972-73	Brown College Teaching Award
1973-74	George R. Brown Prize for Superior Teaching
1976-77	George R. Brown Prize for Superior Teaching

Special Lectures:

Distinguished Visiting Scientist (University of Kentucky, 1980)
Distinguished Karcher Lecturer (University of Oklahoma, 1983)

Invited Conference Papers:

Washington, American Physical Society, April 1970
Yale, American Physical Society (Division of Electron and Atomic Physics), December 1973
Rolla Gaseous Electronics Conference, October 1975
George J. Schulz Memorial Symposium, Yale, 1977
U.S.-Japan Seminar on Electron-Molecule Collisions and Photoionization Processes, CalTech., October 1982

XIII International Conference on the Physics of Electronic and Atomic Collisions, Berlin, July 1983
Atomic Physics in High Temperature Plasmas, February 1985
Conference on "Computers for the Liberal Arts," Reed College, Keynote Address, November 1985
Oji International Seminar on Highly Exited States of Atoms and Molecules, Fuji-Yoshida, Japan, 1986
Ninth Conference on the Application of Accelerators in Research and Industry, Denton, Texas, 1986
International Symposium on Correlation and Polarisation in Electronic and Atomic Collisions, The Queen's University of Belfast, 1987

Book:

___, with M. Morrison and T.L. Estle
Quantum States of Atoms, Molecules and Solids (Prentice Hall, N.M., 1976).

Professional Societies and Services:

Fellow, American Physical Society
Fellow, American Association for the Advancement of Science
Member, American Association of Physics Teachers
Member, Sigma Xi, Chapter President (1978-79)
At various times, General Committee for the International Conference of the Physics of Electronic and Atomic Collisions; Program and Fellowships Committees for the American Physical Society Division of Electron and Atomic Physics (Chairman); Heineman Prize Committee; NRC/NAS Committee on Atomic and Molecular Sciences; Program Committee for the International Conference of Atomic Physics; NSF Advisory Committee for Physics; and NSF Subcommittee for the Review of NSF-Supported Nuclear Physics Laboratories and Nuclear Science Programs.
Chairman, American Physical Society Division of Electron and Atomic Physics (1977-78), Vice Chairman (1976-77)
Chairman, NAS/NRC Evaluation Panel for the Joint Institute for Laboratory Astrophysics (1980-83), Member (1980-84)
Chairman, Nominating Committee, Division of electron and Atomic Physics, American Physical Society (1981)
Councilor at Large, American Physical Society (1981-84)
Member, Executive Committee, American Physical Society (1981-83)
Chairman, Subcommittee on National Scientific Affairs of Panel on Public Affairs/American Physical Society (1982)
Member, Finance Committee, American Physical Society (1981-82)
Member, American Physical Society Panel on Faculty Positions for Women Physicists (1981-82)
Chairman, Panel on Public Affairs of the American Physical Society (1983), Vice Chairman (1982), Member (1982-85)
Member, Committee on Constitution and Bylaws, American Physical Society (1981-83)
Vice Chairman, Executive Committee of American Physical Society International Physics Group (1983-84)
Chairman, NSF Advisory Panel on Advanced Scientific Computing (1984-86), Member (1984-87)
Member, Governing Board, American Institute of Physics (1983-present); Nominating Committee (1986)
Member, Subpanel on Atomic, Molecular and Optical Physics of the National Academy of Sciences "Survey of Physics" (1983-84)

Member, Magnet Selection Panel, Superconducting Super Collider project,
Central Design Group, Lawrence Berkeley Lab (1985)

Member, URA SSC Board of Overseers (1987-present)

Chairman, Panel on Science and Engineering Manpower, Office of Technology
Assessment, U.S. Congress (1986-88)

Member, Texas Scientific Advisory Committee (1988-)

Chairman, NRC Evaluation Panel for the Center for Basic Standards of the National
Bureau of Standards (1986-88) and Center for Atomic, Molecular and Optical
Physics of the National Institute of Standards and Technology (1988-present)

Member, Advisory Board for the Institute in Theoretical Atomic and Molecular Physics
at the Harvard-Smithsonian Center for Astrophysics

Member, Commission on Physical Sciences, Mathematics, and Resources, National
Research Council (1989-92)

THE WHITE HOUSE

WASHINGTON

AC HAS SEEN 6/25

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June 22, 1990

MEMORANDUM TO GOVERNOR SUNUNU

FROM: D. ALLAN BROMLEY Allan

SUBJECT: ASSOCIATE DIRECTOR OF OSTP FOR LIFE SCIENCES

As you know, James Wyngaarden, who has served during this past year as the OSTP ~~Assistant~~ Associate Director for the Life Sciences, has agreed to accept election as the Foreign Secretary of the National Academy of Sciences.

As soon as his election was announced in April I undertook an extensive search for a suitable replacement who could cover the broad range of biological and medical issues that come to OSTP and replace Wyngaarden in such other roles as Chairman of the biotechnology working group for the Competitiveness Council, as an example.

In this search I consulted with the Institute of Medicine, the NAS, FASEB, and the Deans of a number of the major medical schools. One name came to the top of some three quarters of all the lists of possible candidates. That name was:

Donald A. Henderson M.D., M.P.H. *
Dean, School of Public Health
Johns Hopkins University, Baltimore

Other persons who were suggested by a number of consultants included:

J. Edward Rall M.D., Ph.D.
Deputy Director for Intramural Research
National Institutes of Health, Bethesda

David Rall M.D., Ph.D.
Director of Environmental Health Science
National Institute of Health, North Carolina

David Korn, M.D.
Vice President and Dean of the Medical School
Stanford University, Stanford, California

My Associate Directors and I met with all four of these individuals. David Rall subsequently withdrew because of deteriorating health.

We were unanimously in agreement among ourselves and with the majority of our consultants that it would represent a very real coup were we able to bring Henderson to OSTP.

He is considered, worldwide, as the one person who deserves credit for the total eradication of smallpox. He is considered the dean of public health activities in the United States and has the confidence of the biomedical community.

He is a member of the National Academy of Sciences and was awarded the National Medal of Science; this and his other awards, listed on the accompanying curriculum vita, attest to his reputation both nationally and internationally.

The only basis upon which we have a possibility of attracting him is that he is just retiring from the Johns Hopkins Deanship, a position that he has held with distinction since 1977.

My colleagues in OSTP and I have met with him on several occasions for lengthy discussions and are enthusiastic about the possibility of his joining us. He would be a more than worthy successor to James Wyngaarden and would bring a significantly broader range of experience and interest to OSTP.

My recommendation is that the President nominate him as Associate Director for the Life Sciences of the Office of Science and Technology Policy.

APRIL 1990

CURRICULUM VITAE

DONALD AINSLIE HENDERSON

BORN: September 7, 1928
Lakewood, Ohio

OFFICE ADDRESS: 615 N. Wolfe Street
Baltimore, MD 21205
301-955-3540

MARRIED: Nana Irene Bragg
Rochester, New York
September 1, 1951

HOME ADDRESS: 3802 Greenway
Baltimore, MD 21218
301-889-2880

CHILDREN: Leigh Ainslie, 1954
David Alexander, 1956
Douglas Bruce, 1960

EDUCATION:

A.B., Oberlin College, 1950
M.D., University of Rochester School of Medicine, 1954
M.P.H., Johns Hopkins University School of Hygiene and Public Health, 1960

Honoris causa:
M.D., Universite de Geneve (1980)
LL.D., Marietta College (1978)
L.H.D., State University of New York (1981)
Sc.D., University of Rochester (1977);
Oberlin College (1978);
University of Illinois (1979);
University of Maryland (1980);
Yale University (1986)
Albany Medical College (1989)

POSITIONS HELD:

Mary Imogene Bassett Hospital, Cooperstown, New York, Intern in Medicine, 1954-1955; Resident in Medicine, 1957-1959

Communicable Diseases Center, Department of Health, Education, and Welfare, Assistant Chief, Epidemic Intelligence Service, 1955-1956; Chief, Epidemic Intelligence Service and Assistant to Chief, Epidemiology Branch, 1956-1957; Assistant Chief, Epidemiology Branch and Chief, Epidemic Intelligence Service, 1960-1961; Chief, Surveillance Section, Epidemiology Branch, 1961-1965; Chief, Smallpox Eradication Program, 1965-1966

World Health Organization, Chief Medical Officer, Smallpox Eradication, 1966-1977

Johns Hopkins University School of Hygiene and Public Health, Dean and Professor of Epidemiology and International Health, 1977-

PROFESSIONAL SOCIETIES:

American Board of Preventive Medicine, 1963-
American College of Epidemiology, Fellow, 1990-
American College of Preventive Medicine, Fellow, 1978-
American Epidemiological Society, 1963-
American Public Health Association, 1956; Fellow, 1961-
American Society of Tropical Medicine and Hygiene, 1981-
Association of Schools of Public Health, Treasurer, 1978; Vice-President, 1981-1982; 1987-1988; President, 1988-
Indian Society for Malaria and Other Communicable Diseases, Fellow, 1975-
International Epidemiological Association, 1965-
Royal College of Physicians (Edinburgh), Fellow, 1986-
Royal Society of Tropical Medicine and Hygiene, Fellow, 1976-

APRIL 1990

SCIENTIFIC AWARDS AND RECOGNITIONS: *(United States)*

National Medal of Science, 1986
National Academy of Sciences - Public Welfare Medal, 1978
Charles S. Dana Foundation Award for Pioneering Achievement in Health, 1986
American Academy of Arts and Sciences, Fellow, 1986-
Institute of Medicine, National Academy of Sciences, Member, 1978-
Albert Schweitzer International Prize for Medicine, 1985
American College of Physicians - James D. Bruce Memorial Award, 1978
American Public Health Association - Rosenhaus International Award for Excellence, 1975
American Academy of Pediatrics - Honorary Fellow, 1980
Johns Hopkins University - Distinguished Alumnus Award, 1982
Michigan State University - Walter F. Patenge Medal of Public Service, 1984
Vanderbilt University School of Medicine Medal, 1990
Ohio Foundation of Independent Colleges, Hall of Fame, 1990
Blue Cross-Blue Shield - 50th Anniversary Distinguished Service Award, 1979
U.S. Association for the United Nations - Joseph C. Wilson Award in International Affairs, 1978
U.S. General Accounting Office - Comptroller General's Special Recognition, 1986
U.S. Department of Health and Human Services
- Superior Service Award, 1964
- Sustained Superior Performance Award, 1966
U.S. Public Health Service - Distinguished Service Medal, 1976
- Commendation Medal, 1962
Delta Omega Honorary Public Health Society - Member, 1979
- Outstanding Alumnus Award, 1980
Sigma Xi - Member, 1956

SCIENTIFIC AWARDS AND RECOGNITIONS : *(Other Countries)*

The Japan Prize, 1988
Republic of China - Health Medal of the First Grade, 1988
Government of Uruguay - Medal of Abnegation, 1988
Universidad Peruana Cayetano Heredia, Honorary Professor, 1988
Commemorative Award of Seventh World Congress of the International Physicians for the Prevention of Nuclear War, 1987
Gairdner Foundation (Canada) - International Award of Merit, 1983
Royal Colleges of Physicians of the United Kingdom - Faculty of Community Medicine - Honorary Fellow, 1981
Royal Society of Medicine
Richard T. Hewitt Award, 1986
Honorary Member, 1980
London School of Hygiene and Tropical Medicine and Royal Society of Tropical Medicine and Hygiene - George McDonald Prize and Medal, 1976
Government of Ethiopia - Medal for Contributions to Health, 1979
Government of Afghanistan - *Roghtya Neshan* (Health Medal), 1976
Ernst-Jung Foundation, (Germany) - *Ernst-Jung Preis fur Medizin*, 1976
Government of India - Special Award, 1975
Indian Society for Malaria and Other Communicable Diseases - Special Award, 1975
Lahore, Pakistan - Certificate of Merit, 1977

APRIL 1990

AWARD TO WHO FOR SMALLPOX ERADICATION:

Special Albert Lasker Public Health Service Award, 1976

SPECIAL LECTURESHIPS:

Alumni Reunion Lecture, Oberlin College, 1990
Cleveland City Club Forum Speaker, 1990
Vanderbilt University World Health Week, Keynote Speaker, 1990
Kathryn Boucot Sturgis Lecture, 1990
Alumni Reunion Lecture, University of Rochester, 1989
John P. McGovern Lecturer, Baylor College of Medicine, 1989
Annual Banquet Address, Clinico-Pathological Society of Washington, 1989
Phyllis Lewander Memorial Lecture - Children's Hospital National Medical Center, Washington, D.C., 1989
American Pediatric Society - Washington, DC, 1988
Bloomfield Lecture - Case-Western Reserve University, 1987
Joseph Mountin Lecture- Centers for Disease Control, 1987
Agaard Lecture - University of Washington, 1987
Frontiers of Science Lecture - University of Florida, 1987
Eighteenth International Pediatric Congress - Keynote Speaker, 1986
Chief Guest and Keynote Speaker, 30th Aniversary of Indian Public Health Association - Calcutta, India, 1985
National Convention on the Management of Health Systems - Convention Orator; Jaipur, India, 1985
P.D. Agarwal Memorial Oration - Calcutta, India, 1985
Oberlin College Sesquicentennial Speaker - 1983
Harvard Medical School Bicentennial Speaker - 1982
Rameshwar Sharma Oration - School of Medicine, Jaipur, India, 1981
Harben Lecture - Royal Institute of Public Health and Hygiene, London, 1980
Stephens Lecture - Oberlin, Ohio, 1980.
V.W. Scully Distinguished Lecture - Hamilton, Ontario, Canada, 1979
Joseph C. Wilson Lecture - Rochester, New York, 1979
Julia M. Jones Memorial Lecture - American Lung Association and American Thoracic Society, 1979
Merck Sharpe and Dohme Lecture - Canadian Public Health Association, Ottawa, Canada, 1977
James Bordley III Lecture - Mary Imogene Bassett Hospital, Cooperstown, New York, 1977
Jenner Memorial Lecture - Bristol (UK) Royal Infirmary, 1975
Commencement and Convocation Addresses:
San Diego State University School of Public Health - 1988
University of California (San Diego) School of Medicine - 1984
Michigan State University School of Medicine - 1984
University of Southern California School of Medicine - 1978

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PROFESSIONAL COMMITTEES: ***(Present)***

World Health Organization
 Expert Advisory Panel on Virus Diseases, 1976-
 Committee on Orthopoxvirus Infections, 1981-
 Consultant Group on Poliomyelitis Eradication, Chairman, 1988-
Pan American Health Organization
 Technical Advisory Group on Immunization, Chairman, 1985-
American Journal of Epidemiology,
 Board of Overseers, Associate Editor, 1965-1977; Chairman, 1984-
Editorial Advisory Board - Bibliography of Bioethics, 1979-
International Association for Maternal and Neonatal Health, Scientific Council, 1981-
Rotary Foundation of Rotary International, Polio Plus Advisory Committee, 1985-
Government Accounting Office
 Advisory Board, Program Evaluation and Methodology Division, 1988-
U.S. Department of State
 Advisory Committee on Oceans, Environmental and Scientific Affairs, 1988-
Department of Health and Human Services
 National Vaccine Advisory Committee, 1988-1989; Chairman, 1990-
 Secretary's Council on Health Promotion and Disease Prevention, 1989-
 Association of Academic Health Centers
  Task Force on Health Promotion /Disease Prevention, 1989-
"AIDS Patient Care" magazine - Editorial Advisory Panel, 1987-
United Fresh Fruit and Vegetable Association, Scientific Advisory Panel, 1988-
Institute of Medicine, Board on International Health, 1988-
Charles A. Dana Foundation Awards Jury, 1990-
Foundation for Development of International Health (Japan), Scientific Consultant, 1990-

BOARD OF DIRECTORS/TRUSTEES:

Indian Institute of Health Management Research, 1985-
Maryland Society for Medical Research, Inc., 1978-
Population Crisis Committee, 1981-
International Center for Diarrheal Disease Research (Dhaka), 1988-
Medical Alumni Association, Mary Imogene Bassett Hospital, 1989-

BIOGRAPHICAL LISTINGS:

Who's Who in the World
The International Who's Who
Who's Who in America
Who's Who in Frontiers of Science and Technology
American Men and Women in Science: Medical and Health Sciences
Dictionary of International Biography

PROFESSIONAL COMMITTEES: ***(Past)***

American Public Health Association
- Committee on Hepatitis, Chairman, 1961-1965
- Multiple Antigen Committee, 1964-1966
- Epidemiology Section Council, 1965-1967

Surgeon General's Advisory Committees on:
- Influenza, Secretary, 1961-1963
- Measles Vaccines, Secretary, 1963
- Immunization Practice, Secretary, 1964-1966

World Health Organization
- Special Committee on Measles Vaccine, Consultant, 1963
- Scientific Group on Human Virus Vaccines, Member, 1965
- Global Commission for the Certification of Smallpox Eradication, 1978-1980
- Program Advisory Group for the Prevention of Blindness, 1978-1982
- Programme for Research and Training in Tropical Diseases - Scientific and Technological Advisory Committee, 1982-1984
- Caribbean Epidemiology Center - Scientific Advisory Committee, 1980-1983

National Research Council, National Academy of Sciences
- Board on Science and Technology in International Development, 1981-1983
- Committee on Research Grants, 1982-83

National Academy of Sciences, Institute of Medicine,
- AID Health Strategy Study, Steering Committee, 1978
- Steering Committee for the Study on Clinical Investigations in Developing Countries, 1978-1980
- Advisory Committee on Health, Biomedical Research and Development, Chairman, 1981-1983
- Steering Committee, Study of Tropical Diseases, 1984-1987

Government Accounting Office
- Research and Education Advisory Panel to the Comptroller-General, 1977-1986

Department of Health and Human Services
- PHS Hospitals *ad hoc* Advisory Committee, 1978
- Secretary's Committee on Influenza, Vice-Chairman, 1979
- National Ethics Advisory Board, 1977-1980
- CDC Programs and Policy Advisory Committee, 1978-1980
- Immunization Practices Advisory Committee, Centers for Disease Control, 1982-1986

Chairman, Mayor's Task Force on Environmental Carcinogens (Baltimore), 1977-1978

NASA - Planetary Protection Study Group, 1978

Executive Office of the President, Office of Science and Technology
- Task Force for Science and Technology in Foreign Assistance, Chairman, 1980
- Advisory Committee on Science, Technology and Development, 1978-1979
- Consultant, 1978-1982

Harvard University,
- Visiting Committee, University Health Services, 1981-1985

Burroughs-Wellcome Fund - Pharmacoepidemiology Awards Committee, 1983-1987

City University of New York Medical School, National Visiting Council, 1986-1989

Institute of Medicine, National Academy of Sciences,
- Committee on the Evaluation of Poliomyelitis Vaccine, 1987-88

U.S. Agency for International Development
- Research Advisory Committee, 1983-1990

PUBLICATIONS:

More than 100 scientific publications dealing primarily with smallpox eradication, epidemiology and immunization.

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Book

Fenner, F, Henderson, DA, Arita, I, Jezek, Z, and Ladnyi, ID. Smallpox and Its Eradication, published by World Health Organization, 1988.

Book-Chapters (BC)

(1) Karzon, DT, Henderson, DA
Current Status of Live Attenuated Vaccines.
Advances in Pediatrics Volume XIV, 1966, pp. 121-200. Year Book Medical Publishers, Inc.

(2a) Henderson, DA
Smallpox.
Maxey-Rosenau Preventive Medicine and Public Health, 10th edition, edited by Sartwell, P.E. Appleton-Century-Crofts, 1973, pp. 104-116

(2b) Henderson, DA
Smallpox.
Maxcy-Rosenau Preventive Medicine and Public Health, 11th edition, edited by Last, J.M. New York. Appleton-Century-Crofts, 1980, pp. 95-110.

(2c) Henderson, DA
Smallpox.
Maxcy-Rosenau Preventive Medicine and Public Health, 12th edition, edited by Last, J.M. Appleton-Century-Crofts, 1985, pp. 129-138.

(3a) Henderson, DA
Smallpox.
Epidemiology and Community Health in Warm Climate Countries. Edited by Russell and Standard. Churchill Livingstone, Edinburgh, 1976, pp. 160-167.

(3b) Henderson, DA
Smallpox.
Epidemiology and the Community Control of Disease in Warm Climate Countries, edited by Robinson. Churchill Livingstone, Edinburgh, 1985, pp. 249-261.

(4a) Henderson, DA
Variola and Vaccinia.
Cecil Textbook of Medicine, 16th edition, edited by Wyngaarden, J.B. and Smith, L.H. W.B. Saunders, Philadelphia, 1982, pp. 1658-1663.

(4b) Henderson, DA
Variola and Vaccinia.
Cecil Textbook of Medicine, 17th Edition, edited by Wyngaarden, J.B. and Smith, L.H. W.B. Saunders, Philadelphia, 1985, pp. 1724-1728.

(4c) Henderson, DA
Variola and Vaccina.
Cecil Textbook of Medicine, 18th Edition, edited by Wyngaarden, J.B. and Smith, L.H., W.B. Saunders, Philadelphia, 1988 (in press).

(5) Henderson, DA
Smallpox: Eradication of a Killer.
Encyclopedia Brittanica, Medical and Health Annual - 1979, pp. 125-144.

(6) Henderson, DA
Explicit Goals for Prevention and Public Health.
Working for a Healthier America, edited by McNerney, W.J., pp. 87-94. Ballinger Publishing Co., Cambridge, 1980.

(7) Henderson, DA
Lessons from The Smallpox Eradication Experience in Medicine, Science, and Society, edited by K.J. Issalbacher, John Wiley and Sons, New York, pp. 715-726.

(8) Foege, WH and Henderson, DA
Management Priorities in Primary Health Care in Selective Primary Health Care Intervention, edited by Walsh, J.A., Warren, K.S. The University of Chicago Press, Chicago and London, pp. 313-321.

(9) Henderson, DA
Smallpox and Vaccinia in Vaccines, edited by Plotkin, S. and Mortimer, T., pp. 8-30. W.B. Saunders Company, 1987.

(10) Warren, KS, Bundy, DAP, Anderson, RM, Jamison, DT, Davis, A, Senft, A, Prescott, NM, Henderson, DA
Helminth Infections.
Chapter in Evolving Health Sector Priorities in Developing Countries, December, 1989.

February 1990

Scientific Papers

(1) Armijo, R, Henderson, DA, Timothee, R, Robinson, HB
Food Poisoning Outbreaks Associated with Spray-Dried Milk - An Epidemiological Study.
Am. J. of Public Health 47:1093-1100, 1957.

(2) Poskanzer, DC, Henderson, DA, Kunkle, EC, Kalter, SS, Clement, WB and Bond, JO
Epidemic Neuromyasthenia, An Outbreak in Punta Gorda, Florida.
New Eng. J. Medicine 257:356-364, 1957.

(3) Clement, WB, Henderson, DA, Lawrence, JW and Bond, JO
Epidemic Neuromyasthenia, An Outbreak in Punta Gorda, Florida - An Illness Resembling Iceland Disease.
J. Florida State Med. Assoc. 45:422-426, 1958.

(4) Henderson, DA and Shelokov, A
Medical Progress: Epidemic Neuromyasthenia-Clinical Syndrome.
New Eng. J. Med. 260:757-764, 814-818, 1959.

(5) Henderson, DA and Hawn, CVZ
The Epidemiology of Antibiotic-Resistant Staphylococci in the Community.
Surg. Clinics of North America, 40:971-982, 1960.

(6) Trotter, Y, Dunn, FL, Drachman, RH, Henderson, DA, Pizzi, M and Langmuir, AD
Asian Influenza in the United States, 1957-1958.
Am. J. Hyg. 70:34-50, 1959.

(7) Quirce, JM, Vargas-Mendez, O, Nunez, J, Montoya, JA, Brody, J, Henderson, DA and Martins da Silva, M
Vaccination with Attenuated Polioviruses in Costa Rica.
First International Conference of Live Poliovirus Vaccine, Scientific Publication No. 44, Pan American Sanitary Bureau, 1959, pp. 510-513.

(8) Dull, HB, Jensen, KE, Rakich, JH, Cohen, A, Henderson, DA and Pirkle, CI
Monovalent Asian Influenza Vaccine. Evaluation of Its Use during Two Waves of Epidemic Asian Influenza in Partly Immunized Penitentiary Population.
J. Amer. Med. Assoc. 172:1223-1229, 1960.

(9) Aach, RD, Elsea, WR, Lyerly, JL and Henderson, DA
Efficacy of Varied Doses of Gamma Globulin During an Epidemic of Infectious Hepatitis, Hoonah, Alaska, 1961.
Am. J. Pub. Health 53:1623-1629, 1963.

(10) Langmuir, AD, Henderson, DA, Serfling, RE, Sherman, IL
The Importance of Measles as a Health Problem.
Am. J. Pub. Health 52 (Supp.):1-3, 1962.

(11) Guinee, VF, Casey, HL, Ruthig, DW, Henderson, DA, et al.
A Collaborative Study of Measles Vaccines in Five United States Communities.
Am. J. Pub. Health 53:645-651, 1963.

(12) Henderson, DA, Witte, JJ, Morris, L, Langmuir, AD
Paralytic Disease Associated with Oral Polio Vaccines.
J. Amer. Med. Assoc. 190:41-48, 1964.

(13) Langmuir, AD, Henderson, DA, Serfling, RE
The Epidemiological Basis for the Control of Influenza.
Am. J. Pub. Health 54:563-571, 1964.

(14) Henderson, DA
Viral Hepatitis: Experience in the United States.
The Milbank Memorial Fund Quarterly XLIII(2):
Part 2:404-411, 1965.

(15) Foege, WH, Leland, OS, Mollohan, CS, Fulginiti, VA, Henderson, DA, Kempe, CH
Inactivated Measles Virus Vaccine.
Pub. Health Reports 80:60-64, 1965.

(16) Joseph, PR, Millar, JD, Henderson, DA
An Outbreak of Hepatitis Traced to Food Contamination.
New Eng. J. Med. 273:188-194, 1965.

(17) Dizon, JJ, Alvero, MG, Joseph, PR, Tamayo, JF, Mosley, WH, Henderson, DA
Studies of Cholera El Tor in the Philipines.
1. Characteristics of Cholera El Tor in Negros Occidental Province, November 1961 to September 1962.
Bull. Wld. Hlth. Org. 33:627-636, 1965.

(18) Joseph, PR, Tamayo, JF, Mosley, WH, Alvero, MG, Dizon, JJ, Henderson, DA
Studies of Cholera El Tor in the Philippines. 2. A Retrospective Investigation of an Explosive Outbreak in Bacolod City and Talisay, November 1961.
Bull. Wld. Hlth. Org. 33:637-643, 1965.

(19) Tamayo, JF, Mosley, WH, Alvero, MG, Joseph, PR, Gomez, CZ, Montague, T, Dizon, JJ, Henderson, DA
Studies of Cholera El Tor in the Philippines.
3. Transmission of Infection among Household Contacts of Cholera Patients.
Bull. Wld. Hlth. Org. 33:645-649, 1965.

(20) Mosley, WH, Alvero, MG, Joseph, PR, Tamayo, JF, Gomez, CZ, Montague, T, Dizon, JJ, Henderson, DA
Studies of Cholera El Tor in the Philippines.
4. Transmission of Infection among Neighborhood and Community Contacts of Cholera Patients.
Bull. Wld. Hlth. Org. 33:651-660, 1965.

(21) Guinee, VF, Henderson, DA, Casey, HL, Wingo, ST, Ruthig, DW, et al.
Cooperative Measles Vaccine Field Trial. I. Clinical Efficacy. II. Serological Studies.
Pediatrics 37:649-665, 1966.

(22) Witte, JJ, Henderson, DA
The Cerebrospinal Fluid in Type III Poliomyelitis.
Am. J. Epidemiology 83:189-195, 1966.

(23) Morris, L, Witte, JJ, Gardner, P, Miller, G, Henderson, DA
Surveillance of Poliomyelitis in the United States, 1962-1965.
Pub. Health Reports 82:417-428, 1967.

(24) Neff, JM, Lane, JM, Pert, JH, Moore, R, Millar, JD, Henderson, DA
Complications of Smallpox Vaccination. I. National Survey in the United States, 1963.
New Eng. J. Med. 276:125-132, 1967.

(25) Neff, JM, Levine, RH, Lane, JM, Ager, EA, Moore, H, Rosenstein, BJ, Millar, JD, Henderson, DA
Complications of Smallpox Vaccination. II. Results Obtained by Four Statewide Surveys.
Pediatrics 39:916-923, 1967.

(26) Miller, G, Gale, J, Villarejos, V, James, W, Arteaga, CG, Casey, H, Henderson, DA
Edmonston B and Further Attenuated Measles Vaccine - A Placebo Controlled Double Blind Comparison.
Am. J. Pub. Health 57:1333-1340, 1967.

(27) Henderson, DA
Smallpox Eradication and Measles-Control Programs in West and Central Africa - Theoretical and Practical Approaches and Problems.
Industry and Tropical Health VI, 112-120, Harvard School of Public Health, Boston, 1967.

(28) Arita, I, Henderson, DA
Smallpox and Monkeypox in Primates.
Primates in Medicine 3:122-123, 1969.

(29) Gelfand, HM, Henderson, DA
A Program for Smallpox Eradication and Measles Control throughout West Africa.
J. of International Health 2:24-33, 1966.

(30) Arita, I, Henderson, DA
Smallpox and Monkeypox in Non-Human Primates.
Bull. Wld. Hlth. Org. 39:277-283, 1968.

(31) Henderson, DA
La Evaluacion en los Programas de Vacunacion.
Boletin de la Oficina Sanitaria Panamericana 66:426-434, 1969.

(32) Millar, JD, Roberto, RR, Wulff, H, Wenner, HA, Henderson, DA
Smallpox Vaccination by Intradermal Jet Injection.
Bull. Wld. Hlth. Org. 41:749-760, 1969.

(33) Henderson, DA
The Status of the Global Smallpox Eradication Programme in September, 1969.
Proceedings of Symposium on Smallpox, Yugoslav Academy of Arts and Sciences, Zagreb, 23-35.

(34) Arita, I, Henderson, DA
Freeze-dried Vaccine for the Smallpox Eradication Programme.
Proceedings of Symposium on Smallpox, Yugoslav Academy of Arts and Sciences, Zagreb (1969), 39-50.

(35) Henderson, DA
Control and Eradication of Smallpox.
Tropical Doctor 1:33-35, 1970.

(36) Henderson, DA
Smallpox Surveillance in the Strategy of Global Eradication.
Health Centre Journal 12:59-66, 1970.

(37) Wehrle, PF, Posch, J, Richter, KH, Henderson, DA
An Airborne Outbreak of Smallpox in a German Hospital and its Significance with Respect to Other Recent Outbreaks in Europe.
Bull. Wld. Hlth. Org. 43:669-679, 1970.

(38) Henderson, DA, Labusquière, R, Millar, JD, N'Dow, PJ, Nicholas, CC, Rey, M, Ristori, C, Sulianti-Saroso, J
Design for Immunization Programs in the Developing Countries.
International Conference on the Application of Vaccines against Viral, Rickettsial and Bacterial Diseases of Man. PAHO (Washington) (1971) 626-635 and Pediatrica Indonesia 12:408- 426, 1972.

(39) Henderson, DA
Smallpox: The Problem.
International Conference on the Application of Vaccines against Viral, Rickettsial and Bacterial Diseases of Man. PAHO (Washington) (1971) 139-143.

(40) Henderson, DA
Epidemiology in the Global Eradication of Smallpox.
Intl. J. Epidemiology 1:25-30, 1972.

(41) Henderson, DA
Smallpox Vaccination.
Proceedings of the Seminar on Vaccination in Africa. Centre International de l'Enfance (Paris), 1971, pp. 44-46.

(42) Henderson, DA, Arita, I
Monkeypox and its Relevance to Smallpox Eradication.
WHO Chronicle 27:145-148, 1973.

(43) Henderson, DA
La Variole.
Mèdecine et Hygiene 31:709-719, 1973.

(44) Henderson, DA
Eradication of Smallpox: The Critical Year Ahead.
Proc. Royal Soc. 66:493-500, 1973.

(45) Henderson, DA
Genesis, Strategy and Progress of the Global Smallpox Eradication Program.
J. Communicable Dis. 6:155-159, 1974.

(46) Foege, WH, Millar, JD, Henderson, DA
Smallpox Eradication in West and Central Africa.
Bull. Wld. Hlth. Org. 52;209-222, 1975.

(47) Henderson, DA
Global Smallpox Eradication Programme.
Swasth Hind 19:116-118, 1975.

(48) Henderson, DA
Smallpox Eradication - the Final Battle (Jenner Lecture).
J. Clinical Pathology, 28:843-849, 1975.

(49) Henderson, DA
Surveillance of Smallpox.
Intl. J. Epidemiology 5:19-28, 1976.

(50) Henderson, DA
Current Status of Smallpox in the World.
J. Com. Dis. 7:165-170, 1975.

(51) Henderson, DA
The Eradication of Smallpox.
Scientific American 235:25-33, 1976.

(52) Arita, I and Henderson, DA
Monkeypox and Whitepox Viruses in West and Central Africa.
Bull. Wld. Hlth. Org. 53:347-353, 1976.

(53) Henderson, DA
Smallpox Eradication.
Proc. R. Soc., London, 199:83-97, 1977.

(54) Henderson, DA
History of Smallpox Eradication.
Times, Places, and Persons (Supplement to the Bulletin of The History of Medicine), edited by A.M. Lilienfeld, Johns Hopkins Press, 1980, pp. 99-108.

(55) Henderson, DA
The Saga of Smallpox Eradication and Beyond (James Bordley III Lecture).
Occasional Papers. The Mary Imogene Bassett Hospital, Cooperstown, New York, 1977.

(56) Henderson, DA
The Saga of Smallpox Eradication: An End and a Beginning.
Canadian J. of Public Health 70:21-27, 1979.

(57) Henderson, DA
Mobilization of Health Manpower to meet health needs: Lessons learned from the Smallpox Eradication Program.
Human Resources for Primary Health Care in the Middle East, pp. 140-150, Amer. U. of Beirut, Lebanon, 1980.

(58) Henderson, DA
Landmarks in American Epidemiology: Smallpox Eradication.
Public Health Reports 95:422-426, 1980.

(59) Henderson, DA
Strategy and Development of Global Smallpox Eradication Campaign.
J. of International Society for Tropical Medicine and Malaria (in press).

(60) Henderson, DA
The Deliberate Extinction of a Species (Harben Lecture).
American Philosophical Society, 126:461-471, 1982.

(61) Henderson, DA
Expanding Horizons on a Diminishing Planet.
Pediatrics. 61:770-774, 1981.

(62) Henderson, DA
Primary Health Care as a Practical Means for Measles Control.
Reviews of Infectious Diseases 5:606-607, 1983.

(63) Henderson, DA
Education has an Urgent Need for Redirection.
Oberlin College Sesquicentennial Papers, Oberlin Alumni Magazine, pp. 20-22.

(64) Henderson, DA
Public Health Training for Physicians From Abroad: Current Problems and a Look at the Future.
Educational Commission for Foreign Medical Graduates, Public Health Workshop, April, 1984.

(65) Henderson, DA and Arita, I
Utilization of Vaccine in the Global Eradication of Smallpox in Vaccinia Viruses as Vectors for Vaccine Antigens, Elsevier, New York, 1985, pp. 61-67.

(66) Henderson, DA
Challenge and Change in our Health Systems.
Jaipur, India, October 25, 1985 (in press).

(67) Henderson, DA
Public Health and Virus Diseases.
Indian Journal of Public Health, 39:223-225, 1985.

(68) Henderson, DA
P.D. Agarwal Memorial Oration.
Calcutta, India, October 1985.

(69) Henderson, DA
Principles and Lessons from The Smallpox Eradication Programme
Bulletin of the World Health Organization, 65 (4):535-546 (1987).

(70) Henderson, DA
Application and Problem Solving in Health Research for the Developing Countries.
Independent International Commission on Health Research for Developing Countries, Geneva, July 1987 (in press).

(71) Henderson, DA and Sorensen, AA
Relationship Between the Work Setting and Professional Education in Public Health, IOM, March 1987 (in press).

(72) Henderson, DA
Eradication of Infectious Diseases: Utopian or Realistic?
Ernst Jung Prize Symposium, 1987 (in press).

(73) Henderson, DA
Session I: Strategies for Vaccine Delivery: Introduction
Reviews of Infectious Diseases, Volume II, Supplement 3, May-June 1989, 1987 (in press).

(74) Henderson, DA
New Dimensions in International Health
Reviews of Infectious Diseases, 1987 (in press).

(75) Henderson, DA
Child Survival Revolution
Bellagio III Conference, March 12, 1988 (in press).

(76) Henderson, DA
The Child Survival Revolution
Pediatric Research, 1987 (in press).

(77) Mosley, WH, Henderson, DA
International Health in Development in the 1990s.
Issues in Science and Technology 1988 (in press).

(78) Henderson, DA
Defining Global Medical Education Needs
Academic Medicine, Volume 64, Number Five Supplement, 59-S12 (1989)

(79) Henderson, DA
Point-Counterpoint. Medical vs. the Public Health Model of Prevention
Am Journal of Preventive Medicine, 1989 (in press).

(80) Henderson, DA
Introduction to Session II: Strategies for Vaccine Delivery
Reviews of Infectious Diseases, 1989 (in press).

(81) Henderson, DA
Conference on Emerging Viruses
Surveillance Systems and Intergovernmental Cooperation
Washington, D.C., May 1989 (in press).

(82) Henderson, DA, Rakel, RE
The Worldwide Eradication of Smallpox
Houston Medicine, September 1989 (in press).

(83) Mosley, WH, Jamison, D, Henderson, DA
The Health Sector in Developing Countries: Problems for the 1990s and Beyond
Annual Review of Public Health, July 1989 (in press).

February 1990

<u>Other</u>

(1) Henderson, DA
An End - and a Beginning.
World Health (Feb.-March, 1975), pp. 12-17.

(2) Henderson, DA
Smallpox Eradication - the Global Strategy.
World Health (October 1973) pp. 8-16.

(3) Henderson, DA
Smallpox - Death of a Disease.
National Geographic, December, 1978, pp. 796-805.

(4) Henderson, DA
Smallpox Shows the Way.
World Health (February, 1977) pp. 22-27.

(5) Henderson, DA
Smallpox Target Zero.
Rochester Review (Spring, 1980), pp. 2-5.

(6) Henderson, DA
A Victory for All Mankind.
World Health (May 1980), pp. 3-5.

(7) Henderson, DA
Commentary on the Feasibility of Eradication.
World Health Forum 2:482-484, 1982.

(8) Henderson, DA
Book Review of P. Razzell's <u>Edward Jenner's Cowpox Vaccine: The History of a Medical Myth</u>.
J. Hist. Med. 37:236-238, 1982.

(9) Henderson, DA
Letter to the Editor: Global Measles Eradication.
Lancet, July 24, 1982.

(10) Henderson, DA
Smallpox After Eradication: Storing the Virus.
Encyclopedia Brittanica, <u>Medical and Health Annual - 1980</u>, pp. 254-256.

(11) Henderson, DA
Book Review of D. Baxby's <u>Jenner's Smallpox Vaccine: The Riddle of the Vaccinia Virus and Its Origin</u>.
J. Hist. Med. 37:595-597, 1982.

(12) Henderson, DA
Continuing Education in Health Management.
Jaipur, India 1986 (in press).

(13) Henderson, DA
Op-Ed: "How the U.S. Shortchanges World Health."
The Evening Sun, Friday, January 30, 1987.

(14) Henderson, DA
Stocks of Variola Virus.
American Journal of Public Health, Vol. 77, No. 2, pp. 238-239, February 1987.

(15) Halsey, NA; Henderson, DA
Editorial: "HIV Infection and Immunization,"
New England Journal of Medicine, 316, pp. 683-685, 1987.

(16) Henderson, DA
The Lessons Learnt
World Health Forum, Vol. 8, 1987.

(17) Henderson, DA
Op-Ed: ... And for the World Health Organization, Washington Post, June 17, 1987.

(18) Henderson, DA
Introductory Note to: "Outbreaks of Smallpox Due to Variolation in China 1962-1965," American Journal of Epidemiology, Vol. 128, No. 1, 1988.

(19) Henderson, DA
Poliomyelitis and Smallpox Eradication
World Health, 1989 (in press).

HENDERSON, DONALD AINSLIE, university dean; b. Cleve., Sept. 7, 1928; s. David Alexander and Grace Eleanor (McMillan) H., m. Nana Irene Bragg, Sept. 1, 1951; children: Leigh Ainslie, David Alexander, Douglas Bruce. B.A., Oberlin (Ohio) Coll., 1950, D.Sc. (hon.), 1979; M.D., U. Rochester (N.Y.), 1954, D.Sc. (hon.), 1977; M.P.H., Johns Hopkins U., 1960; LL.D. (hon.), Marietta (Ohio) Coll., 1978; D.Sc. (hon.), U. Ill., 1979, U. Md., 1980; M.D. (hon.), U. Geneva, 1980; L.H.D. (hon.), SUNY, 1981; D.Sc. (hon.), Yale U., 1986. Diplomate: Am. Bd. Preventive Medicine. Intern, then resident Mary Imogene Bassett Hosp., Cooperstown, N.Y., 1954-55, 57-59; chief epidemic intelligence service Center Disease Control, USPHS, Atlanta, 1955-57; chief surveillance sect. Center Disease Control, USPHS, 1960-66; chief med. officer smallpox eradication WHO, Geneva, 1966-77; dean Johns Hopkins U. Sch. Hygiene and Pub. Health, 1977—. Contbr. articles to med. jours. Recipient Commendation medal USPHS, 1962, Disting. Service medal, 1976; Ernst Jung prize, 1976; award Govt. India-Indian Soc. Malaria and Other Communicable Diseases, 1975; Rosenhaus internat. award for excellence, 1975; George MacDonald medal London Sch. Hygiene and Tropical Medicine, Royal Soc. Tropical Medicine and Hygiene, 1976; Health medal Govt. Afghanistan, 1976; Spl. Albert Lasker Pub. Health Service award for WHO, 1976; Public Welfare medal Nat. Acad. Scis., 1978; Joseph C. Wilson award in internat. affairs, 1978; James D. Bruce Meml. award, 1978; 50th Anniversary Disting. Service award Blue Cross-Blue Shield, 1979; medal for contbns. to health Govt. of Ethiopia, 1979; Outstanding Alumnus award Delta Omega, 1980; Disting. Alumnus award Johns Hopkins U., 1982; Internat. Merit award Gairdner Found., 1983; Albert Schweitzer Internat. prize for medicine, 1985; Nat. Medal Sci., 1986; Richard T. Hewitt award Royal Soc. Medicine, 1986, Charles Dana Found.award for Pioneering Achievement in Health, 1986; Japan prize in Preventative Medicine, 1988. Fellow Nat. Acad. Arts and Scis., Am. Acad. Pediatrics (hon.), Royal Coll. Physicians U.K. (hon.); mem. Nat. Acad. Arts & Scis., Inst. Medicine Nat. Acad. Scis., Am. Public Health Assn., Internat. Epidemiol. Assn., Royal Coll. Physicians (Edinburgh), Royal Soc. Tropical Medicine and Hygiene, Indian Soc. Malaria and Other Communicable Diseases. Home: 3802 Greenway Baltimore MD 21218 Office: John Hopkins U Sch Hygiene Pub Health 615 N Wolfe St Baltimore MD 21205

THE WHITE HOUSE

WASHINGTON

June 8, 1989

copy to chase, original in my file "OSTP"
6/26/89 Sent to Chase

MEMORANDUM FOR JOHN H. SUNUNU

FROM: D. ALLAN BROMLEY Allan

SUBJECT: Associate Directors of OSTP

As we discussed earlier today, I should much appreciate it if we could initiate the FBI clearance and other paperwork that would be required were you and the President to accept my nomination of the following two very able individuals as Associate Directors of OSTP:

Dr. Thomas Ratchford
Dr. James Wyngaarden

I am enclosing up-to-date biographical data on each. As you will recall, these are Presidential appointments confirmed by the Senate.

I make this request in order to reduce the delay that would ensue were we to wait until after my own Senate confirmation to begin this process. Currently, we are hoping to meet the Commerce, Science and Transportation Committee reporting requirements so that my confirmation hearing can be scheduled for June 20. If we miss this window, the next opportunity will be in late July or early August.

Attachments

?, political check

Biographical Information

J. THOMAS RATCHFORD

Dr. J. Thomas Ratchford is the Associate Executive Officer of the American Association for the Advancement of Science (AAAS). At AAAS he serves as deputy to the chief executive officer and heads the Association's six program offices.

Educated and trained as a solid state physicist, he taught at Washington and Lee University and has served on research staffs of various private and governmental laboratories. From 1964 to 1970, he was responsible for formulating and administering a basic research program in the solid state sciences for the Office of Scientific Research of the Department of the Air Force. Dr. Ratchford served on the professional staff of the Committee on Science and Technology of the United States House of Representatives from 1970 to 1977, and was one of the first scientists to serve the Congress on a full-time basis. His responsibilities there dealt mainly with policy and funding for science and for energy research and development.

As a Congressional Fellow of the American Political Science Association during 1968-69, he served in the offices of Members of the House and Senate with particular interests in scientific and technological issues. In 1976 Dr. Ratchford was a Research Scholar at the International Institute for Applied Systems Analysis in Laxenburg, Austria, doing research on the economics and technologies of global energy system.

Over the years he has chaired outside advisory panels for organizations such as the Gas Research Institute and the Congressional Office of Technology Assessment, and has served as consultant and advisor to governmental, university and industrial organizations. He recently completed a three-year term as chair of the National Science Foundation's Advisory Committee on International Programs. Formerly Secretary of the International Development Conference, he remains a trustee of that organization.

Dr. Ratchford received his B.S. in mathematics and physics from Davidson College in 1957. The University of Virginia awarded him an M.A. in 1959 and a Ph.D. in 1961, both in physics. A member of Phi Beta Kappa and Sigma Xi, he is a Fellow of the AAAS and a member of the American Physical Society and the Virginia Academy of Science.

12/88

JAMES BARNES WYNGAARDEN, M.D.

Director, National Institutes of Health
U.S. Public Health Service
Department of Health and Human Services

Born October 19, 1924, East Grand Rapids, Michigan

Education Calvin College, 1942-43, Western Michigan University, 1943-44. M.D., University of Michigan Medical School, 1948.

Professional History Intern and Resident, Massachusetts General Hospital, Boston, 1948-52. Visiting Investigator, Public Health Research Institute of the City of New York, New York, 1952-53. Investigator, National Heart Institute, NIH, 1953-54, National Institute of Arthritis and Metabolic Diseases, NIH, 1954-56. Clinical Instructor in Medicine, George Washington University, Washington, D.C., 1954-56. Associate Professor of Medicine, Duke University Medical Center, Durham, North Carolina, 1956-59. Associate Professor of Medicine and Biochemistry, Duke University, 1959-61. Professor of Medicine and Associate Professor of Biochemistry, Duke University, 1961-65. Visiting Scientist, Institut de Biologie-Physiochemique, Paris, 1963-64. Frank Wistar Thomas Professor and Chairman, Department of Medicine, and Professor of Biochemistry, University of Pennsylvania School of Medicine, Philadelphia, 1965-67. Physician-in-Chief, Medical Service, Hospital of the University of Pennsylvania, 1965-67. Frederic M. Hanes Professor and Chairman, Department of Medicine, Duke University, 1967-82. Physician-in-Chief, Medical Service, Duke University Hospital, 1967-82. Chief of Staff, Duke University Hospital, 1981-82. Director, National Institutes of Health, 1982-present.

Professional Organizations American Academy of Arts and Sciences, American Association for the Advancement of Science, American Board of Internal Medicine, American Clinical and Climatological Association, American College of Physicians, American Federation for Clinical Research, American Rheumatism Association, American Society for Clinical Investigation, American Society of Biological Chemists, Association of American Physicians, Endocrine Society, National Academy of Sciences, NAS/Institute of Medicine, Southern Society for Clinical Investigation, Sigma Xi.

Honors, Awards University Scholar in Professional Schools (Medical), University of Michigan, 1946. Alpha Omega Alpha (University of Michigan), 1947. Cum laude with First Honors, University of Michigan, 1948. Dalton Scholar in Medicine, Massachusetts General Hospital, 1948. Honorary Membership in the Italian Society of Rheumatology, 1961. Consultant to the Office of Science and Technology, Executive Office of the President, 1966-72. Sesquicentennial Award, University of Michigan, 1967. Appointed to the President's Science Advisory Committee, 1972. Modern Medicine Award for Distinguished Achievement, 1974. Election to the National Academy of Sciences, 1974. North Carolina Governor's Award in Science, 1974. Appointed to the President's Committee for the National Medal of Science, 1977-80. Founder's Medal, Southern Society for Clinical Investigation, 1978. The John Phillips Memorial Award, American College of Physicians, 1980. Honorary Membership in the Sociedad Medica de Santiago de Chile, 1981. Fellow of the Royal College of Physicians of London, 1984. Distinguished Alumnus Award, Western Michigan University, 1984. Election to Royal Academy of Sciences of Sweden, 1987. U.S.-Israel Binational Foundation Board of Governors, 1987. French and American AIDS Foundation Board of Trustees, 1987. World AIDS Foundation Board of Directors, 1987. Chairman, Biotechnology Sciences Coordinating Committee, OSTP, 1988.

Honorary Degrees University of Michigan, D.Sc., 1980. Medical College of Ohio, D.Sc., 1984. University of Illinois at Chicago, D.Sc., 1985. George Washington University, D.Sc., 1986. Tel Aviv University, Israel, Ph.D., 1987.

The Federal High Performance Computing Program

Executive Office of the President
Office of Science and Technology Policy
September 8, 1989

The Federal High Performance Computing Program

High Performance Computing Systems

Research for Future Generations

System Design Tools

Advanced Prototype Development

Evaluation of Early Systems

Advanced Software Technology and Algorithms

Support for Grand Challenges

Software Components and Tools

Computational Techniques

High Performance Computing Research Centers

National Research and Education Network

Interagency Interim NREN

Gigabits Research and Development

Deployment of Gigabits NREN

Structured Transition to Commercial Service

Basic Research and Human Resources

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

In November 1987, my predecessor, William R. Graham, transmitted to Congress A Research and Development Strategy for High Performance Computing. That report laid out a five-year strategy for federally supported R&D on high performance computing, including hardware for state-of-the-art supercomputers, software, computer networks, and supporting infrastructure. It was written with the assistance of the Committee on Computer Research and Applications under the OSTP Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). This strategy document was to be followed by a detailed program plan.

I am pleased to transmit to Congress that program plan -- the result of an intense interagency effort by a special task force within the Committee on Computer Research and Applications. Following the general organizational structure of the 1987 strategy report, it lays out a broad R&D policy and program plan designed to advance U.S. leadership in high performance computing. This plan calls for a federally coordinated government, industry, and university collaboration to accelerate the development of high speed computer networks and to accelerate the rate at which high performance computing technologies -- both hardware and software -- can be developed, commercialized, and applied to leading-edge problems of national significance.

High performance computing is a vital and strategic technology, exerting strong leverage on the rest of the computer industry and other cutting-edge areas. However, U.S. leadership and diversity in the supercomputer industry itself has declined dramatically; and history shows that a scant 15 years separates the first appearance of a top-of-the-line supercomputer from the appearance of that same computing power in the higher end of the personal computer market. A future national high speed computer network could have the kind of catalytic effect on our society, industries, and universities that the telephone system has had during the twentieth century.

We cannot afford to cede our historical leadership in high performance computing and in its applications. We need to encourage the dynamism of the U.S. computer industry and, hence, our economy. I would ask all of the federal agencies with research programs in high performance computing to work toward implementing the recommendations in this report.

D. Allan Bromley
Director

Foreword

High Performance Computing is a powerful tool to increase productivity in industrial design and manufacturing, scientific research, communications, and information management. It represents the leading edge of a multi-billion dollar world market, in which the U.S. is increasingly being challenged. A strong, fully competitive domestic high performance computer industry contributes to U.S. leadership in critical national security areas and in broad sectors of the civilian economy, including the technical base for many national economic and military security needs. For this reason we are initiating the preliminary planning to address this important U.S. technology.

GOALS

Accordingly, the goals of the Federal High Performance Computing (HPC) Program are to:

- Maintain and extend U.S. leadership in high performance computing, and encourage U.S. sources of production;
- Encourage innovation in high performance computing technologies by increasing their diffusion and assimilation into the U.S. science and engineering communities; and
- Support U.S. economic competitiveness and productivity through greater utilization of networked high performance computing in analysis, design, and manufacturing.

COMPONENTS

The HPC Program is implemented through four complementary, closely coordinated, multidisciplinary Components:

- High Performance Computing Systems;
- Advanced Software Technology and Algorithms;
- The National Research and Education Network; and
- Basic Research and Human Resources.

POLICY

The Federal High Performance Computing (HPC) Program features increased cooperation between business, academia and government. While each of these sectors will retain its current role, the success of this Program will depend in large part on an effective transition from R&D to commercialization—an outcome of successful cooperation among the above sectors.

The measure of success of this Program in the area of R&D will be an increased rate of development of new computing concepts, systems, and architectures. A longer term measure of success will be the rate at which this technological progress shows up in commercialized products. The HPC Program will be consistent with the traditional roles of government, business and academia.

Specifically:

- The government will provide R&D support for HPC and will coordinate R&D among its agencies;
- Business will be the decision maker and source of capital investment for commercialization of HPC technology in response to its assessment of market opportunities; and
- Universities and Federal laboratories will be the primary institutions receiving government funding under this Program.

The government will, in addition, foster a number of mechanisms for increased collaboration and interaction among government, business and universities. Specifically:

- The government will continue to serve as a market for commercial prototypes and for commercial products. This particularly will be the case in the defense sector. These markets will exist in U.S. laboratories, Federal agencies, university centers of excellence and industrially led consortia;
- The government will assist in the development of industrially–led consortia in cases where appropriate (an existing example is SEMATECH); and
- The government will promote centers of excellence, jointly funded and staffed by government, academia, and industry. Technology transfer to industry from government and academia will happen automatically as a result of this ongoing collaboration.

Foreign policy objectives will be supported through existing or future international science and technology agreements. "Symmetry and reciprocity," protection of U.S. proprietary interests, and enforcement of intellectual property rights will continue to be guiding principles.

The Federal High Performance Computing Program will ensure the broadest possible national benefit by addressing:

- Many problems susceptible to computational solution;
- A wide geographic and demographic distribution; and
- The inclusion of government, academia and industry.

STRATEGY

To achieve the policy goals of the HPC Program, our strategy is to:

- Support computational advances through R&D effort to address U.S. scientific and technical challenges;
- Reduce the uncertainties to industry for development and use of this technology though increased cooperation among government, industry and academia and the continued use of government and government–funded facilities as a market for HPC prototypes and commercial products;

- Support the underlying research, network and computational infrastructures on which U.S. high performance computing technology is based; and
- Support the U.S. human resource base to meet needs of industry, academia and government.

ROLE OF FEDERAL, ACADEMIC AND INDUSTRIAL SECTORS

Federal agencies

- Funding for the Program will come from agencies their annual appropriations;
- User agencies will continue to define their respective missions and goals, though guided by the High Performance Computing Program goals and objectives; and
- OSTP, through its Federal Coordinating Council on Science, Engineering, and Technology (FCCSET) Committee on Computer Research and Applications, will assist the agencies as part of its continuing responsibility for coordination and policy guidance. OSTP will also assist by recommending special computational opportunities. However, final priority setting will reside with the respective agencies.

Academia

Universities and colleges will participate in the HPC Program in the following ways:

- Responding to agency program announcements;
- Forming consortia with government and industry;
- Focusing research capabilities on specific areas of computational science;
- Enhancing curricula to take advantage of new generations of computing technologies, attracting additional manpower into various disciplines of computational science; and
- Bringing the Program to the attention of State leaders for potential leveraging of Federal funds.

Industry

- Private industry will develop hardware, software, and networks in response to the Program. Commercialization will be at the initiative and discretion of private industry;
- Industry will join and help finance university or government laboratory R&D activities (at its choosing) to obtain access to expertise and government funded facilities. As a result of these collaborative relationships, the partnership will supply industry with R&D and technology information;
- A broadly representative industry body will assist in making long-range demand and robustness projections for: high capacity research networks; the spectrum of

computer architectures; the adequacy of software development; and the level of the manpower pool. This body will help assure a smooth transition between successive generations of high performance computing systems; and

- Private industry suppliers will provide the network services to Federal agencies in the first two stages of the National Research and Education Network. Industry should plan to operate the NREN fully as soon as feasible.

FUNDING OF THE HPC PROGRAM

The magnitude of the program envisioned by this Program will require major new Federal R&D investment. It is assumed that existing Federal base funding for computer and information science and technology research and development, roughly $500 million annually, will continue. Preliminary planning estimates suggest that the first year of the program would require an augmentation of $150 million, which would then grow to an incremented annual level of $600 million by the fifth year.

MANAGEMENT OF THE HPC PROGRAM

The components of the Program will be managed by existing Federal agencies.

Oversight of the HPC Program will be the responsibility of the Office of Science and Technology Policy with the assistance of the FCCSET Committee on Computer Research and Applications and the help of a High Performance Computing advisory panel which will report to the Director of OSTP:

- The HPC advisory panel will interact regularly with the FCCSET Committee on Computer Research and Applications; and
- The HPC advisory panel will have representation from all sectors and will monitor the progress of the Program for cross-sector balance, breadth of applicability, network security, competitiveness versus international cooperation, and technology transfer effectiveness.

SCOPE OF THIS REPORT

This report is designed for agency-level planning purposes and does not represent the Administration's approval or support of any program not included in the President's budget requests. Programs discussed in this document are subject to budget constraints and Administration approval.

TABLE OF CONTENTS

1. Executive Summary

*High Performance Computing** is a pervasive and powerful technology for industrial design and manufacturing, scientific research, communications, and information management. A strong U.S. high performance computer industry contributes to our leadership in critical national security areas and competitiveness in broad sectors of the civilian economy.

The goals of the High Performance Computing Program are to:

Goals

- Maintain and extend U.S. leadership in high performance computing, and encourage U.S. sources of production;
- Encourage the pace of innovation in high performance computing technologies by increasing their diffusion and assimilation into the U.S. science and engineering communities; and
- Support U.S. economic competitiveness and productivity through greater utilization of networked high performance computing in analysis, design, and manufacturing.

Strategy

These goals will be accomplished through Federally coordinated government, industry, and university collaboration to:

- Support computational advances through a more vigorous R&D effort to expedite solutions to U.S. scientific and technical challenges;
- Reduce the uncertainties to industry for R&D and use of this technology through increased cooperation between government, industry and academia and the continued use of government and government-funded facilities as a market for HPC early commercial products;
- Support the underlying research, network and computational infrastructures on which U.S. high performance computing technology is based; and
- Support the U.S. human resource base to meet needs of industry, academia and government.

* *High performance computing* refers to the full range of advanced computing technologies including existing supercomputer systems, special purpose and experimental systems, and the new generation of large scale parallel systems.

The HPC Program

The Program will consist of four complementary, coordinated components in each of the key areas of high performance computing. The components are planned carefully to produce not only long term results but a succession of intermediate national benefits. Figure 1 shows the relationship of the components of the Program. The High Performance Computing Program will build on those programs already in place, providing additional funds in carefully selected areas to meet its goals. Selected computational challenges, which will have significant effect on national leadership in science and technology, will be used as focal points for these efforts.

High Performance Computing Systems: The United States' leadership in supercomputing is increasingly being challenged. We have developed new, more powerful supercomputing architectures based on innovations. Particularly in parallel processing, we must capitalize on these innovations. To do this, a long range effort involving Federal support will be required for basic research on high performance computing technology and the appropriate transfer of research and technology to U.S. industry, consisting of efforts in the following areas:

- Research for future generations of computing;
- System design tools;
- Advanced prototype development; and
- Evaluation of early systems.

Advanced Software Technology and Algorithms: Historically, software improvements have increased computational performance much more than hardware investments. Yet software productivity is generally poor, and existing software can seldom be re-used without modification. In computing systems for industrial, scientific and military applications, software costs have exceeded those of hardware more than fivefold. Advances in software will be critical to the success of high performance computers with massively parallel architectures. To improve software productivity, an interagency effort will support joint research among government, industry and universities to improve basic software tools, data management, languages, algorithms, and associated computational theory with broad applicability for the *Grand Challenge** problems. These complex problems will require advances in software that have widespread applicability to computational problems in science and technology.

* A *Grand Challenge* is a fundamental problem in science or engineering, with broad economic and scientific impact, that could be advanced by applying high performance computing resources.

Effort in this component focuses on:

- Support for Grand Challenges;
- Software components and tools;
- Computational techniques; and
- High performance computing research centers.

National Research and Education Network: For the past decade technology developed by the U.S. has been available to eliminate distance as a factor in computer access and in collaborations among high technology workers. To maintain our leadership, the U.S. government, together with industry and universities, will jointly develop a high-speed research network to provide a distributed computing capability linking government, industry and higher education communities. This network will serve as a prototype for future commercial networks which will become the basis for a distributed industrial base. This component will consist of:

- An interagency effort to establish an interim National Research and Education Network;
- Research and development for a billions of bits per second (gigabits) network adequate to support national research needs;
- Deployment of the gigabits National Research and Education Network; and
- Structured transition to commercial service.

Basic Research and Human Resources: U.S. universities are not meeting the expanding needs of industry for trained workers in computer technology. There is not an adequate number of high quality computer science departments in this country, and many industrial and Federal laboratories have inadequate research capabilities. Furthermore, existing university, government, and industrial groups do not collaborate effectively enough, and their interdisciplinary activities are too limited. To correct these deficiencies a long term effort to support basic research in computer science and engineering (creating computing systems) will be established by building upon existing programs. This component will also establish industry, university, and government partnerships to improve the training and utilization of personnel and to expand the base of research and development personnel in computational science and technology (using computers).

Organization

Leadership of the Program is the responsibility of the Office of Science and Technology Policy, through the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) Committee on Computer Research and Applications, whose members include representatives of the key agencies that fund R&D in high performance computing. Duties and responsibilities of the Committee include:

- Interagency planning and coordination;
- Technology assessment;
- Policy recommendations to OSTP; and
- Formal annual reports of progress to OSTP.

A High Performance Computing Advisory Panel will be formed, consisting of eminent individuals from government, industry, and academia. Members of the Advisory Panel will be selected by and will report to the Director of OSTP. The Panel will provide the Director and the Committee on Computer Research and Applications with an independent assessment of:

- Progress of the Program in accomplishing its objectives;
- Continued relevance of the Program goals over time;
- Overall balance among the Program Components; and
- Success in strengthening U.S. leadership in high performance computing, and integration of these technologies into the mainstream of U.S. science and industry.

This implementation plan was prepared by the FCCSET Committee on Computer Research and Applications under the leadership of the Office of Science and Technology Policy. It represents a broad spectrum of government, industrial and university interests. The Committee has established subcommittees that will be responsible for planning, organizing, monitoring and coordinating the components of the Program.

SCOPE OF THIS REPORT

This report is designed for agency-level planning purposes and does not represent the Administration's approval or support of any program not included in the President's budget request. Programs discussed in this document are subject to budget constraints and Administration approval.

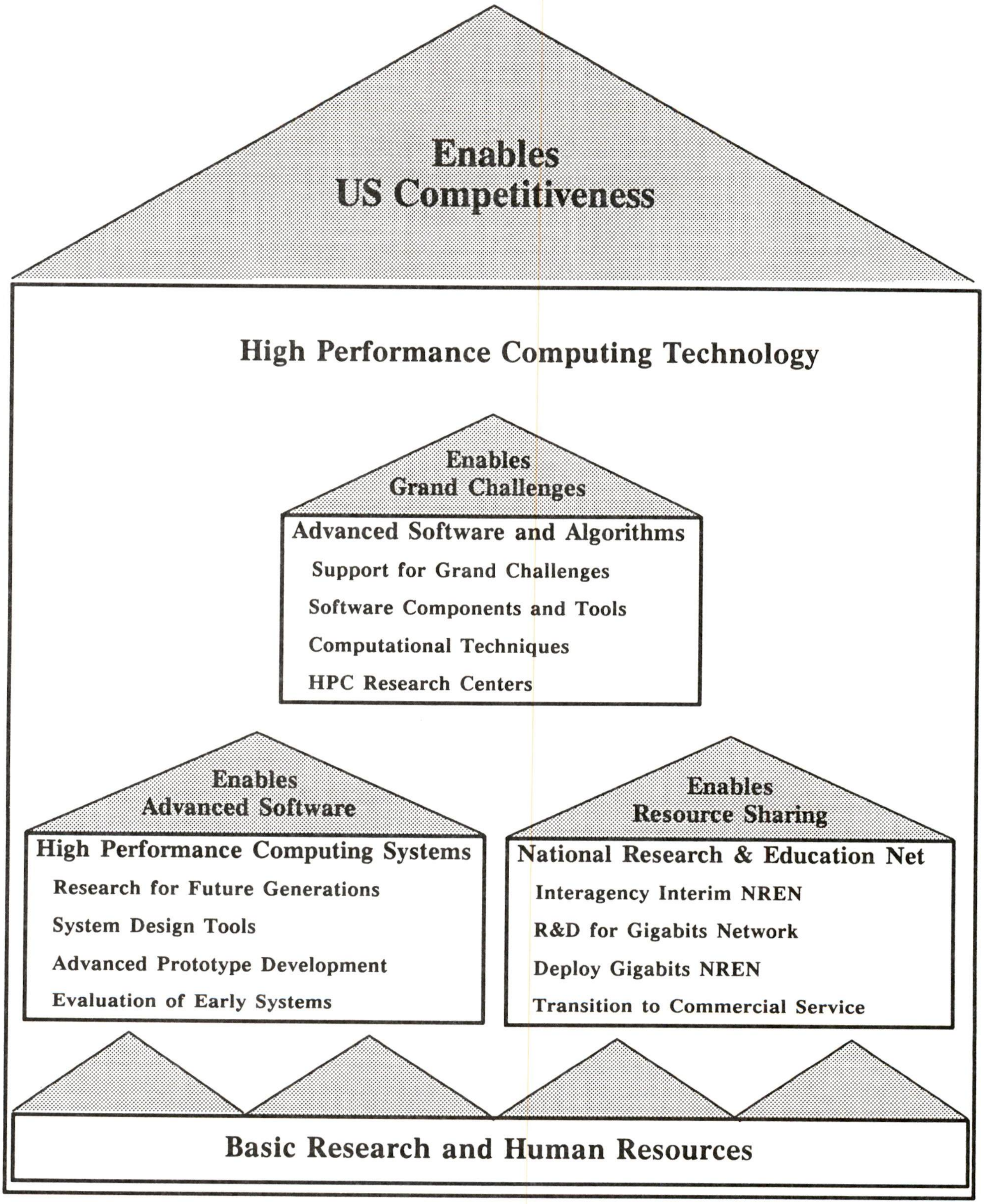

Fig. 1 – Relationship of HPC Program Components

2. Introduction

Purpose and Scope of Report

The purpose of this document is to provide the initial implementation plan for the U.S. High Performance Computing Program. This plan encompasses the first five year period and provides for periodic reviews to be conducted by the Federal Coordinating Council on Science, Engineering and Technology (FCCSET) with the participation of government, industry, and university representatives.

This document discusses:

- National economic and technical issues associated with high performance computing;
- Goals and strategy of this Program;
- Plans for synergistic government, industrial, and university participation;
- Organizational structure to coordinate, manage and review the Program program;
- Economic and technical benefits of the Program; and
- Proposed budget for the first five years of the Program.

This implementation plan was prepared by the FCCSET Committee on Computer Research and Applications under the leadership of the Office of Science and Technology Policy. It represents a broad spectrum of government, industrial, and university interests. This report is designed for agency-level planning purposes and does not represent the Administration's approval or support of any program not included in the President's budget request. Programs discussed in this document are subject to budget constraints and Administration approval.

Background

The Federal Coordinating Council on Science, Engineering and Technology (FCCSET), chartered by the Office of Science and Technology Policy (OSTP), coordinates Federal interagency activities of broad national interest. The FCCSET Committee on Computer Research and Applications serves as the forum for developing a national agenda for computing technology needs, opportunities, and trends.

This FCCSET Committee has examined the scientific, technological and economic effects of high performance computing. The Committee issued reports as early as 1983 that assessed the status of high performance computing and possible supporting government activities. These studies have consistently demonstrated the need for a strategy to coordinate high performance computing related activities in the government, industrial and university sectors. Dramatic increases in foreign investments in computer related technology have been noted, which challenge the world leadership of the U.S. computing industry. The studies also emphasized that advances in critical areas of national security and broad sectors of the civilian economy depend strongly on high performance computing technology.

The unprecedented power of high performance computing systems has created a new mode of scientific research: computational investigations that complement the traditional modes of experiment and theory. Computational research is being applied to a wide range of scientific and engineering problems called Grand Challenges. *A Grand Challenge is a fundamental problem in science or engineering, with potentially broad economic, political, and/or scientific impact, that could be advanced by applying high performance computing resources.* While the Grand Challenges are already being addressed to some extent using existing supercomputers, progress is often severely limited by current computer speeds and memory capacities. Examples of Grand Challenges are:

(1) Computational fluid dynamics for the design of hypersonic aircraft or efficient automobile bodies and recovery of oil.

(2) Computer based weather and climate forecasts, and understanding of global environmental changes.

(3) Electronic structure calculations for the design of new materials such as chemical catalysts, immunological agents and superconductors.

(4) Plasma dynamics for fusion energy technology and for safe and efficient military technology.

(5) Calculations to improve our understanding of the fundamental nature of matter, including quantum chromodynamics and condensed matter theory.

(6) Machine vision to enable real-time analysis of complex images for control of mechanical systems.

The sample Grand Challenge areas provided in Appendix A are representative of the science and technology areas that will be affected by application of leading edge computational resources and supporting systems. Figure 2 illustrates some of the Grand Challenges that can be adequately addressed through existing high performance computing technology and problems that could be attacked much more successfully with a thousandfold increase in performance.

2. Introduction

Agency Activities: In the early 1980's, Federal agencies initiated programs that provide the basis for the opportunities described in this Program. The NSF established the National Supercomputer Centers to provide high performance computers to the science and engineering community and interconnected them with the research community via the NSFNET. The centers and network have stimulated the development of innovative computational approaches to a wide range of scientific and engineering problems related to the Grand Challenges. NSF also reorganized to create a new Directorate of Computer and Information Science and Engineering (CISE) with increased emphasis and funding for computer and computational disciplines, with a focus on computer networking as a tool for scientific and engineering research.

DARPA initiated the Strategic Computing program to accelerate development of an alternate approach to building high performance computer systems. This program focuses on large scale parallel systems, custom VLSI and associated software, including symbolic processing for the advanced functionality characterized by artificial intelligence. Strategic Computing stimulated the first generation of commercially available scalable parallel computer systems using conservative components and packaging. Early production models of these systems were acquired by several agencies for experimental use. A second generation of these systems is being developed, using custom VLSI. The military services have participated in this program, providing applications focus and technical consultation.

The Office of Naval Research, Air Force Office of Scientific Research, and Army Research Office have separately sponsored important research and development in basic research for advanced computing.

The DOE expanded the National Magnetic Fusion Computer Center and its MFE Network to serve all energy research users in national laboratories, universities, and industry. Several of the National Laboratories have formed computational groups to experiment with novel high performance computers and to develop algorithms that exploit the power of those computers. Special funding was provided to enable university, industry, laboratory collaborations with the national laboratories to acquire parallel computer prototypes to test ideas for advanced high performance computing architectures.

NASA upgraded the computational capability at several of its research and flight centers and established a data network to link them together. At the Ames Research Center, the Numerical Aerodynamics Simulation (NAS) was set up to provide a focused attack on computational aerodynamics employing the highest powered computers available surrounded by data reduction and visualization systems.

HPC Strategy: In 1986 Congress requested that OSTP conduct a study of the critical problems and options for communication networks that support the U.S. high performance computing environment. The charter of the FCCSET Committee on Computer Research and Applications was broadened to include the technical aspects of this study. A number of working groups were formed to ensure a perspective that spanned all aspects of the U.S. high performance computing environment. In addition a consortium of government, industry and university experts focused on national infrastructure requirements for high performance computing.* The FCCSET study is documented in "A Research and Development Strategy for High Performance Computing" also known as the *High Performance Computing Strategy (HPC Strategy)*, published by the Office of Science and Technology Policy (included as Appendix B). It provides the foundation for this Program.

The *HPC Strategy* findings were:

- A strong domestic high performance computer industry contributes to maintaining U.S. leadership in critical national security areas and in broad sectors of the civilian economy.
- Research progress and technology transfer in software and applications must keep pace with advances in computing architectures and microelectronics.
- The U.S. faces serious challenges in networking technology which could become a barrier to the advance and use of computing technology in science and engineering.
- Federal research and development funding has established laboratories in universities, industry, and government which have become the major sources of innovation in the development and use of computing technology.

The recommendations of the *HPC Strategy* form the basis for the four components of the High Performance Computing Program.

Four National Research Council reports issued in the period following publication of the *HPC Strategy* have confirmed its findings and emphasized the need to carry out its recommendations: *Toward a National Research Network* (1988), *The National Challenge in Computer Science and Technology* (1988), *Global Trends in Computer Technology and Their Impact on Export Control* (1988), and *Information Technology and the Conduct of Research* (1989).

In December 1988, the Office of Science and Technology Policy charged the FCCSET Committee on Computer Research and Applications to develop this implementation plan for the High Performance Computing Program. The goals, strategy, and actions to implement the Program are discussed in the following sections.

* *A National Computing Initiative*,
Society for Industrial and Applied Mathematics, Philadelphia, PA 1987.

What is High Performance Computing?

High Performance Computing refers to a productive computing environment that includes high performance components, system and applications software, networking, and the underlying research and human resource infrastructure.

High performance computing systems are those at the forefront of the computing field in terms of computational power, storage capability, input/output bandwidth, and software. These systems include high speed vector and pipeline machines, special purpose and experimental systems, scalable parallel architectures, and associated mass storage systems, input/output units, and systems software. Underlying these advanced systems are microelectronics, optoelectronics, logic devices, and storage technologies.

Advanced software technology and algorithms includes general–purpose operating systems for high performance computer systems and tools and utilities, such as compilers, analysis tools, debuggers, and data management systems. Mathematical algorithms and other general purpose libraries facilitate the use of high performance computers for science and engineering. Software tools will allow high performance computing systems to be embedded transparently in a distributed environment which includes applications specific software and other specialized methods and algorithms. The technology base required to build such environments includes software engineering and data management tools, and basic research in high–level languages and algorithms. Improving these capabilities will greatly enhance scientific and engineering software productivity.

Computer network technology consists of communications and switching capable of providing a very high speed backbone on which the high performance computing environment is distributed. Internetworking and feeder network technology connects local or mid–level high speed networks to the national high speed network. User services such as directories are also essential components of an effective networking environment. Advanced networks will provide improved access to high performance computing systems and increased collaboration opportunities for universities, industry, and government.

Development of high performance computing environments requires a long term, continuing investment in basic research over a wide spectrum of computer and computational science and engineering. A basic infrastructure of knowledge, research, computing facilities, and people are required to create and exploit high performance computing technology.

Why is High Performance Computing Important to the U.S.?

During the last two decades computing has become an important complement to experimental and theoretical research. Computer aided design and engineering techniques are replacing manual ones. Computer assisted and automated manufacturing is increasing productivity and improving the value and reliability of industrial products, while reducing the time required for engineering and manufacturing cycles. New knowledge and new industries are increasingly dependent upon computing.

Most of these advances in computing have originated in the United States. However, many of them have been most successfully applied in other countries, where their use has eroded the competitive edge that the U.S. had previously enjoyed. This Program is intended to maintain the U.S. edge by focusing our research advantage in high performance computing toward applications with high value to our economy and national security. Fortunately, current U.S. leadership in high performance computing offers a strategic opportunity to maintain our industrial momentum. The HPC Program provides a way to do this.

The national economic benefits of a strong high performance computing industry are recognized and pursued by other countries. Those nations have formed and funded collaborations between their private and public sectors. Their successes constitute vigorous competition for technological and economic leadership in high performance computing. Foreign computing industries benefit tremendously from government support. To retain our leadership, domestic industrial efforts must be encouraged by a strategy that shares the economic risk of innovation in this capital-intensive field.

National economy: High performance computing is by definition the leading edge of computing technology, which in turn supports many areas of science and technology. Computing constitutes a significant portion of the U.S. economy. For example, in 1988 the U.S. computing industry accounted for 10% of GNP, and almost 10% of all capital investment.* The pace of innovation that it sets pervades the domestic computing industry technology and economics. In terms of capability, today's supercomputer is tomorrow's desk-top workstation and the following day's classroom tool. Thus, U.S. competitive success in the world computing market is supported by leadership in high performance computing.

National security: High performance computing technology is used in critical national security areas. Examples include advanced computer systems architectures, computer network communication technology, and signal processing techniques. Continued acceleration of this technology, including availability of U.S. sources of production, is important to U.S. national security.

Science and technology: High performance computing provides a basis for other innovative scientific and engineering efforts. The pace of rapidly developing technologies, such as robotics, artificial intelligence, communications, high definition

* *The National Challenge in Computer Science and Technology,* National Academy Press, Washington, D.C., 1988, p. 7.

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television (HDTV), campus network applications, semiconductor design, superconductivity, transportation, speech recognition, and data visualization are all dependent on a strong and innovative high performance computing industry.

Manufacturing: High performance computing constitutes an important tool for many industries. Its use in simulation and design improves the productivity of large industries such as aircraft production and automobile manufacturing and is rapidly being extended to other industries. Recent vigorous growth in use of high performance computing in electronics, energy, chemical and pharmaceutical industries illustrates the role of computing in the long term strength of the U.S. economy.

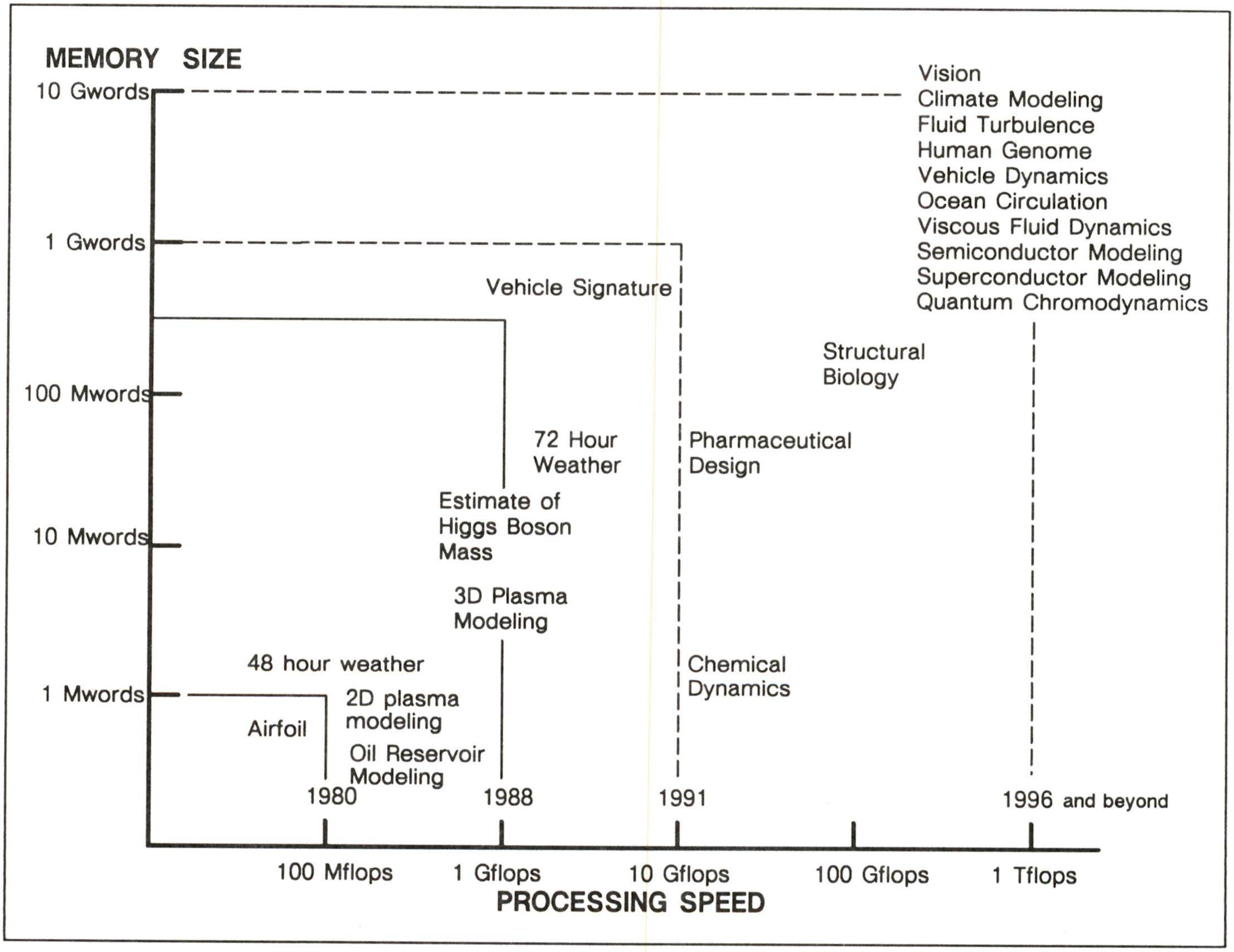


Fig. 2 – Some Grand Challenges and their Projected Computational Requirements

3. Program Plan

Introduction

The goals of the High Performance Computing Program are to:

- Maintain and extend U.S. leadership in high performance computing, and encourage U.S. sources of production;
- Encourage innovation in high performance computing technologies by increasing their diffusion and assimilation into the U.S. science and engineering communities; and
- Support U.S. economic competitiveness and productivity through greater utilization of networked high performance computing in analysis, design, and manufacturing.

To achieve these goals, a strategy has been established to:

- Support computational advances through R&D efforts to address U.S. scientific and technical challenges;
- Increase the use of this technology by reducing the uncertainties to industry for R&D and by increasing cooperation among government, industry, and academia;
- Continue use of government and government-funded facilities as a market for HPC early commercial products;
- Support the underlying research, network and computational infrastructures on which U.S. high performance computing technology is based; and
- Support the U.S. human resource base to meet needs of industry, academia and government.

The HPC Program is composed of four coordinated program components: High Performance Computing Systems, Advanced Software Technology and Algorithms, the National Research and Education Network, and Basic Research and Human Resources. Each of the four program components stimulates the development of progressively more advanced products for use throughout computing technology. The four areas build upon each other and upon the existing research base, as illustrated in Figure 1. Each component carries out a recommendation of the November 20, 1987 *HPC Strategy* (see Appendix C.)

Although the program components are described separately, they are interdependent, so that success of the Program depends on balanced support for all of them. For example, the development of high performance computing systems depends on development of advanced software technology and algorithms, because algorithm and software requirements largely determine the corresponding architecture of successful computing systems. Similarly, as the new computing systems become available, new algorithms and software systems are required to take advantage of their capabilities and allow the systems to be used in practical ways.

The High Performance Computing Program requires an unprecedented level of coordination among agencies of the Federal government that are involved in high performance computing. The agencies involved have already begun cooperation to meet this challenge in order to mount a sufficiently comprehensive program in support of U.S. competitiveness.

The remainder of this section describes the goals for each of the four components of the Program, the actions that will be taken to achieve these goals, and the responsibilities of each of the participating federal agencies. Although the Program builds on the existing research base, its goals extrapolate significantly from those of the base and will require significant additional funding. This funding is presented in Table 1 at the end of the plan, with the funding elements keyed to each component and action of the Program.

High Performance Computing Systems

Recommendation: The U.S. Government should establish a long range strategy for Federal support for basic research on high performance computer technology and the appropriate transfer of research and technology to U.S. industry. [*HPC Strategy*, 1987]

Goals

High performance computing systems consist of processors, memory, mass storage, input/output, and associated system software. The systems are characterized in this report by overall sustained performance on large problems. They will be designed so that memory capacities, storage sizes and input/output rates scale to provide sustained performance in proportion to processing.

The goal is to support the development of high performance computing systems which will be capable of sustaining trillions of operations per second on significant problems. The program builds upon present government supported efforts which have established U.S. leadership in developing large scale computer systems and the underlying component technologies. However, achieving and effectively exploiting this thousandfold improvement in performance will require developing a new technology base through a program of research in computer architectures, microelectronics and packaging, and associated systems software .

A primary objective of the plan is to assist the continued viability of domestic sources of high performance computers and their critical components that meet the requirements of U.S. industry and Federal programs, both civil and defense. The plan will focus Federally funded research and promote transfer of results between Federally–funded research programs and U.S. industry. This requires close collaboration of researchers in the nation's universities and government laboratories with industrial scientists and engineers. Government funding will also assist risk reduction in critical areas and will complement private capital in the computer market.

To date Federal investment in high performance computing systems has taken two forms: (1) purchase of early market and production model systems and (2) research and development which has the led to commercial high performance systems. In both cases Federal funding has reduced the R&D risk of the high performance computing systems for U.S. manufacturers. Because many foreign computer manufacturers are willing to accept greater R&D risk due to their financial environment, the Federal strategy has been important in maintaining U.S. technical leadership in high performance computing systems.

Early purchase has served several critical functions. It has often provided essential financial assistance and early technical feedback to manufacturers during production of their first model of a new high performance computing system. The substantial computational resources provided by these early purchases have maintained the rapid technological advance of the U.S. in both civil and defense sectors, thereby supporting the nation's economic and military security. Early users have devised efficient ways of exploiting the capabilities of new systems, providing a performance characterization of the design. They have also furnished significant new concepts to be incorporated in the designs of succeeding generations. This information has often led to improvements leading to more viable commercial products.

For example, NASA and DOE encouraged industry to develop a more advanced supercomputer to meet their research needs, which resulted in the Cray 2 supercomputer. This powerful new machine with greatly expanded memory might not have achieved market acceptance without the identified high performance computing requirement and subsequent acquisition by these Federal agencies. DOE and NASA acquired the first Cray 2 systems, and their early experience showed the broader market for computational research the importance of memories of hundreds of million words and provided valuable feedback that led to engineering changes for better performance.

Federal research and development investment has facilitated advanced research partnerships between industrial firms and university researchers. Industry provides practical knowledge and advanced manufacturing technology to produce high performance computing systems, while universities have developed new concepts and experimental systems. The results of these partnerships have often been significant in supporting the U.S. economy and national security.

The DARPA Strategic Computing program, DOE, and NASA have funded industry/university partnerships which have established U.S. leadership in scalable, highly parallel, high performance computing systems. Unlike the present generation of supercomputers, the resulting systems employ hundreds to thousands of processors. These architectures are generally scalable to higher levels of parallelism and, in the future, can exploit higher performance components and packaging with corresponding increases in sustained performance. This program has produced very promising results: the first generation of scalable parallel systems are now commercially available and have demonstrated high performance in both numeric and non–numeric applications. The second generation of this class of high performance computers is now emerging and scientific, engineering, defense, and business users are preparing for their arrival. Additional results include enhanced performance for workstations, personal computers, mass storage, graphics and input/output systems.

This Component of the HPC Program will build on recent experience in coordinated funding by different agencies of high performance computing systems research and development. For example, the Strategic Computing program at DARPA invested in R&D for an advanced parallel computer which was subsequently commercialized by

Thinking Machines Corporation. DARPA then collaborated with DOE and NASA to facilitate early use of this system in their research laboratories. The NSF recently funded a Science and Technology Center at Rice University, California Institute of Technology, Argonne National Laboratory, and Los Alamos National Laboratory which will consider more effective applications of this and other parallel architectures.

Action Plan

The focused high performance computing systems projects in this plan will be undertaken in cooperation with the software development projects. The systems also must be coordinated with advances in networking to ensure that their potential performance is available to remote users via the National Research and Education Network. The advanced research tasks provide excellent training grounds for the next generation of computer and computational scientists and engineers. Collaboration among these components is essential to the success of the Program.

Research for future generations of computing: Research in computer science, scalable parallel computer architectures, high density packaging technology, VLSI technology and optoelectronics will be increased. New packaging and component technologies will be developed together with associated design, analysis, simulation, and testing tools to enable their use in implementing larger scale computer architectures. This includes creating and extending models of computation, together with sufficient efforts in adaptation of fundamental algorithms, operating systems, and programming languages. These systems–specific activities complement the more generic and applications–focused software described in Advanced Software Technology and Algorithms where the emphasis is to develop the full potential of the new architectures.

System design tools: Support for rapid design, prototyping, and integration is essential to reach the capabilities needed for the Program. Progress in research, development and manufacturing of high performance computing systems is presently limited by lack of adequate automated design and analysis tools. A new generation of design tools and techniques will be developed for integrated, computer–assisted design and manufacturing of high performance computing systems from functional specifications through full systems. The tools will be developed so as to provide rapid prototyping in support of research, interfaced with the latest advances in automated manufacturing so as to boost U.S. industrial capabilities in addition to increasing research and development productivity. These facilities will make use of the latest high–density packaging technology which will be required to create systems at the targeted level of performance.

Transfer of technology to stimulate advanced prototypes: Cooperative university/industry high–risk research and development projects will provide rapid technology transfer from research results to working prototypes. Revolutionary concepts are emerging from the frontiers of research in computer science and engineering, innovative computer architectures, mass storage systems, input/output systems, high density packaging, Very Large Scale Integration (VLSI) and optoelectronics. Government funds will be invested where opportunities exist for leverage to accelerate the transfer of the Federally–funded computing technology to American industry and vice versa. Advanced application–specific integrated circuits (ASICs) will be utilized where appropriate in these general purpose high performance computing systems. Joint projects in high risk areas will be pursued on a cost sharing basis with industry in close collaboration with government laboratories and academia. The focus of these projects will be to accelerate transition of high risk, revolutionary concepts from research laboratories into the commercial market while encouraging a domestic means of production for all critical components.

By the mid 1990s, it is expected that commercial advanced prototypes will be capable of sustaining two or three orders of magnitude better performance than today's systems for complex science, engineering, and defense applications, and for other problems of national importance. System software, including operating systems, programming languages, and software analysis tools, will be developed to determine the computational potential of the commercial systems. Performance analysis and measurement tools will be improved to enable the design and configuration of heterogeneous systems.

Evaluation of Early Systems: Evaluation of early production models of new high performance computing systems will be undertaken using representative problems. These systems will be acquired at the smallest scale that can evaluate their potential performance. The resulting evaluations will form a basis for decisions to develop the associated generic software and specific large scale applications in the Advanced Software Technology and Algorithms component. Needs of the Grand Challenges will be considered fully, and some early production models of high performance computers may be utilized in one or more of the Grand Challenges, at the sites performing this research.

This component of the HPC Program does not include acquisition of full scale systems. Some of these will be acquired under the High Performance Computing Research Centers in the Advanced Software Technology and Algorithms component; others will be purchased by Federal agencies to fulfill their missions. This investment will sustain the U.S. competitive edge and must be protected by ensuring appropriate export controls.

Rationale

Improvements in materials and component technology are advancing computer capability rapidly. Memory and logic circuits are continuing to improve in speed and density, but as fundamental physical limits are approached, advances are being sought through improved computer architectures, custom components, and software and algorithms. Application-specific integrated circuits, such as for real-time signal processing, are being incorporated into special purpose computing systems. Computer architectures have begun to evolve into large scale parallel systems. Scalable architectures provide a uniform approach that enables a wide range of capacity, from workstations to very high performance computers.

At current performance levels our ability to model many important science, engineering, and economic problems is still limited. Computational models which have been developed for these problems require for realistic solutions speeds of trillions of operations per second and corresponding improvement in memory size, mass storage, and input/output systems. *Achievement of this performance level in the next five years is feasible, based on extrapolations of processor capability, demonstrated architectures, number of processors, and improved software performance.*

Responsibilities

NSF, NASA, DOE and DOD share responsibility for long-range research on the foundations of high performance systems. Within the DOD this responsibility will rest with DARPA, the Army Research Office (ARO), the Office of Naval Research, (ONR) and the Air Force Office of Scientific Research (AFOSR). These agencies have all been involved in this area and have considerable knowledge of the status and opportunities.

DARPA will carry the prime responsibility for high-risk research and development leading to commercialization of highly parallel high performance computing systems and will work with ARO, ONR, and AFOSR to achieve this end. DARPA will also have the lead responsibility for supporting research facilities for rapid design, prototyping, and integration of these systems, using advanced components and packaging. DARPA's unique style of managing high risk, large scale projects is particularly effective for transfering technology in joint university and industrial efforts.

The DOE, NASA and DARPA will continue to acquire first production models of high performance computing systems. The diversity of interests represented by these agencies has been important to the broad range of systems developed by industry in the U.S.. This healthy arrangement will continue.

NIST will expand its program for development of measurement techniques and performance modeling for high performance computer systems, and will support transfer of this technology to industry.

Advanced Software Technology and Algorithms

Recommendation: The U.S. should take the lead in encouraging joint research with government, industry, and university participation to improve basic tools, languages, algorithms, and associated theory for the scientific Grand Challenges with widespread applicability. [*HPC Strategy*, 1987]

Goals

Sustained improvements in computing hardware performance and sophistication have resulted in a shift from hardware and architecture to software and algorithms as the primary determiners of the power, flexibility, and reliability of major computing systems. Today the ability to exploit computing technology to address scientific and technological problems of competitive and national importance is determined primarily by software capability.

Breakthroughs in software technology enable computer solutions to problems whose scale, complexity or evolving nature previously inhibited any organized approach. Breakthroughs in algorithm design improve problem solving performance by orders of magnitude, making tractable computational solutions in problem areas where previously no solutions of any sort, or only traditional analytical or experimental methods, were available.

The goal for the Software Technology and Algorithms component of the High Performance Computing Program is to develop a base of software technology and algorithms that (1) will enable solution of Grand Challenge application problems in science and engineering, and that (2) will have broad national impact on software productivity and on systems capability and reliability.

The approach taken is to develop the advanced algorithms and software technology required to address applications problems on the scale of Grand Challenges, while ensuring that the generic technology developed can be applied to a broad range of computational problems. This investment may lead to the development of commercial products, but only after the new concepts have been illustrated and their feasibility demonstrated. Therefore, specific investments will be made to reduce the risks associated with the transition and adoption of these advanced technologies.

The U.S. lead in many areas of science and technology will be closely linked to advances made on important fundamental problems identified as Grand Challenges. Grand Challenges come from many fields from basic science to applied technology. Their solutions will have significant, national-level impact across diverse fields of interest to many Federal agencies. Appendix A describes several Grand Challenges and the agencies concerned with their solutions.

Improvements in algorithm design and implementation are as important to total "user realized" system performance as are performance improvements in the computer systems in which these algorithms will be executed. High performance computing offers scientists and engineers the opportunity to simulate conditions that are difficult or impossible to create and measure. This new paradigm of computational science and engineering offers an important complement to traditional theoretical and experimental approaches, and it is already having major impact in many areas. New approaches combining numeric and symbolic methods are emerging. Development of new instruments and data generation methods in fields as diverse as genetics, seismology, and materials is accelerating demand for computational power. As problems grow to the size and complexity of Grand Challenges, and as computer architectures grow more complex in order to provide increased computing power, the software and algorithms challenge becomes significantly greater.

Effective exploitation of the performance potential of the emerging parallel systems poses a special challenge both to software technology and to algorithm design. The required software technology has many dimensions, ranging from systems software, advanced compilers, and languages, to programming environments for developing and adapting software, to large scale distributed data repositories. Also included are techniques for analyzing and constructing software with high reliability and numerical accuracy, design of high performance algorithms for solving generic problems on specific architectures, and development of algorithmic and software architectural approaches specific to solving the Grand Challenges.

Research in fundamental parallel algorithms is needed to provide a sufficient base of algorithms for high performance architectures. The characteristics of the generic algorithms are often strongly dependent on the computational model embodied in a particular machine architecture. Various models of parallelism yield different algorithms, as do heterogeneous systems configurations involving hybrid computational models.

Networking technology will also have significant influence on the design of algorithms for distributed systems. Fundamental algorithms must be specialized and combined to provide application-specific algorithms appropriate for the Grand Challenges. Algorithm design, development, optimization, and validation requires substantial resources and collaboration. Experimental facilities are a critical tool for developing and demonstrating applications and systems software, computer architectures, and networks.

Action Plan

Support for Grand Challenges: A principal focus of activity will be providing advanced software technology support to research groups collaborating to address the Grand Challenges. The purpose of this is not to provide sustaining support for this research, but rather to provide a means to reduce the risks assumed by Grand Challenge researchers when adopting innovative high performance computing technologies.

Collaborative groups will include scientists and engineers concerned with Grand Challenge areas, software and systems engineers, and algorithm designers. These groups will be supported by shared computational and experimental facilities, including professional software engineering support teams, linked together by the National Research and Education Network. Groups may also create a central administrative base, which can be located anywhere on the network. Experimental facilities, often called testbeds, are included in the network in order to provide real–time access to data streams and support for rapid validation of computational models.

Technical contributions arising from this investment will include development of application–specific codes for innovative high performance computing systems, design and analysis of algorithms for Grand Challenge problems, and architecture and performance assessment as it relates to specific applications.

Agencies will select Grand Challenge applications to be included in this Program on the basis of the national importance of the specific area and the extent of cost–sharing from sources directly concerned with the specific scientific and engineering applications. An additional consideration will be the leveraging potential in other areas, in particular the commercial domain. Investment related to high performance computing will complement the traditional sources of support for Grand Challenge research by enabling exploratory use of advanced computational techniques.

Software components and tools: The Grand Challenge applications groups will have common needs in many areas of software technology including programming environments for code development and adaptation, advanced compiler technology. Also needed will be tools for optimization and parallelization, data management and interoperability, analysis and performance measurement, user interaction and visualization, debugging, and instrumentation. Advances in these generic software technology areas will have broad national impact, beyond the immediate scope of the Grand Challenge applications.

In order to provide these tools in a manner that is responsive to the needs of the applications researchers, collaborative groups will be formed that cut across the Grand Challenge areas in order to coordinate and share supporting software technology. This will enable multiple applications groups to sustain more easily a fast pace of innovation in the underlying software technology. These groups will include industrial, academic, and government researchers. Innovative approaches will be used to provide incentive for industry to participate and share costs.

A major focus of systems design and engineering will be developing advanced software applications that exploit the high capacity of the National Research and Education Network to provide new capabilities to researchers. An important example is a distributed operating system that permits high capacity interactions among programs at multiple network sites. This capability will enable a researcher to develop applications that may involve several high performance computers located at diverse sites to work together effectively. Other applications include distributed shared data and program libraries, research report dissemination systems, and advanced user interaction and visualization systems. For example, security support and data interoperability are required to enable distributed databases that exploit the National Research and Education Network.

Computational techniques: Developing software tools and components is basic to fundamental research in computational technology. It is this research that yields the fundamental algorithms, models of computation, new approaches to program analysis, and language approaches that provide fundamental generational advances.

Research in computational techniques includes the areas of parallel algorithms, numerical and mathematical analysis, parallel languages, and program refinement techniques. Also included are models of computation, formal methods for high assurance, theoretical and empirical techniques for algorithm analysis, and related areas.

Results in design and theory of algorithms are as important to breaking down computational scaling barriers as are performance improvements in computing hardware. Algorithm breakthroughs continue to be made on even fundamental problems such as linear algebra that are often assumed to be well understood. Breakthroughs can yield thousandfold speedup factors above and beyond hardware advances, as illustrated in Figure 3.

Parallel computing is the principal source of opportunity to improve computational performance. There are many differences among the models of computation embodied in parallel computers, and all of these differ from the purely sequential model that dominated the first half-century of computing. Algorithm theory has already yielded scalable parallel solutions to many computational problems that were assumed by most practitioners to be inherently sequential. In order to realize the potential for performance and scaling implicit in the parallel computer technology, research in the design of algorithms will be supported.

The evolution of parallel computing technology has also stimulated renewed activity in the area of high level programming languages. Languages that have inherently sequential semantics force programmers to make unnecessary and undesirable computational commitments that must, in any case, be undone by optimizing compilers. Efforts will be funded to develop higher level languages that will enable computational scientists to consider separately the abstract computational problem being solved and the specific implementation approach. This will also enable use of emerging programming tools that integrate program transformation and optimization with analysis to yield implementations with higher assurance and predictable numerical characteristics.

High performance computing research centers: The HPC Program will support deployment of innovative high performance computing architectures to computational scientists and engineers working on Grand Challenge applications, and to other computer scientists and engineers. Centers will be established to accelerate transition to new generations of high performance computing technology by enabling researchers to explore applications of this new technology.

Information gained from evaluating prototypes of new architectures as part of the High Performance Computing Systems Component will aid the choice of architectures to support the Grand Challenges. As the risks associated with application of innovative systems diminishes in individual Grand Challenges, the costs associated with the facilities will be transferred to the interested sponsors of the applications research. In this component we include computing hardware, network access to the operating systems of scientific instrumentation, and operational support for the Grand Challenge cooperative groups.

Facilities will also be provided to researchers in computing technology in order to support a more rapid transition to the new technology base. Researchers in areas such as algorithms, software environments, and operating systems require experimental access to new generation hardware. For example, there are a number of theoretical models for parallel computation in general use among algorithm designers, but only through empirical work can these models by adjusted to reflect more faithfully the models embodied in the parallel systems. Crucial systems parameters, for example, the relation of processing time to communications time and memory speed, interact with algorithm design parameters in ways that can best be explored empirically.

It is expected that many of the facilities allocated as part of Advanced Software Technology and Algorithms component will be used to facilitate transition of Grand Challenge applications to the new high performance computing systems. The remaining portion will be provided to computing technology researchers in order to support the development of generic algorithms and software technology. These facilities are in addition to those which will be provided as part of the High Performance Computing Systems component of the Program as a means to accelerate the transition from prototypes into products.

Responsibilities

DOE, NASA, NSF, NOAA and **DARPA** share responsibility for clearly defining the computational requirements of the Grand Challenges. They will select Grand Challenge applications areas in which collaborative groups are to be formed, and are responsible for providing advanced software technology support to the research groups collaborating to address the Grand Challenges applications in their domains.

NASA will carry lead responsibility for organizing and chairing the Federal Advanced Software, Technology and Algorithms Coordinating Committee. DOE, NSF, DARPA and other DOD research activities will be among the agencies participating in this committee.

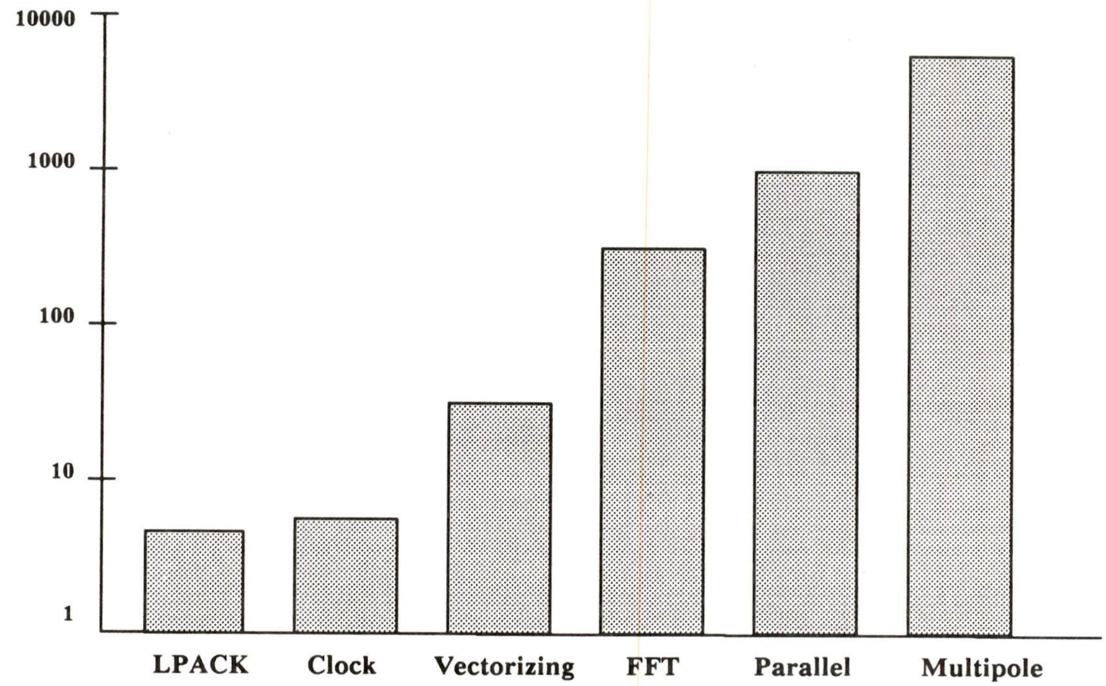
3. Program Plan: Advanced Software Technology and Algorithms

NASA, DARPA, NSF and **DOE** will support development of software tools and standard components for use across the spectrum of the Grand Challenges. DOE and NASA share responsibility for exploiting the nearer term potential for commercialization of these software developments.

DOE, NASA, NSF and **DARPA** will incorporate early production models of the high performance computing systems into high performance computing laboratories. These high performance computing laboratories will include the advanced software tools and components, innovative computational techniques and the application-specific algorithms and experimental code for the Grand Challenges. These facilities will support the required integrated research, and will be available to users through the National Research and Education Network.

NSF, DOE, NOAA and **NASA** will build on their existing supercomputer centers which will provide the facilities for several high performance computing research centers, accessible to the national research community.

NOAA will be responsible for organizing the coordination of R&D in data management, and will play a lead role in supporting basic research in tools and techniques required for management and analysis of large-scale scientific data bases and distributed data handling.



Factors in Computational Speedup

Examples using vectors of length n=4096 (2^{12})

Method	Type	Order	Speedup
LAPACK: BLAS1->BLAS3 {Dongarra, et al.}	Algorithm & Software	constant	4
Hardware Clock Speed {1976 to 1989}	Microelectronics	12ns->2 ns	6
Vectorizing Compilers {CFT, VAST, KAP}	Algorithm & Software	32*scalar	32
Fast Fourier Transform {Cooley and Tukey}	Algorithm	$O(n^2)$->O[n*ln(n)]	340
Parallel Processors {Gustafson, Montry and Benner}	Algorithm & Architecture	Linear in nr. of processors	1000
Fast Multipole Method {Greengard & Rokhlin}	Algorithm	$O(n^2)$->O(n)	4000

Fig. 3 - Speedup Due to Advances in Algorithms

The National Research and Education Network

Recommendation: U.S. Government, industry and universities should coordinate research and development for a research network to provide a distributed computing capability that links the Government, industry, and higher education communities. [*HPC Strategy*, 1987]

Introduction

The United States must develop a National Research and Education Network (NREN) to support communication between persons and organizations involved in open research and scholarly pursuits in the United States. This need has become increasingly obvious to the research community, especially among those who have experienced the benefits of electronic mail and database access, exchange of files between computers, and remote access to specialized and high-performance computing systems. As networking technology grows in power, network-based collaboration continues to allow substantive improvements in research effectiveness. These themes are well expressed in the recent National Research Council report *Toward a National Research Network* (1988). In developing the plan for this component the growing importance of the interrelationships between the network, the research components of the Program, and the U.S. academic community became increasingly clear. *Education* has been included in the name of the network in explicit recognition of this importance.

Today, all major organizations and government agencies use computer networking to some extent, and those with the most progressive and demanding missions have organized major transcontinental networks. A number of these networks are interconnected, notably those of the National Science Foundation (NSFNET), the Department of Defense (ARPANET and MILNET), the Department of Energy (ESNET), and the National Aeronautics and Space Administration (NASA Science Internet). These and many other commercial and regional networks collectively form the Internet, which currently supports a large portion of the U.S. science and engineering research community.

Today's Internet is far from uniform in the type and quality of service provided, and it does not yet reach the entire research community. Even so, expanding the Internet and enhancing its performance as far as technology allows will fall far short of what can and should be accomplished. The goal of this component is to create a new NREN which operates at rates of gigabits per second nationwide. This tremendous challenge is within the grasp of the United States in the next ten years. A network with this level of performance will provide another major improvement in the effectiveness of the national research community and their resulting ability to contribute to U.S. competitiveness.

3. Program Plan: The National Research and Education Network

Availability of the NREN will provide an environment which enhances collaboration both for software technology development and for basic research and scholarship nationally. In return the development of the NREN will benefit from advances in software technology, particularly in the area of network services.

The eventual impact of the NREN on national competitiveness may well extend beyond such gains in research productivity. The NREN should be the prototype of a new national information infrastructure which could be available to every home, office and factory. Wherever information is used, from manufacturing to high-definition home video entertainment, and most particularly in education, the country will benefit enormously from deployment of this technology.

Stages of the NREN: The stages of NREN development as articulated in the *HPC Strategy* are:

> The *first stage* involves an upgrade of the existing Internet to 1.5 megabit per second trunks. (This process is underway.)
>
> The *second stage* will deliver upgraded network services to 200 to 300 research installations, using a shared backbone network with 45 megabit per second capacity.
>
> The *third stage* will deliver one to three gigabit per second networking service to selected research facilities, and 45 megabit per second networking to approximately 1000 sites nationwide.

The stages of the NREN are illustrated in Figure 4.

Government/Industry/University roles: The Federal government plays a dual role in the development of computer networking. Federal funding has supported networking research and technology development in academic, industrial, and (to a lesser degree) government laboratories. The government also supports operational networks and network services. These are expected eventually to create a commercially viable market whose needs can be supplied by the private sector. In this latter role, the government has supplied networks as value-added services on communication circuits leased from the common carriers, and has subsidized their use by segments of the scholarly and research communities.

Universities play a major research role in advanced networking technology. Whereas most of the improvements in *communications* technology have come from industry, many of the most important *networking* technologies have been developed by universities. Educational institutions are also the primary users of networking nationwide, both for access to high performance computing and for collaboration among themselves and with government and industry.

To date, the role of industry has mostly been to provide communications links and produce equipment for networking. This situation is changing and in fact must be radically altered in order to develop the high speed networks of the future. At data rates of gigabits per second the switching elements of the network need to be integrated with the communications links within the facilities of the communications industry. Applications of networks within and between industrial groups should also increase to support a more competitive U.S. industrial posture.

It is anticipated that the government will continue to fund networking research in partnership with academia and industry, and will continue to support parts of the national research networking infrastructure which do not yet have a sizable market. This will be necessary both to build the market for private offerings as well as other commercial goals. It also will be necessary for those government agencies sponsoring development of advanced networking to coordinate the work of multiple government laboratories, industrial, and university groups.

Action Plan

The Federal Research Internet Coordinating Committee (FRICC), a collaboration of the NSF, DARPA, DOE, NASA, and the Department of Health and Human Services (HHS), has begun transforming the present day Internet toward the goal of an NREN. This is being accomplished through sharing communications circuits, network access points, and even entire networks, leading to streamlined operations and reduced costs. The FRICC has established coordinating members in other agencies and national networking organizations and has developed a program plan for implementing the NREN. While these activities have provided a healthy start for the NREN, an additional effort will be necessary to achieve the ultimate goals of the High Performance Computing Program. FRICC, while not formally a part of the FCCSET structure of OSTP, works closely with the Committee on Computer Research and Applications and conducts its activities consistent with the policy guidance of the HPC Program.

Interagency effort to produce an interim NREN. Coordinating an interagency project as large as the NREN will not be easy. It is clear that a unified focus for management is necessary. It is equally clear that the project will not be fully supported by the diverse agencies involved unless they have a decisive role in shaping the project, and are kept in constant, close communication so that the resulting network fills their needs.

In *Stage 1* the agencies will continue to upgrade their networks to 1.5 megabit per second (T1) trunks. This effort is already well underway. In addition, DARPA project known as the *Research Internet Gateway (RIG)* is acquiring a prototype platform for development of "policy-based routing" mechanisms which will allow interconnection of these trunks. Also the FRICC has plans to develop enhanced capabilities such as directory services in support of network users.

As the Internet expands, issues of *network security* have become a source of increasing concern. Recent incidents have demonstrated the vulnerability of computers attached to national networks. A significant effort in implementing the NREN will be development and implementation of mechanisms to enhance the security of the connected computing systems, and mechanisms to protect the networks themselves. These mechanisms will rely on policy-based routing capabilities, and also on recent advances in public-key cryptography.

In *Stage 2* the agencies are planning to acquire a common set of 45 megabit per second transcontinental trunks, the *Research Interagency Backbone (RIB)*. The ability to share backbone trunks, resulting in lower costs and improved service for all agencies, will be enabled by gateways with policy-based routing capabilities. When the RIB is fully operational, it will be interconnected with the NSFNET backbone; the result will be the interim NREN. Another equally important result will be the stage 2 technologies, which will provide a base from which commercial providers can offer compatible networking services nationally.

Research and development for billions of bits per second (gigabits) net. The ultimate structure of the *Stage 3* network will not become clear until this research effort is complete. However, it is clear that fiber-optic trunks now being installed by communications carriers will become increasingly important, new switching systems and network protocols must be developed, new high-speed interconnections to workstations and supercomputers will be needed, and some form of interconnection with the Stage 2 network will be needed. An additional goal of stage 3 is to support such advanced capabilities as remote interactive graphics, nationwide data files, and network-based high definition displays for education. Managing the dynamics of these activities will be a major challenge, but the payoff for success in terms of national capabilities will be enormous in terms of research productivity and, subsequently, in the form of technologies and services available from commercial sources.

Deployment of gigabits NREN. Stage 3 culminates in an operational national network with gigabits trunks. Deployment is not expected to begin until the middle to late 1990's.

Structured transition to commercial service: Mid-level networks organized on a regional basis or by other limited constituencies have sprung up indigenously (for example BITNET and several state-funded networks). Other mid-level networks have been formed with seed funding from NSF, NASA, and DARPA. These have become, in varying degrees, part of the existing Internet. They provide an important vehicle for the economic participation of state and local governments and of industry by providing access to the national network and by giving these other sectors a stake in its operation, thus reducing the funding burden on the Federal government. Moreover, each of these networks is typically a private and autonomous (although possibly subsidized) business entity; thus elements of the emerging national network have already become part of the private sector. Continuation of this trend will result in opportunities for many companies to become involved in leading-edge data communications.

By the end of Stage 2, it is expected that every university and major laboratory will be connected to the NREN through a mid-level network. Present regional offerings vary widely in reliability and scope. To provide homogeneous and universal networking service, interaction of the Federal government with mid-level networks must increase. It is also to be expected that competition and other market forces will come into play between these networks.

Each of the services developed for the NREN must become available commercially at the earliest practical time. The intention is that networking infrastructure should be a commercial offering nationwide. The government and its contractors would then purchase network connections from companies which would provide service to subscribers in general.

Eventually, computer networking should be as pervasively available as telephone service is today. The corresponding ease of inter-computer communication will then provide the benefits associated with the NREN to the entire nation, improving the productivity of all information-handling activities. To achieve this end, the deployment of the Stage 3 NREN will include a specific, structured process resulting in transition of the network from a government operation to a commercial service.

Agency Responsibilities

NSF will be the lead agency for deploying the operating NREN within the HPC Program. NSF has assumed responsibility for supporting a backbone for the NREN, and will coordinate collaboration among Federal agencies in this area. The NSF role of support and coordination will expand as the NREN grows; NSF will upgrade and extend the operational network, providing advanced network services, and collaboration technology. NSF will also support and participate in the interagency networking testbed.

DARPA will be the lead agency for the Program's advanced networking technology research and development. DARPA's research leading to the advanced networking technology for gigabit speeds (Stage 3) will take place within its Command, Control, and Communications programs as the primary contribution of the Department of Defense to the NREN. DARPA will also create a testbed, jointly funded with other participating agencies, for advanced network technology and inter-agency collaboration.

DOE will provide networking support for the energy research community and participate in the interagency networking testbed.

NASA will provide networking support for the aerospace research community, participate in the interagency testbed, and support research on aerospace applications and technology with a focus on telescience research and development.

3. Program Plan:
The National Research and Education Network

DARPA, NSF, DOE and NASA will continue their active roles in governance of the Internet, and will expand these roles by providing representatives on the council which sets policy for the NREN.

NOAA will provide networking in support of the climate and global change research community and will participate in the interagency testbed.

NIST will participate by establishing networking standards, with particular emphasis on protocols and security standards. NIST will continue its traditional role of coordinating developing technologies such as Broadband ISDN with service providers, computer manufacturers, telecommunication manufacturers, system integrators and end users through the standards process.

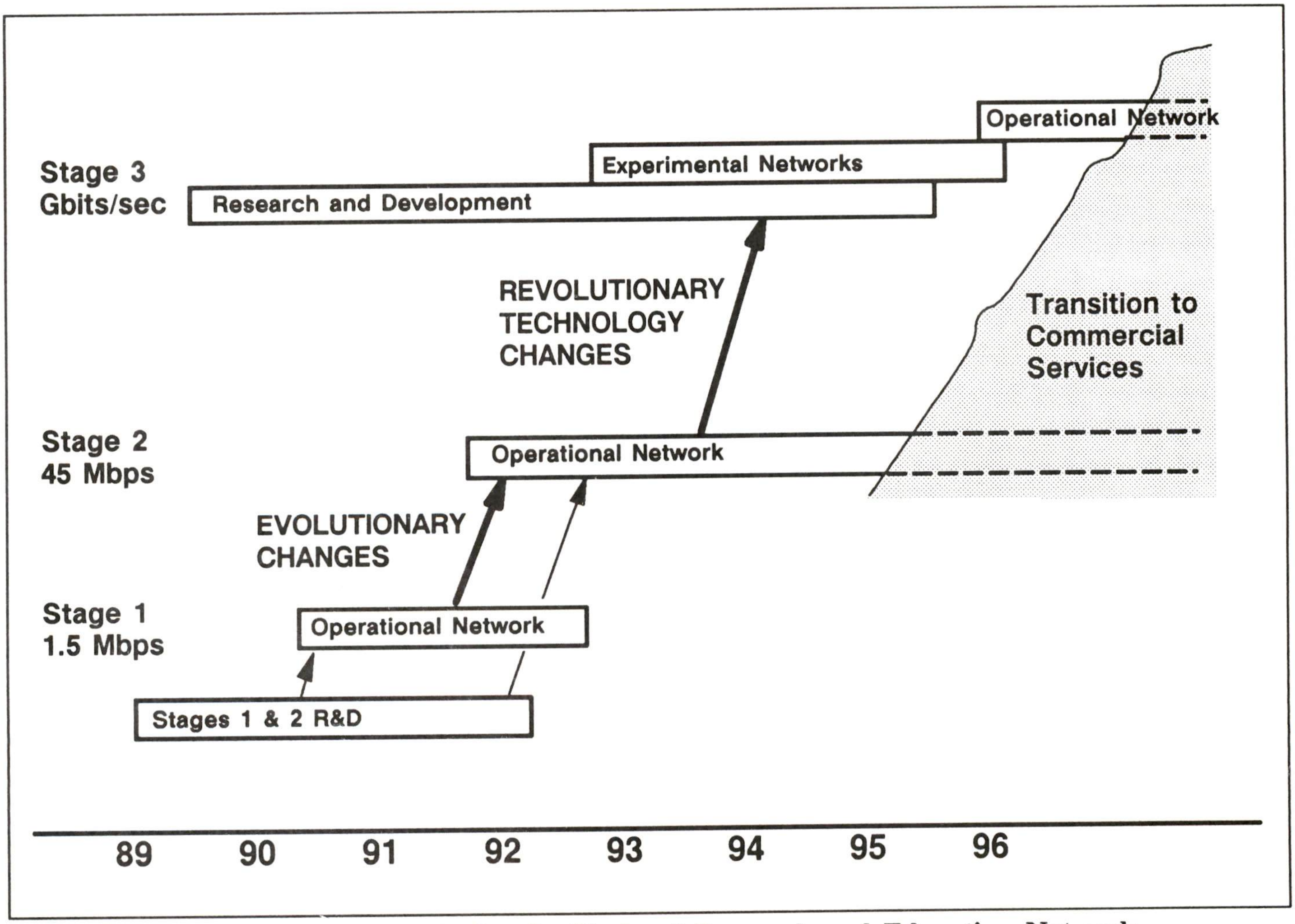


Fig. 4 – Timetable for the National Research and Education Network

Basic Research and Human Resources

Recommendation: Long term support for basic research in computer science should be increased within available resources. Government, industry, and universities should work together to improve the training and utilization of personnel to expand the base of research and development in computational science and technology. [*HPC Strategy*, 1987]

Goals

This component of the High Performance Computing Program addresses longer term national needs for high performance computing. The rapid growth of computing technology and computational science and engineering has created extraordinary demands for more rapid innovation, significantly increased manpower, and accelerated transfer of technology. The basic research community plays a major role in addressing these needs.

We must sustain a rapid pace of innovation in computer science and in computational science by investing in long term basic research.

Proprietary control is difficult to retain in an industry that is characterized by periodic major structural innovations, such as the shift now in progress from central timeshared computing to distributed networked workstations. Because of this, industry has little incentive to invest in long term approaches unless costs and risks are shared. For this reason, most of the major breakthroughs in computing have been the result of basic research activity. Examples include timesharing, local and national networks, VLSI design technology, personal computing, parallel computing, artificial intelligence, and many others. Each of these breakthroughs has had an enormous impact in the marketplace.

Increased numbers of qualified people are needed both in computational science and engineering, and in computer science and engineering. Universities are beginning to create new academic programs in areas of computational science and engineering that develop skills in both computer technology and in specific areas of science and engineering. The rapid evolution of this technology requires practitioners with a broad range of generic skills.

There is a need to reduce risk to industry in adapting and applying new technology. Technology is transferred rapidly from research into practice when the research community is an active participant in the process and when there is consensus in the research community on basic technical issues. The diversity of parallel computing models and algorithmic approaches now emerging provides unusual opportunity for application. The rapid pace of technology development in computing and computational science demands active participation of basic researchers in accomplishing transfer of the emerging technologies.

3. Program Plan:
Basic Research and Human Resources

Support for basic research must be supported in several respects. The High Performance Computing Program addresses this need through direct basic research support, improved infrastructure to increase research productivity, and facilitation of collaboration. The goals of this component of the Program are:

- **Basic research.** Ensure an adequate level of basic research activity to produce the next generation of innovative results in computing technology.
- **Human resources.** Support basic research, education, and training in order to meet the needs of research, personnel, and transition support in both computing technology and in computational science and engineering.
- **Support for collaboration.** Promote collaborations involving the basic research community, industry, and government to allow attacks on larger scale problems and accelerate dissemination of results.
- **Infrastructure.** Supprt the effectiveness of the research community by providing facilities and research infrastructure, including experimental high performance computers, networks, associated systems software, and applications software components.

The Basic Research Enterprise. Basic research programs already underway and supported by current Federal funding provide a base from which many computing applications goals can be achieved, but this base is already under great pressure even without the demands of important new thrusts[1]. The pace of expansion of computing technology and its applications greatly exceeds the rate of expansion of basic research, with consequent strain on the basic research community[2].

Effectively integrating new high performance computing technology into the US technological and scientific mainstream will require sustained research effort across the spectrum of computing technology. Some examples are microsystems component technology and packaging, computer architecture, fundamental algorithms and complexity, software engineering languages and tools, networking and distributed computing, artificial intelligence, numerical algorithms, and applications-specific algorithms.

Human Resources. Several studies in the past 10 years have documented the human resources challenges to the continued development and exploitation of computer technology[3]. A particular focus of these studies has been the severe undersupply of computer scientists and computer engineers at advanced degree levels. Computational scientists and engineers are in even shorter supply.

1. *The National Challenge in Computer Science and Technology*, Computer Science and Technology Board of the National Research Council, National Academy Press, Washington, 1988.
2. Gries, D., et al. *Imbalance Between Growth and Funding in Academic Computer Science: Two Trends Colliding*, Communications of the Association for Computing Machinery, 29(9), Sept 1986.

3. Program Plan:
Basic Research and Human Resources

Addressing the Grand Challenge applications requires large scale collaborative effort involving diverse groups of scientists, engineers, and mathematicians. The manpower shortage in computing technology and in computational science and engineering is hindering progress in these areas.

Collaboration. Interactions among multiple research teams and potential technology recipients contribute significantly to reducing the risks associated with transfer of major technologies into production. Collaboration can be facilitated in the basic research community by ensuring a high level of access to the network applications software based on the National Research and Education Network and by involving basic research groups in Grand Challenge applications.

The network support software will include capabilities for activities such as rapid distribution and sharing of research results, software distribution and configuration management support mechanisms, high–capacity interaction support for remote computers, access to instrumentation in remote experimental laboratories, rapid search and retrieval in distributed library databases, and so on.

Infrastructure. Scarcity of funds in computing technology research has hindered modernization of university computing research and education facilities. A rapid pace of technological innovation requires aggressive investment to ensure that universities remain at the forefront. Networked access to high performance computing with advanced software support is important for training computational scientists and engineers. The potential for using networks to disseminate results and conduct collaborative research at all educational levels is just beginning to be realized.

Basic infrastructure for computer research has been a concern for some years. Several agencies have programs that support the needs of the HPC Program. The Institutional Infrastructure Program at NSF has helped to equip approximately 25 computer science and computer engineering departments in the past eight years. DARPA for many years has been instrumental in building a core research base at major universities. The University Research Instrumentation program of the Department of Defense has provided important equipment and research support. The DOE research program has provided modern parallel computer facilities to several of its national laboratories and universities to promote basic research in high performance computing and to provide training facilities for graduate students and young faculty in all the disciplines involved in computational sciences. NASA maintains several research institutes and centers of excellence to interface with universities.

3. Gries, *op. cit.;* Feldman, Jerome A. and William R. Sutherland. *Rejuvenating Experimental Computer Science*. Comm. ACM 22, 9 (Sept. 1979), 497–502.; Kosaraju, S. Rao., et al. *Meeting the Basic–Research Needs of Computer Science*, Study report of the NSF CCR Advisory Committee, December, 1986; *Profiles -- Computer Science: Human Resources and Funding,* National Science Foundation report 88–324, February, 1989.

Action Plan

Several specific approaches are taken to address the goals. These approaches will, in most cases, be implemented as possible expansions of existing research funding programs.

Expand basic research. Increase basic research activity in computing technology areas that influence high performance computing, including algorithms, software languages and tools, architectures, systems software, microsystems, networks, distributed computing, and symbolic processing.

Attain a level of 1000 computer science Ph.D.s per year by 1995. Strengthen the human resource infrastructure for basic research. Support university risk investment in computational science and engineering degree programs. This should be done by expanding the number of universities capable of providing high quality advanced education in computer and computational science and engineering.

Promote at least 10 computational science and engineering degree programs. Sponsor interdisciplinary programs in universities to accelerate the maturing of computational science and engineering subdisciplines.

Upgrade 10 university computer science departments toward the standards of current 10 best. Include facilities for research in high performance computing. Also, upgrade an additional 25 computer science departments to nationally competitive quality.

Provide National Research and Education Network access for every U.S. university and major laboratory. Every university and major laboratory will be connected to the National Research and Education Network through a mid-level network.

Improve facilities available to support basic research and advanced education. High performance computing facilities currently available to researchers are in such demand that there is only limited availability for educational usage in computational science and engineering degree programs. The effective introduction of computational science and engineering techniques into industry requires students to receive exposure to high-performance machines.

Improve ties between computing technology and other disciplines. Many breakthroughs in computational science and engineering applications result from interactions with computer scientists. Correspondingly, computer science, through exposure to the needs of computational science and engineering, is producing technology to address future needs. Funding will be directed to promote these interactions.

Provide access to professional engineering support. Professional engineering staff should be available to basic research groups for assistance in construction and maintenance of large scale prototype systems, including software and hardware. This can be accomplished through industrial collaborations or through placement of professional staff in university laboratories.

Responsibilities

Federal agencies historically have supported activities which advance basic research by developing and improving infrastructure for the nation's knowledge and human resource base in computing. The HPC Program will exploit existing mechanisms to meet needs in these areas.

The **DOE** has established advanced computational science research facilities at several national laboratories and universities. Although the DOE labs already maintain a strong university cooperation program, more needs to be done to provide closer ties with the academic computational science community below the top echelon. For example, an expansion of the summer program for high school students using national facilities would be beneficial in providing interested and trained students to the universities.

The national laboratories are ideal training centers for graduate students in the sciences because of the wealth of experience in solving real world problems. This environment makes a valuable addition to the training of new scientists and should be made available to many more senior graduate students, post–doctoral fellows and young faculty than is currently possible.

The **NSF**'s primary mission is broad support of basic research and human resources in science and engineering. NSF recently reorganized to support a new research directorate, Computer and Information Science and Engineering (CISE), to focus resources on computing as a strategic research area. CISE supports research grants for academic institutional improvement as well as research. The research community supported by CISE will be primary participants in this Program.

Several NSF Centers (Science and Technology Centers, Engineering Research Centers, and Supercomputer Centers) focus on topics central to the HPC Program. These Centers illustrate the type of university–industry and interagency programs which can be employed directly as testbeds and sources of high performance computing technology.

The five NSF National Supercomputer Centers, for example, have provided advanced hardware and software to advance the utility of computational science across an entire spectrum of researchers. More than 11,000 scientists at some 300 institutions have used these facilities during the past few years. The research facilities and advanced experimental systems developed under the Program can be made available broadly to the entire U.S. research community through the National Research and Education Network.

NASA supports leading–edge applications of high performance computing technology. It also supports development of computational science programs in universities.

3. Program Plan:
Basic Research and Human Resources

NASA Institutes (ICASE, RIACS, ICOMP, CESDIS) and Centers of Excellence (CASIS, ICLASS) provide settings at NASA Centers or at Universities where computer scientists and computational scientists can work together using state of the art equipment on a permanent or temporary basis (summers, sabbaticals, etc.) These programs would be for undergraduates, graduate students, postdoctorals, university faculty, and researchers from industry and government.

NASA has supercomputer facilities at several of its field centers (Ames, Goddard, Langley, Lewis, and Marshall). NASA has also established the Numerical Aerodynamics Simulation (NAS) Facility, which is a national facility for aerospace applications which operates not only state-of-the-art supercomputers, but advanced parallel computers like the Connection Machine. NASA has also established a significant Artificial Intelligence Laboratory in the Information Sciences Division at ARC. These facilities are used for a wide range of mathematical, algorithm, systems software, and computer architectural research. These facilities are available to NASA centers, institutes, and grantees, and to the aerospace community. Under this program NASA facilities will be expanded to include scalable testbeds to support interdisciplinary research which combines mathematics, algorithms, systems software, and computer architecture.

NOAA has supercomputer facilities, and has also created generic, broad spectrum workstation design facilities to support the Program for Regional Observing and Forecasting Systems (PROFS). Under this Component, NOAA will expand the opportunities for collaborative research at its facilities for development of algorithms and techniques for large scientific data bases, use of artificial intelligence in data management, and development of climate prediction models.

DARPA provides high performance computing systems for research community use on two scales: small-scale for experimentation, software and algorithm development by computer and computational science research groups, and medium-scale for shared-use facilities intended for access by dozens of groups via the National Research and Education Network. DARPA funding also supports key university and industrial labs for research and advanced development in computer and network architecture, network protocols and management, microsystems design and prototyping, advanced components and packaging, software tools and parallel algorithms.

4. Organization

Leadership of the HPC Program is the responsibility of the Office of Science and Technology Policy. It will be coordinated through the FCCSET Committee on Computer Research and Applications, whose members include representatives of the key agencies. The Committee will work closely with the President's Science Advisor and the various government funding agencies to ensure the continuing success of the Program. The components of the program that implement the Program will be executed by the cognizant agencies. Duties and responsibilities of the Committee include:

- Interagency planning and coordination;
- Policy development and technology assessment;
- Liaison with the industrial and university sectors; and
- Annual reporting of progress to the Office of Scientific and Technology Policy.

A High Performance Computing Advisory Panel will be formed, consisting of eminent individuals from government, industry, and academia. Members of the Advisory Panel will be selected by and will report to the Director of OSTP. The Panel will provide the Director and the Committee with an independent assessment of:

- Progress of the Program in accomplishing its objectives;
- Continued relevance of the Program goals over time;
- Overall balance among the Program components; and
- Success in strengthening U.S. leadership in high performance computing, and integration of these technologies into the mainstream of U.S. science and industry.

A broadly representative industry body will assist in making long-range demand and robustness projections for: high capacity research networks; the spectrum of computer architectures; the adequacy of software development; and the level of the manpower pool. This body will help assure a smooth transition between successive generations of high performance computing systems.

The FCCSET Committee on Computer Research and Applications has established subcommittees that will be responsible for planning, organizing, monitoring and coordinating the components of this Program. This includes liaison with the industrial and academic sectors, and published annual reports.

5. Budget

Budgets for the Program are presented in Table 1. Each budget element corresponds to a key activity in one of the four components of the HPC Program. The activities are described for each component in Section 3 of this plan. The yearly additional funding requested for this Program corresponds to the estimate given in the *HPC Strategy*, with some adjustment to yearly funding levels as a result of more detailed planning and inflation. Significant portions of the Program's funding will be allocated in each of the three participating sectors: universities, industry, and government laboratories.

Currently, the four principal funding agencies are spending about $500 Million per year on research and development for high performance computing. It is important that this funding continue with coordination by the FCCSET Committee as discussed in this plan, because the ability of the Program to achieve its goals depends upon maintenance of the broad base of computational and computer science and engineering research presently funded by the Federal government.

Preliminary planning estimates suggest that the first year of the program would require an augmentation of $150 million, which would then grow to an incremental annual level of $600 million by the fifth year.

Special attention has been devoted to the subcomponents "Early Systems for Evaluation" and "High Performance Computing Research Centers". There is an explicit strategy for investment in emerging high performance computing systems (including associated software) in these activities, to ensure that adequate funding is available. It is intended that the Early Systems for Evaluation budget sustain acquisition of the smallest scale systems which will allow characterization of their potential performance. For systems which prove to have good performance potential, the High Performance Computing Research Centers budget will support scaling these systems up, to demonstrate that potential in the Grand Challenges or other advanced applications. This will reduce risk to both producers of the systems and researchers using them, to provide the necessary incentive for early deployment in the most advanced applications.

The Basic Research and Human Resources component also requires special discussion, because it is funded in two ways. First, ten percent of the Program funding is set aside for this component. Second, it is intended that an additional fifteen percent of the total Program funding in the other three components will consist of basic research, carried out largely in Universities, which will also support the Program goals in Basic Research and Human Resources. Integrating this research with the rest of the Program allows a smooth flow of research from basic ideas through to applications.

Summary of Additional Funds

(Millions of Dollars)

Reference Page	Component	Year 1	Year 2	Year 3	Year 4	Year 5
17	**High Performance Computing Systems**	**55**	**91**	**141**	**179**	**216**
19	Research for Future Generations	11	17	24	32	37
19	System Design Tools	10	18	21	25	25
19	Advanced Prototype Development	22	36	65	86	116
20	Evaluation of Early Systems	12	20	31	36	38
23	**Advanced Software Technology and Algorithms**	**51**	**90**	**137**	**172**	**212**
24	Support for Grand Challenges	9	19	34	43	48
25	Software Components and Tools	15	30	41	60	78
26	Computational Techniques	6	10	18	19	31
26	High Performance Computing Research Centers	21	31	44	50	55
31	**National Research and Education Network**	**30**	**50**	**95**	**105**	**110**
33	Interagency Interim NREN	14	23	55	50	50
34	Gigabits Research and Development	16	27	40	55	60
34	Deployment of Gigabits NREN		(Funding begins after Year 5)			
34	Structured Transition to Commercial Service		(Funding begins after Year 5)			
37	**Basic Research and Human Resources**	**15**	**25**	**38**	**46**	**59**
		NOTE:	15% of the other three Components is also commited to this general area			
	TOTAL High Performance Computing Program	**151**	**256**	**411**	**502**	**597**

Table 1 – Budget Summary by Program Component

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APPENDIX A: SUMMARY OF GRAND CHALLENGES
FOR WHICH SOLUTION IS LIKELY TO BE POSSIBLE USING SYSTEMS DEVELOPED UNDER THIS INITIATIVE

PREDICTION OF WEATHER, CLIMATE, AND GLOBAL CHANGE. The aim is to understand the coupled atmosphere, ocean, biosphere system in enough detail to be able to make long range predictions about its behavior. Applications include understanding CO2 dynamics in the atmosphere, ozone depletion, climatological perturbations due to man made releases of chemicals or energy into one of the component systems, and detailed predictions of conditions in support of military missions.
Agencies: DOE, DOD, NASA, NSF, NOAA

CHALLENGES IN MATERIALS SCIENCES. High performance computing has provided invaluable assistance in improving our understanding of the atomic nature of materials. These have an enormous impact on our national economy. A selected list of such materials includes: semiconductors, such as silicon and gallium arsenide and superconductors such as the high Tc copper oxide ceramics that have been shown recently to conduct electricity at about 100 degrees Kelvin.
Agencies: DOD, DOE, NSF, NASA

SEMICONDUCTOR DESIGN. As intrinsically faster materials, such as gallium arsenide are used, a fundamental understanding is required of how they operate and how to change their characteristics. Essential understanding of overlay formation, trapped structural defects, and the effect of lattice mismatch on properties are needed. Currently, it is possible to simulate electronic properties for simple regular systems, however, materials with defects and mixed atomic constituents are beyond present capabilities.
Agencies: DOD, DOE, NSF

SUPERCONDUCTIVITY. The discovery of high temperature superconductivity in 1986 has provided the potential of spectacular energy-efficient power transmission technologies, ultra sensitive instrumentation, and devices using phenomena unique to superconductivity. The materials supporting high temperature superconductivity are difficult to form, stabilize, and use, and the basic properties of the superconductor must be elucidated through a vigorous fundamental research program.
Agencies: DOE, NSF, DOD

STRUCTURAL BIOLOGY. The function of biologically important molecules can be simulated by computationally intensive Monte Carlo methods in combination with NMR of crystallographic data. Molecular dynamics methods are required for the time dependent behavior of such macromolecules. The determination, visualization, and analysis of these 3D structures is essential to the understanding of the mechanisms of enzymic catalysis, recognition of nucleic acids by proteins, antibody/antigen binding, and many other dynamic events central to cell biology.
Agencies: DOE, HHS, NSF

DESIGN OF DRUGS. Predictions of the folded conformation of proteins and of RNA molecules, by computer simulation is rapidly becoming accepted as a useful, and sometimes primary tool in understanding the properties required in drug design.
Agencies: DOE, HHS, NSF

HUMAN GENOME. Comparison of normal and pathological molecular sequences is our current most revealing computational method for understanding genomes, and the molecular basis for disease. To benefit from the entire sequence of a single human will require capabilities for more than three billion subgenomic units, as contrasted with the ten to two hundred thousand units of typical viruses.
Agencies: DOE, HHS, NSF

QUANTUM CHROMODYNAMICS. In high energy theoretical physics, computer simulations of QCD are yielding first principle calculations of the properties of strongly interacting elementary particles. New phenomena have been predicted including; the existence of a new phase of matter, and the quark-gluon plasma. Properties under the conditions of the first microsecond of the big bang, and in the cores of the largest stars have been calculated by simulation methods. Beyond the range of present experimental capabilities, computer simulations of grand unified "theories of everything" have been devised using QCD (Lattice Gauge Theory).
Agencies: DOE, NSF

ASTRONOMY. Data volumes generated by Very Large Array (VLA) or Very Long Baseline Array (VLBA) radio telescopes currently overwhelms the available computational resources. Greater computational power will significantly enhance their usefulness in

exploring important problems in radio astronomy, resulting in better return on a major national investment.
Agencies: NASA, NSF

CHALLENGES IN TRANSPORTATION. In the nearer term, substantial contributions to vehicle performance can be made using more approximate physical modeling and reducing the amount of interdisciplinary coupling. Examples include, modeling of fluid dynamical behavior for three dimensional flow-fields about complete aircraft geometries, flow inside of engine turbomachinery, duct flow, and flow about ship hulls.
Agencies: NASA,DOD,DOE,NSF,DOT

VEHICLE SIGNATURE. Reduction of vehicle signature (acoustic and electromagnetic, and thermal characteristics) is critical for low detection military vehicles.
Agencies: NASA, DOD

TURBULENCE. Turbulence in fluid flows impacts the stability and control, thermal characteristics, and fuel performance of virtually all aerospace vehicles. Understanding the fundamental physics of turbulence is requisite to reliably modeling flow turbulence for the analysis of realistic vehicle configuration.
Agencies: NASA, DOD, DOE, NSF, NOAA

VEHICLE DYNAMICS. Analysis of the aeroelastic behavior of vehicles, as well as the stability and ride analysis of vehicles are critical assessments of land and air vehicle performance and life-cycle.
Agencies: NASA, DOD, DOT

NUCLEAR FUSION. Development of controlled nuclear fusion requires understanding the behavior of fully ionized gasses at very high temperatures under the influence of strong magnetic fields in complex three dimensional geometries.
Agencies: DOE, NASA, DOD

EFFICIENCY OF COMBUSTION SYSTEMS. To attain significant improvements in combustion efficiencies requires understanding the interplay between the flows of the various substances involved and the quantum chemistry which causes those substances to react. In some complicated cases the quantum chemistry required to understand the reactions is beyond the reach of current supercomputers.
Agencies: DOE NASA, DOD

ENHANCED OIL AND GAS RECOVERY. This challenge has two parts: to locate as much of the estimated 300 billion barrels of oil reserves in the US and then to devise economic ways of extracting as much of this as possible. Thus improved seismic analysis techniques as well as improved understanding of fluid flow through geological structures is required.
Agencies: DOE

COMPUTATIONAL OCEAN SCIENCES. The objective is to develop a global ocean prediction model incorporating temperature, chemical composition, circulation, and coupling to the atmosphere and other oceanographic features. This will couple to models of the atmosphere in the effort on global weather as well as having specific implications for physical oceanography.
Agencies: DOD, NASA, NSF, NOAA

SPEECH. Speech research is aimed at providing a communications interface with computers based on spoken language. Automatic speech understanding by computer is a large modeling and search problem in which billions of computations are required to evaluate the many possibilities of what a person might have said within a particular context.
Agencies: NASA, DOD, NSF

VISION. The challenge is to develop human-level visual capabilities for computers and robots. Machine vision requires image signal processing, texture and color modeling, geometric processing and reasoning, as well as object modeling. A competent vision system will likely involve the integration of all of these processes with close coupling
Agencies: NSF, DARPA, NASA

UNDERSEA SURVEILLANCE FOR ASW. The Navy faces a severe problem in maintaining a viable anti-submarine warfare (ASW) capability in the face of quantum improvements in Soviet submarine technology, which are projected to be so substantial that evolutionary improvements in detection systems will not restore sufficient capability to counter their advantages. An attractive solution to this problem involves revolutionary improvements in long-range undersea surveillance which are possible using very high gain acoustic arrays and active acoustic sources for ASW surveillance. These methods will be computationally intensive; even taking advantage of inherent parallelism and judicious design of algorithms, computational demands for the projected post-2000 era submarine threat mandate achieving signal processing computation rates of in excess of a trillion operations per second.
Agencies: DOD

APPENDIX B: GLOSSARY

bits– binary digits (the smallest units of digital information); also an abbreviation for "bits per second"

broadband ISDN (BISDN)– broadband integrated services data network, an evolving standard commercial communications offering which will provide data rates of hundreds of megabits per second

byte– one character of computer storage

common carrier– a regulated commercial company which offers communication services in an open market

flops– abbreviation for floating-point operations per second, a unit which characterizes the performance of a computer for certain scientific and engineering calculations

giga– prefix meaning billion, e.g. "gigaops" means "billion operations per second" and "gigabits" means "billion bits per second"

links– long-distance communications circuits, also known as "trunks"

mega– prefix meaning million, e.g. "megaops" means "millions operations per second" and "megabytes" means "million characters of storage"

mid-level network– a computer network with scope which falls between a nationwide network and a local network, such as one of the state or regional networks

ops– abbreviation for "operations per second", a general measurement of computer performance

policy-based routing– a computer network function which treats data packets in different ways depending on some policy, for example certain packets may be given high priority, certain others may be rejected as not authorized to use some portion of the network

telescience– science practiced at a distance, using telecommunications

tera– prefix meaning trillion, e.g. "teraops" means "trillion operations per second"

testbed– an configuration intended to allow experimentation with systems in an application environment

trunks– long-distance communications circuits, also known as "links"

value-added services– services provided in addition to basic communication links (and at extra cost); for example, computer networking using communications provided by a common carrier

A RESEARCH AND DEVELOPMENT STRATEGY FOR HIGH PERFORMANCE COMPUTING

Executive Office of the President
Office of Science and Technology Policy
November 20, 1987

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

This year the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) Committee on Computer Research and Applications began a systematic review of the status and directions of high performance computing and its relationship to federal research and development. The Committee held a series of workshops involving hundreds of computer scientists and technologists from academia, industry, and government. A result of this effort is the report that follows, containing findings and recommendations concerning this critical issue. It has been sent to the appropriate committees of Congress for their review.

A consistent theme in this report is the need for industry, academia, and government to collaborate and exchange information on future R&D efforts. Partners need to give one another signals as to their intent for future activities, and this report is a necessary first step in that process. The vision it represents must continue to grow. For that reason, I have asked the Committee to initiate the appropriate forums for discussing it further with the computing community.

Another theme has come out of this report: within four decades, the field of computer science has moved from a service discipline to a pervasive technology with a rigorous scientific basis. Computer science has become important to our national security and to our industrial productivity, and as such it provides the United States with many opportunities and challenges. Three of those opportunities are addressed in the report's findings and recommendations: High Performance Computers, Software Technology and Algorithms, and Networking. The fourth recommendation involves the Basic Research and Human Resources that will be required to conduct the other initiatives.

One thing is clear: the competition in an increasingly competitive global market cannot be ignored. The portion of our balance of trade supported by our high performance computing capability is becoming more important to the nation. In short, the United States must continue to have a strong, competitive supercomputing capability if it is to remain at the forefront of advanced technology. For that reason the Office of Science and Technology Policy is encouraging activities among the federal agencies together with the academic community and the private sector.

William R. Graham

William R. Graham
Science Adviser to the President and
Director, Office of Science and Technology Policy

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   o U.S. high performance computer industry leadership is challenged by government supported research and development in Japan and Europe.

   o U.S. leadership in developing new component technology and applying large scale parallel architectures are key ingredients for maintaining high performance computing leadership. The first generation of scalable parallel systems is now commercially available from U.S. vendors. Application-specific integrated circuits have become less expensive and more readily available and are beginning to be integrated into high performance computers.

2. **SOFTWARE TECHNOLOGY AND ALGORITHMS: Research progress and technology transfer in software and applications must keep pace with advances in computing architecture and microelectronics.**

   o Progress in software and algorithms is required to more fully exploit the opportunity offered by parallel systems.

   o Computational methods have emerged as indispensable and enabling tools for a diverse spectrum of science, engineering, design, and research applications.

   o Interdisciplinary research is required to develop and maintain a base of applications software that exploits advances in high performance computing and algorithm design in order to address the "grand challenges" of science and engineering.

3. **NETWORKING: The U.S. faces serious challenges in networking technology which could become a barrier to the advance and use of computing technology in science and engineering.**

   o Current network technology does not adequately support scientific collaboration or access to unique scientific resources. At this time, U.S. commercial and government sponsored networks are not coordinated, do not have sufficient capacity, do not interoperate effectively, and do not ensure privacy.

   o Europe and Japan are aggressively moving ahead of the U.S. in a variety of networking areas with the support of concentrated government and industry research and implementation programs.

4. **BASIC RESEARCH AND HUMAN RESOURCES: Federal research and development funding has established laboratories in universities, industry, and government which have become the major sources of innovation in the development and use of computing technology.**

Summary of Recommendations For a National High Performance Computing Strategy

1. <u>HIGH PERFORMANCE COMPUTERS:</u> The U.S. Government should establish a long range strategy for Federal support for basic research on high performance computer technology and the appropriate transfer of research and technology to U.S. industry.

2. <u>SOFTWARE TECHNOLOGY AND ALGORITHMS:</u> The U.S. should take the lead in encouraging joint research with government, industry, and university participation to improve basic tools, languages, algorithms, and associated theory for the scientific "grand challenges" with widespread applicability.

3. <u>NETWORKING:</u> U.S. government, industry, and universities should coordinate research and development for a research network to provide a distributed computing capability that links the government, industry, and higher education communities.

4. <u>BASIC RESEARCH AND HUMAN RESOURCES:</u> Long term support for basic research in computer science should be increased within available resources. Industry, universities, and government should work together to improve the training and utilization of personnel to expand the base of research and development in computational science and technology.

APPENDIX C: *HPC Strategy* REPRINT

A RESEARCH AND DEVELOPMENT STRATEGY FOR HIGH PERFORMANCE COMPUTING

High performance computing refers to the full range of supercomputing activities including existing supercomputer systems, special purpose and experimental systems, and the new generation of large scale parallel architectures.

THE CHALLENGE

In the span of four decades, computing has become one of the most pervasive and powerful technologies for information management, communications, design, manufacturing, and scientific progress.

The U.S. currently leads the world in the development and use of high performance computing for national security, industrial productivity, and science and engineering, but that lead is being challenged. Through an increased foreign industrial capability, the U.S. technology lead in computing has diminished considerably in recent years, but the U.S. continues to maintain strength in basic science and technology. The technology is changing rapidly and the downstream rewards for leadership are great. Progress in computing can be accelerated through the continued pioneering of new hardware, software, algorithms, and network technology and the effective transition of that technology to the marketplace. A shared computing research and development vision is needed to provide to government, industry, and academia a basis for cooperative action. The successful implementation of a strategy to attain this vision and a balanced plan for transition from one generation of technology to the next can result in continued strength and leadership in the forthcoming decades.

High performance computing technology has also become essential to progress in science and engineering. A **grand challenge** is a fundamental problem in science or engineering, with broad applications, whose solution would be enabled by the application of the high performance computing resources that could become available in the near future. Examples of grand challenges are: (1) Computational fluid dynamics for the design of hypersonic aircraft, efficient automobile bodies, and extremely quiet submarines, for weather forecasting for short and long term effects, efficient recovery of oil, and for many other applications; (2) Electronic structure calculations for the design of new materials such as chemical catalysts, immunological agents, and superconductors; (3) Plasma dynamics for fusion energy technology and for safe and efficient military technology; (4) Calculations to understand the fundamental nature of matter, including quantum chromodynamics and condensed matter theory; (5) Symbolic computations including speech recognition, computer vision, natural language understanding, automated reasoning, and tools for design, manufacturing, and simulation of complex systems. Many of these could be considerably advanced by the use of computer systems capable of trillions of operations per second.

THE STRATEGY

A **High Performance Computing Strategy**, involving close coordination of existing programs and augmented effort, is required to address this national challenge. This strategy involves the coordinated pursuit of computing technology goals through joint efforts of government, industry, and academia. The strategy will have impact in clarifying and focusing the direction of Federally-funded computing research, which continues to be the major source of innovation for computing technology and a primary catalyst for industrial development. Government support should be highly leveraged with resources provided by industry participants. To be effective, the strategy should also be defined and continually updated in cooperation with industry and academia by making them participants in developing and implementing a shared vision of the future to ensure continued U.S. leadership.

The high performance computing strategy is designed to sustain and focus basic Federally-funded research and promote the transfer of basic science from the laboratory to U.S. industrial development and finally to the marketplace. Technology development will be encouraged as appropriate to meet immediate needs as well as to create a foundation for long term leadership. Strong emphasis will be placed on continued transfer of the results of government funded R&D to industry and on cooperation with industry to insure the continued strength of American high technology trade in the international marketplace.

The basic elements of the strategy are research and development programs in high performance computer architecture, in custom hardware, in software and algorithms, and in networking technology, all supported by a basic research foundation. In each of these areas, major opportunities exist that require coordinated support and management, building on existing government programs. Access to high performance computing is essential for providing scientists and engineers at research institutions throughout the country with the ability to use the most advanced computers for their work. The strategy needs to concurrently address the appropriate Federal role in each of the basic elements of the R&D process—basic research, applied research, and industrial development—in order to meet long term, intermediate, and short term technology development goals. Explicit attention must be directed to the flow of technology from basic to applied areas and to the marketplace, as well as back into the research community to create the next generation of computing infrastructure, achieving a cumulative effect. Technology developments within individual element areas will contribute extensively to other activities. Simultaneous and coordinated pursuit of the areas is therefore an important element of the strategy.

CURRENT STATUS AND TRENDS

• **High performance computing systems.** Improvements in materials and component technology are rapidly advancing computer capability. Memory and logic circuits are continuing to improve in speed and density, but as fundamental physical limits are approached, advances are being sought through improved computer architectures, custom hardware, and software. Computer architecture has begun to evolve into large scale multiple processor systems, and in the past four years a first generation of scalable parallel systems has progressed from the research laboratory to the marketplace. Scalable architectures provide a uniform approach that enables a wide range of capacity, from workstations to very high performance computers. Application–specific integrated circuits, such as for real–time signal processing, are being incorporated into special purpose computers.

At current performance levels our ability to model many important science, engineering, and economic problems is still limited. Formulations of computational models presently exist that for realistic solutions would require speeds of teraflops (trillions of floating point operations per second) and equivalent improvement in memory size, mass storage, and input/output systems. In addition, symbolic processing is complementing and enhancing numeric approaches. Achievement of this performance level in the next 5 years appears to be a feasible goal, based on credible extrapolations of processor capability, number of processors, and software sophistication. In developing the new architectural approaches, however, careful collaboration will be required with the applications community to assess the various approaches and to achieve transition to the new approaches where appropriate. As transitions are made, the high performance computing industry should strive to maintain its continued leadership and competitveness.

• **Software technology and algorithms.** As high performance computing systems evolve and become more critical in science, engineering, and other applications domains, software technology becomes an increasingly central concern. As experienced in many U.S. space and defense programs, for example, software can become the dominant computational cost element in large systems because of the need to support evolution throughout the system life cycle from design and development to long term maintenance and transition to the next generation. Future software environments and tools should support the development of trustworthy systems capable of evolution, while increasing productivity of developers and users of the systems. Effective exploitation of the performance potential of the emerging parallel systems poses a special challenge both to software and to algorithm design.

High performance computing offers scientists and engineers the opportunity to use computer models to simulate conditions difficult or impossible to create and measure in the laboratory. This new paradigm of computational science and engineering offers an important complement to traditional theoretical and experimental approaches, and it is already having major impact in many areas. New approaches combining numeric and symbolic methods are emerging. The development of new instruments and data generation methods in fields as diverse as genetics, seismology, and materials accelerates demand for computational power. In addition, the opportunity is created to coordinate and focus effort on important grand challenges, such as computational fluid dynamics, weather forecasting, plasma dynamics, and other areas.

• **Computer network technology.** A modern high speed research network is one of the elements needed to provide high performance distributed computation and communication support for research and technology development in government, academia, and industry. A coordinated research network based on very high bandwidth links would enable the creation of large-scale geographically distributed heterogeneous systems that link multiple high performance workstations, databases, data generation sources, and extremely high performance servers as required, in order to provide rapid and responsive service to scientists and engineers distributed across the country. The existing national network is a collection of loosely coupled networks, called an internet, based on concepts pioneered in the U.S.

Technical issues being addressed include utilization of fiber optics to improve performance for the entire research and higher education enterprise of the nation. An additional issue of pressing concern, particularly within the governmental and industrial sectors, is that of computer and network security to ensure privacy and trustworthiness in a heterogeneous network environment. At present, responsibility for privacy and the assurance of trust are vested principally in the computers and switching nodes on the network. Further research, already actively underway, is urgently needed to develop models, methodology, algorithms and software appropriate to the scale of a coordinated research network.

• **Basic research and human resources in Computer and Computational Science.** Federal funding has historically been, and will likely remain, a major source of support for important new ideas in computing technology. Carefully managed and stable funding is required to maintain vigorous research in computer and computational science and sufficient growth in computer science manpower. It is important to maintain the strength of the existing major research centers and to develop new research activity to support the growth in computer and computational science. Interactions should be fostered among academia, industry, and national laboratories to address large problems and to promote transfer of technology. In the longer term, enhancement of the computing technology base will have significant impact in productivity, efficiency, and effectiveness of government, industry, and the research community.

IMPACT

Computing technology is vital to national security. Advanced computer systems and software are now integral components in most major defense, intelligence, and aerospace systems. Computing technology has a central role in energy research, oil exploration, weapons research, aircraft design, and other national security technology areas.

Major advances in science and engineering have also accrued from recent improvements in supercomputing capability. The existence of machines with hundred megaflop (hundreds of millions of floating point operations per second) speed and multimillion word memories has allowed, for the first time, accurate treatment of important problems in weather prediction, hydrodynamics, plasma physics, stress analysis, atomic and molecular structure, and other areas. The emerging machines with 1 to 10 gigaflop (billions of flops) speed and 100 to 300 million word memories are expected to produce comparable advances in solving numeric and symbolic problems.

Many of these advances in science and engineering are the result of the application of high performance computing to execute computational simulations based on mathematical models. This approach to science and engineering is becoming an important addition to traditional experimental and theoretical approaches. In applications such as the National Aerospace Plane, supercomputing provides the best means to analyze and develop strategies to overcome technical obstacles that determine whether the hypersonic vehicle can fly beyond speeds of Mach seven, where wind tunnels reach their maximum capability. The list of applications for which supercomputing plays this kind of role is extensive, and includes nearly all high-technology industries. The extent of its usage makes supercomputing an important element in maintaining national competitiveness in many high technology industries.

The high performance computing strategy will have impact in many sectors of the economy. Nearly all sectors of advanced industry are dependent on computing infrastructure. Any improvement in computing capability will have substantial leveraged impact in broad sectors, particularly as applications software increases in power and sophistication.

The computer hardware industry alone amounted to $65 billion in 1986, and U.S. technical market dominance, long taken for granted, is now challenged in this and other critical areas, including networking, microsystems and custom high-performance integrated circuit technology. Foreign investment in computing research and technology has grown considerably in the last decade.

As stated in the report of the White House Science Council, *Research in Very High Performance Computing*, November 1985, "The bottom line is that any country which seeks to control its future must effectively exploit high performance computing. A country which aspires to military leadership must dominate, if not control, high performance computing. A country seeking economic strength in the information age must lead in the development and application of high performance computing in industry and research."

BACKGROUND

The Federal Coordinating Council on Science, Engineering and Technology (FCCSET) was established by Congress under the Office of Science and Technology Policy (OSTP) to catalyze interagency consideration of broad national issues and to coordinate various programs of the Federal government. The FCCSET in turn, established a series of committees, with interagency participation to assess and recommend action for national science and technology issues. The committees have become recognized as focal points for interagency coordination activity, addressing issues that have been identified by direct requests through the OSTP and indirect requests by member agencies (such as the NSF requirement to provide an update to the Lax Report on Large Scale Computing in Science and Engineering). These studies have enabled the FCCSET Committee on Computer Research and Applications to develop a national view of computing technology needs, opportunities, and trends.

From its inception, the FCCSET Committee on Supercomputing (the original name of this committee) was chartered to examine the status of high performance computing in the U.S. and to recommend what role the Federal Government should play regarding this technology. The committee issued two reports in 1983 that provided an integrated assessment of the status of the supercomputer industry and recommended government actions. The FCCSET Committee on Computer Research and Applications concluded that it would be proper to include an update of the earlier reports to address the changes that have occurred in the intervening period as a complement to the technical reports. The review was based upon periodic meetings with and site visits to supercomputer manufacturers and consultation with experts in high performance scientific computing. White papers were contributed to this report by industry leaders and supercomputer experts. The report was completed in September 1987 and its findings and recommendations are incorporated in the body of this report.

In developing the recommendations presented in this report, the FCCSET Committee reviewed findings and recommendations from a variety of sources, including those mentioned above. A related activity has been the preparation by the White House Science Council (WHSC) Committee on Research in Very High Performance Computing of the report *Research in Very High Performance Computing*, November 1985. The WHSC Committee, composed of respected individuals from academia, industry, and government, made recommendations related to the issues more recently addressed by the FCCSET Committee. In the areas addressed by both committees, there is a significant consistency of recommendations, and, indeed, progress in recent months further strengthens the case for the recommendations. The convergence of views expressed in the many reports, the strong interest in many sectors of government in developing a policy, the dramatic increase in foreign investment and competitiveness in computing and network technology, and the considerable progress in computing technology development worldwide are all indicators of the urgency of developing and implementing a strategy for nationwide coordination of high performance computing under the auspices of the government.

One of the of the direct requests that this report responds to is in Public Law 99-383, August 21, 1986, in which Congress charged the Office of Science and Technology Policy to conduct a study of critical problems and of current and future options regarding communications networks for research computers, including supercomputers, at universities and federal research facilities in the United States. The legislation asked that requirements for supercomputers be addressed within one year and requirements for all research computers be addressed within two years. Dr. William R. Graham, Director of the Office of Science and Technology Policy, subsequently charged the Federal Coordinating Council on Science Engineering and Technology (FCCSET) Committee on Computer Research and Applications to carry out the technical aspects of the study for OSTP.

It was recognized by the FCCSET Committee on Computer Research and Applications that networking technology needs to be addressed in the context of the applications of computing and the sources of computing power that are interconnected using the network technology. This report, therefore, presents an integrated set of findings and recommendations related to Federal support for computer and related research.

Three subcommittees carried out the work. Each of these committees contributed to the Findings and Recommendations contained in this report. The result is an integrated set of recommendations that addresses the technical areas.

- The **Subcommittee on Computer Networking, Infrastructure, and Digital Communications** invited experts in government, industry and academia to write white papers on networking trends, requirements, concepts applications, and plans. A workshop involving nearly 100 researchers, network users, network suppliers, and policy officials was held in San Diego, California in February 1987 to discuss the white papers and to develop the foundation for the report. Workshop leaders and other experts later met in Washington to summarize the workshop discussions and focused on six topics: access requirements and future alternatives, special requirements for supercomputer networks, internet concepts, future standards and services requirements, security issues, and the government role in networking. As a result of this work, the participants recommended that no distinction should be made between networks for supercomputers and other research computers and that the final report to the Congress should address networks generally. The requirements for both supercomputers and for other research computers are, therefore, addressed in this report.

- The **Subcommittee on Science and Engineering Computing** assessed computing needs related to computational science and engineering. The committee focused its deliberations on requirements for high performance computing, on networking and access issues, and on software technology and algorithms. Under the auspices of the Society for Industrial and Applied Mathematics (SIAM), and with the support of NSF and DOE, a workshop involving 38 recognized leaders from industry, academia, and national laboratories was held at Leesburg, Virginia in February 1987 on research issues in large-scale computational science and engineering. This workshop focused on advanced systems, parallel computing and applications. As a result of the workshop report, recommendations were made related to the role of computing technology in science and engineering applications.

- The **Subcommittee on Computer Research and Development** assessed the role of basic research, the development of high performance computing technology, and issues related to software technology. Contributing to this activity were two workshops. The National Science Foundation (NSF) Advisory Committee for Computer Research reviewed the field and produced an Initiatives Report in May 1987. This report recommended investment in three areas, including parallel systems and software technology. In September 1987, the Defense Advanced Research Projects Agency (DARPA) held a workshop on advanced computing technology in Gaithersburg, Maryland involving 200 researchers from academia, industry, and government. The workshop focused on large-scale parallel systems and software approaches to achieving high performance computing.

An important result of the activity of the FCCSET Committee on Computer Research and Applications and its subcommittees is that increased coordination among the Government elements is necessary to implement a strategy for high performance computing. The findings and recommendations presented here represent a consensus reached among the subcommittees and convey the powerful and compelling vision that emerged. As a result of this process, the next step would be for the members of the Committee on Computer Research and Applications to develop a plan to help ensure that the vision is shared between government, academia, and American industry. Subsequently, the Committee should develop an implementation plan for Federal government activities, including a detailed discussion of overall priorities.

1. High Performance Computers

- **FINDING: A strong domestic high performance computer industry is essential for maintaining U.S. leadership in critical national security areas and in broad sectors of the civilian economy.**

U.S. prominence in technology critical to national defense and industrial competitiveness has been based on leadership in developing and exploiting high performance computers. This preeminence could be challenged by dependency upon other countries for state of the art computers. Supercomputer capability has contributed for many years to military superiority. In addition, industrial applications now constitute more than half of the supercomputer market and are an important factor in U.S. industrial competitiveness. However, continued progress in computational science and engineering will depend in large part on the development of computers with 100 to 1000 times current capability for important defense, scientific, and industrial applications. These applications are represented by the grand challenges.

- **U.S. high performance computer industry leadership is challenged by government supported research and development in Japan and Europe.**

The U.S. currently leads the world in research, development, and use of supercomputers. However, this leadership faces a formidable challenge from abroad, primarily from the Japanese. The 1983 FCCSET report stated that "The Japanese have begun a major effort to become the world leader in supercomputer technology, marketing, and applications." Most of the analyses and projections advanced in support of that statement have proven to be accurate.

Japanese supercomputers have entered the marketplace with better performance than expected. Japanese supercomputer manufacturers have attained a high level of excellence in high speed, high density logic and memory microcircuits required for advanced supercomputers. As a result, some U.S. computer manufacturers are dependent on their Japanese competitors for sole supply of critical microcircuits. Japanese manufacturers, universities, and government have demonstrated the ability to cooperate in developing and marketing supercomputers as well as in advancing high performance computing. Recent successes in dominating related high-technology markets underscore their financial, technical, and marketing capability.

- **U.S. leadership in developing new component technology and applying large scale parallel architectures are key ingredients for maintaining high performance computing leadership. The first generation of scalable parallel systems is now commercially available from U.S. vendors. Application–specific integrated circuits have become less expensive and more readily available and are beginning to be integrated into high performance computers.**

The current generation of supercomputers achieve their performance through the use of the fastest possible individual components, but with relatively conservative computer architectures. While these computers currently employ up to eight parallel processors, their specific architectures cannot be scaled up significantly. Large scale parallel processing, in which the computational workload is shared among many processors, is considered to be the most promising approach to producing significantly faster supercomputers. The U.S. is currently the leader in developing new technology as well as components. However, exploiting these techniques effectively presents significant challenges. Major effort will be required to develop parallel processing hardware, algorithms, and software to the point where it can be applied successfully to a broad spectrum of scientific and engineering problems.

Government funded R&D in universities and industry has focused on an approach to large–scale parallelism that is based on aggressive computer architecture designs and on high levels of circuit integration, albeit with somewhat slower individual components. Unlike current supercomputers, the resulting systems employ 100s to 10,000s of processors. Equally important, these architectures are scalable to higher levels of parallelism with corresponding increase in potential performance.

The first generation of scalable parallel systems is now commercially available from U.S. vendors. These systems have demonstrated high performance for both numeric and non–numeric, including symbolic processing. Comparable systems do not yet exist outside the U.S. The second generation, with higher speed individual components and more parallelism, is already in development here. Experience with these systems has shown that, even with existing software, they are effective for certain classes of problems. New approaches to software for these large–scale parallel systems are in the process of emerging. These approaches suggest that parallel architecture may be effective for wide classes of scientific and engineering problems. An important benefit of the scalable architectures is that a single design, with its attendant components and software, may prove to be useful and efficient over a performance range of 10 to 100 or more. This allows one design to be used for a family of workstations, mini–supercomputers, and supercomputers.

• **RECOMMENDATION: The U.S. Government should establish a long range strategy for Federal support for basic research on high performance computer technology and the appropriate transfer of research and technology to U.S. industry.**

The program should build upon existing government supported efforts. However, government funding should not be viewed as a substitute for private capital in the high performance computer marketplace. A primary objective is to ensure continued availability of domestic sources for high performance computers that are required for Federal programs, both civilian and defense. These actions should include:

- Government should support, when appropriate for mission requirements, the acquisition of prototype or early production models of new high performance computers that offer potential for improving research productivity in mission areas. These computers could be placed in centers of expertise in order to allow sophisticated users to share initial experiences with manufacturers and other users, and to develop software to complement the vendor's initial offerings. These initial acquisitions should not require the vendor to supply mature operating systems and applications software typical of production computers. However, a criterion for acquisition should be that the hardware designs reflect a sensitivity to software issues, and that the computer has the potential for sustained performance in practical applications that approaches the peak hardware performance.

- Government agencies should seek opportunities to cooperate with industry in jointly funded R&D projects, concentrating especially on those technologies that appear scalable to performance levels of trillions of operations per second (teraops) for complex science, engineering, and other problems of national importance. Systems are needed for both numeric and symbolic computations.

However, since government mission requirements typically exceed those of industrial applications, cooperating with industry in R&D for computers to meet these missions will help to assure that the necessary computers are available. It will also drive supercomputer development at a faster pace than would be sustained by commercial forces alone, an important factor retaining and increasing U.S. leadership in this area.

- Government agencies should fund basic research to lay the foundation for future generations of high performance computers. Steps should be taken to ensure that development of state-of-the-art computers continues to be monitored for appropriate export controls.

2. Software Technology and Algorithms

- **FINDING: Research progress and technology transfer in software and applications must keep pace with advances in computing architecture and microelectronics.**

  - **Progress in software and algorithms is required to more fully exploit the opportunity offered by parallel systems.**
  - **Computational methods have emerged as indispensable and enabling tools for a diverse spectrum of science, engineering, and design research and applications.**
  - **Interdisciplinary research is required to develop and maintain a base of applications software that exploits advances in high performance computing and algorithm design in order to address the "grand challenges" of science and engineering.**

A **grand challenge** is a fundamental problem in science and engineering, with broad application, whose solution will be enabled by the application of the high performance computing resources that could become available in the near future.

As high performance computing systems evolve and are applied to more challenging problems, it is becoming increasingly clear that advances in software technology and applications are essential to realize the full performance potential of these systems. Software development, analysis, and adaptation remain difficult and costly for traditional sequential systems. Large scale complex systems including parallel systems pose even greater challenges. Market pressures for the early release of new computing system products have created a tradition of weak systems software and inadequate programming tools for new computers.

Current approaches to software development provide only limited capabilities for flexible, adaptable, and reusable systems that are capable of sustained and graceful growth. Most existing software is developed to satisfy nearer term needs for performance at the expense of these longer term needs. This is particularly the case for applications in which specific architectural features of computers have been used to obtain maximum performance through low level programming techniques. The lack of portability of these programs significantly raises the cost of transition to newer architectural approaches in many applications areas. Approaches are beginning to emerge in the research community that have a potential to address the reuse and portability problems.

Experiments with parallel computers have demonstrated that computation speeds can increase almost in direct proportion to the number of processors in certain applications. Although it is not yet possible to determine in general the most efficient distribution of tasks among processors, important progress has nonetheless been made in the development of computational models and parallel algorithms for many key problem areas.

Access to advanced computing systems is an important element in addressing this problem. Experience has shown that the quality of systems and applications software increases rapidly as computing systems are made more available. Initial generic operating systems and extensions to existing programming languages can provide access through coupling high performance computers with existing workstations using either direct or network connections. However, in order to achieve the full potential impact of large scale parallel computing on applications, major new conceptual developments in algorithms and software are required.

The U.S. leads in many areas of software development. The Japanese, however, also recognize the need for high quality software capability and support in order to develop and market advanced machines. They have demonstrated the ability to effectively compete, for example in the area of sophisticated vectorizing compilers.

The U.S. will need to encourage the collaboration of computer scientists, mathematicians, and the scientists in critical areas of computing applications in order to bring to bear the proper mix of expertise on the software systems problem. Such collaboration will be enhanced by network technology, which will enable geographically dispersed groups of researchers to effectively collaborate on "grand challenges." Critical computer applications include problems in fluid dynamics, plasma physics, elucidation of atomic and molecular structure, weather prediction, engineering design and manufacturing, computer vision, speech understanding, automated reasoning, and a variety of national security problems.

- **<u>RECOMMENDATION:</u> The U.S. should take the lead in encouraging joint research with government, industry, and university participation to improve basic tools, languages, algorithms, and associated theory for the scientific "grand challenges" with widespread applicability.**

Software research should be initiated with specific focus on key scientific areas and on technology issues with widespread applicability. This research is intended to accelerate software and algorithm development for advanced architectures by increased early user access to prototype machines. It would also provide settings for developing advanced applications for production machines. Software technology needs to be developed in real problem contexts to facilitate the development of large complex and distributed systems and to enable transition of emerging parallel systems technology into the computing research community and into the scientific and engineering applications communities.

As part of a mixed strategy, longer term and more basic software problems of reliability and trust, adaptability, and programmer productivity must continue to be addressed. Languages and standards must be promoted that permit development of systems that are portable without sacrificing performance.

In applications areas including computational science and engineering, technology should be developed to support a smooth transition from the current software practice to new approaches based on more powerful languages, optimizing compilers, and tools supported by algorithm libraries. The potential of combining symbolic and numeric approaches should be explored. Progress in these areas will have significant impact on addressing the "grand challenges" in computational science and engineering. Although there are many pressing near term needs in software technology, direct investment in approaches with longer term impact must be sustained if there is to be significant progress on the major challenges for software technology while achieving adequate system performance.

Applications include (1) distributed access to very large databases of scientific, engineering, and other data, (2) high bandwidth access to and linking among shared computational resources, (3) high bandwidth access to shared data generation resources, (4) high bandwidth access to shared data analysis resources, such as workstations supporting advanced visualization techniques.

3. Networking

• **FINDING: The U.S. faces serious challenges in networking technology which could become a barrier to the advance and use of computing technology in science and engineering.**

- **Current network technology does not adequately support scientific collaboration or access to unique scientific resources. U.S. commercial and government sponsored networks presently are not coordinated, do not have sufficient capacity, do not interoperate effectively, and do not ensure privacy.**
- **Europe and Japan are aggressively moving ahead of the U.S. in a variety of networking areas with the support of concentrated government and industry research and implementation programs.**

Computer network technology provides the means to develop large scale distributed approaches to the collaborative solution of computational problems in science, engineering, and other applications areas. Today, researchers sharing a local area network are able to exploit nearly instantaneous communication and sharing of data, creating an effect of linking their workstations and high performance servers into a single large scale heterogeneous computing facility. This kind of capability is now appearing in larger scale campus-wide computer networks, enabling new forms of collaboration. National networks, on the other hand, have low capacity, are overloaded, and fail to interoperate successfully. These have been expanded to increase the number of users and connections but the performance of the underlying network technology has not kept pace with the increased demands. Therefore, the networks which in the 1970s had significant impact in enabling collaboration, are now barriers. Only the simplest capabilities, such as electronic mail and small file transfers, are now usable. Capacity, for example, is orders of magnitude less than the rates required, even if the network is used only for graphics.

Other countries have recognized the value of national computing networks, and, following the early U.S. lead, have developed and installed national networks using current technology. As a result, these countries are now much better prepared to exploit the new opportunities provided by distributed collaborative computing than the U.S. is at the present time. The basic technologies for later generations are also being developed in the U.S., but there have been no major efforts to apply them to address the needs.

A longer term goal is the creation of large scale geographically distributed heterogeneous systems that link multiple superworkstations and high performance supercomputers to provide service to scientists and engineers distributed across the country. A well-coordinated national network could link these resources together when required on an *ad hoc* basis to provide rapid response to computational needs as they arise. This could reduce the number of sites needed for the physical presence of supercomputers. Present access to computer networks by researchers is dependent upon individual funding or location. There is unnecessary duplication in the links from various agencies to each campus. The development of improved networking facilities could greatly stimulate U.S. research and provide equitable access to resources.

Many scientific research facilities in the U.S. consist of a single, large, and costly installation such as a synchrotron light source, a supercomputer, a wind tunnel, a particle accelerator, or a unique database. These facilities provide the experimental apparatus for groups of scientific collaborators located throughout the country. Wide area networks are the logical mechanism for making data from such facilities more easily accessible nationwide. An important issue is that of computer and network security to ensure privacy and trustworthiness in a heterogeneous network environment. At present, responsibility for privacy and the assurance of trust are vested principally in the computers and switching nodes on the network.

Existing government-supported wide-area networks include ARPANET, HEPNET, MFENET, NSFNET, NASNET, MILNET, and SPAN, as well as private and commercial facilities such as TYMNET, TELENET, BITNET, and lines leased from the communication carriers. Longer-range estimates vary, but it is expected that by the year 1995 the nation's research community will be able to make effective use of a high capacity national network with capacity measured in billions of bits per second. Without improved networks, speed of data transmission will be a limiting factor in the ability of researchers to carry out complex analyses. The digital circuits most widely available today with transmission speeds of 56 kilobits per second (kb/s) are impediments to leading edge research and to optimal remote high performance computer use.

Point-to-point connections require interconnects through multiple vendors with cumulative costs. Greater network speed can reduce the time required to perform a given experiment and increase both the volume of data and the amount of detail that can be seen by researchers. Scientists accessing supercomputers would benefit because access speed is often critical in their work. Improved functionality frees scientists to concentrate directly on their experimental results rather than on operational details of the network. Increased network size extends these opportunities to thousands of individuals at smaller academic institutions throughout the nation. These modernization measures would significantly enhance the nation's position in scientific research. A national network would help maintain the U.S. leadership position in computer architectures, microprocessors, data management, software engineering, and innovative networking facilities, and promote the development of international networking standards based on U.S. technology.

Integrated Systems Digital Networks (ISDN–voice and data) have been installed abroad on a national or regional scale. Research abroad is being conducted on service up to 1 Gb/s. Within the next five years, Integrated Services Digital Network (ISDN) circuits ranging from 64 kb/s to 1.5 Mb/s will be available in the larger metropolitan areas of the U.S. However, these services will fall short of the requirements for computer networks. By 1988 more than fifty Campus Area Networks will be operational at speeds approaching 100 Mb/s. Wide area networks operating at 1.5 Mb/s or less will not be able to handle the data volume expected.

Japan and Europe have extensive efforts with experimental nets in intermediate (40Mb) and high (gigabit) range. Japan is studying operational aspects of fiber nets using their national research network as a testbed, which includes exploring the feasibility of fiber optic services to residences.

To estimate the network bandwidth needed to support research at a major installation, the kinds and volume of traffic that would be used have been estimated at a representative campus, extrapolated ten years into the future. Three models were used to compute three independent estimates of the requirements for bandwidth needed by type of work, information needs by type of user, and information flowing at the installation boundary. In each model, the peak bandwidth was estimated for each type of service. For example, in the Task model, the need is dominated by that of at least one researcher to receive full color and full-motion high resolution images. A high-resolution color image contains about 30 megabits of information, so that a display rate of 30 frames per second requires a bandwidth of nearly one gigabit per second (Gb/s). In the User model, a research university with 35,000 students and 3,000 faculty and research staff using a mix of bandwidths again requires an aggregate bandwidth of approximately one Gb/s. In the Edge of the Installation model, bandwidth is estimated by the types of remote facilities being accessed and the expected number of simultaneous users; typical facilities include particle accelerators, supercomputers, and centers for imaging and/or animation. The aggregate bandwidth needed is one Gb/s. Thus three independent means of estimating bandwidth arrive at nearly the same requirement for a large research installation, and one Gb/s can confidently be used as a lower bound on the bandwidth of a national research network.

• **<u>RECOMMENDATION:</u> U.S. government, industry, and universities should coordinate research and development for a research network to provide a distributed computing capability that links the government, industry, and higher education communities.**

A research network should be established in a staged approach that supports the upgrade of current facilities and development of needed new capabilities. Achievement of this goal would foster and enhance the U.S. position of world leadership in computer networking as well as provide infrastructure for collaborative research. The FCCSET Committee on Computer Research and Applications should provide a forum for interagency cooperations. Elements of the plan should include:

- *Stage 1.* Upgrade existing facilities in support of a transition plan to the new network through a cooperative effort among major government users. The current interagency collaboration in expanding the Internet system originated by DARPA should be accelerated so that the networks supported by the agencies are interconnected over the next two years.
- *Stage 2.* The nation's existing networks that support scientific research should be upgraded and expanded to achieve data communications at 1.5 Mb/sec for 200 to 300 U.S. research institutions.
- *Stage 3.* Develop a system architecture for a national research network to support distributed collaborative computation through a strong program of research and development. A long–term program is needed to advance the technology of computer networking in order to achieve data communication and switching capabilities to support transmission of three billion bits per second (3 Gb/s) with deployment within fifteen years.
- Develop policy for long term support and upgrading of current high performance facilities, including timetables for backbone and connection development, industry participation, access, agency funding, tariff schedules, network management and administration. Support should be given to the development of standards and their harmonization in the international arena.

Until the national research network can replace the current system, existing networks should be maintained and modified as they join the national network. Remedial action should be initiated as soon as possible. Upgrading the backbone to at least 1.5 Mb/s should be accomplished by 1990. This will ensure that the new generation of high performance computing can be effectively interconnected.

Industry should be encouraged to participate in research, development, and deployment of the national research network. Telecommunication tariff schedules which have been set for voice transmission should be reviewed in light of the requirements for transmission of data through computer networking.

Prompt effective coordination is needed to increase user participation in the standards development process, to get requirements for standards expressed early in the development process, and to speed the implementation of standards in commercial off-the-shelf products. It is essential that standards development be carried out within the framework of overall systems requirements to achieve interoperability, common user interfaces to systems, and enhanced security.

4. Basic Research and Human Resources

• **FINDING: Federal research and development funding has established laboratories in universities, industry, and government which have become the major sources of innovation in the development and use of computing technology.**

Many of the advances in computer science and technology in the U.S. were made possible by Federal programs of research support to universities and industry. For example, the advances that have occurred since 1983 in the area of parallel computing are the direct result of Federal research investment through agencies including DARPA and NSF. In the area of application of supercomputers to science and engineering, the majority of this investment came from the NSF Advanced Scientific Computing centers. In the area of parallel architectures, the major investment came from the DARPA Strategic Computing Program. Programs sponsored by DOE, NASA, and Defense to support critical mission needs have been a major source of investment in computational applications research. In industry, support for basic research is only a small fraction of industry research most of which is focused on nearer term product development. This can be attributed in part to the long term and high risk nature of basic research, but a more significant inhibitor of investment is the difficulty in the computer industry of maintaining proprietary protection for certain kinds of key fundamental advances.

• **RECOMMENDATION: Long term support for basic research in computer science should be increased within available resources. Industry, universities, and government should work together to improve the training and utilization of personnel to expand the base of research and development in computational science and technology.**

Maintain vigorous research in Computer Science and sufficient growth of computer science manpower to support the scientific/technological basis of the computer field. Foster interactions among academia, industry, and national laboratories by creating interdisciplinary teams to address large scale problems. Extend the technology base to attain significant impact on competitiveness and industrial productivity.

Innovative very high performance computing systems should be made available to universities and basic research laboratories in order to assist in the evaluation and exploitation of new technology and new industrial innovations.

Continue the following successful approaches to basic research and development: (1) The practice of loosely coordinated and flexible basic research supported through various federal sectors and applied to a diversity of institutions, (2) The mixed strategy of peer review to support a broad range of exploratory basic research throughout the academic community and the complementary technical program management approach of larger scale experimental systems programs which exploit new opportunities as they emerge, (3) Support for individuals and small groups in theoretical areas, (4) The practice of supporting the relevant basic research as part of larger experimental systems projects.

IMPLEMENTATION

Success of the National High Performance Computing Strategy will require an attitude of cooperation in which academia, industry and government work effectively together in developing and assessing new technology and in achieving the transition of promising new ideas into the marketplace. The rapid pace of developments in computing technology creates a number of implementation challenges that must be addressed explicitly if the Strategy is to have maximum impact.

The FCCSET Committee on Computer Research and Applications provides an appropriate forum for coordination of Federal agency programs. Specifically:

- The subcommittee on Computer Networking, Infrastructure, and Digital Communications will develop a coordinated implementation plan for the national research network.

- The subcommittee on Science and Engineering Computing will review the *grand challenges* through the use of high performance computing systems, including the research that will be involved.

- The subcommittee on Computer Research and Development will review the need for advanced software, algorithms, and hardware for future high performance computing systems.

All of the subcommittees will consider appropriate action to secure a foundation of basic research and human resources. In all three subcommittees we expect some overlap of responsibility and interchange of ideas to be compatible with success.

As has been firmly stated, the full cooperation through a shared vision between government, industry and the research community will be a necessary ingredient for the successful implementation of this strategy. The FCCSET Committee on Computer Research and Applications therefore calls for timely consideration of the vision and strategy by representative bodies of the research community and industry.

It is essential, however, that implementation of the strategy be undertaken in a timely manner. There is a need to follow through on the breakthroughs that occurred partially as a result of federal investment in the early 1980s. The fast pace of development dictates that appropriate Federal efforts are needed to help ensure continued excellence in high speed networking technology and leadership in high performance computing. Foreign investment in technology development in these key areas has increased dramatically. The prudent strategy is to maintain a consistent strong lead in research and to transfer the results as quickly as possible to American industry.

COST ESTIMATES

Many of the basic elements of the high performance computing strategy are already being implemented as part of ongoing agency programs at DOE, DARPA, NSF, NASA, and other Federal agencies, and important progress is being made. The FCCSET Committee activity has contributed to achieving a shared vision, and early coordination is already occurring in anticipation of implementation of the strategy. Implementation of the strategy involves three principal funding components, including the national research network, joint research to address the "grand challenges," and basic research in high performance computing architecture, custom hardware design, software, algorithms, and supporting technologies. Multiple agencies are involved in the implementation and funding of each of these components.

The funds that would be associated with each of these components are described below. Obviously, any incremental funding must be evaluated and approved within the context of current activities and research needs in other high priority fields. Currently, the Federal government is spending about $500M per year on all aspects of high

Summary of Additional Funds
(Millions of Dollars)

Current Funds			Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
50 [a]	National Research Network	Stage 1	5	5	5	0	0
		Stage 2	5	5	55	55	55
		Stage 3	40	40	40	40	40
150 [b]	Joint Research in Computational Science and Engineering		30	60	90	120	150
300	Basic Research in Computer Science and High Performance Computing		60	120	180	240	300
500	TOTAL (above current funds)		140	230	370	455	545
	Funding Increase by Year (noncumulative)		140	90	140	85	90

a Estimated network research and support in grants and contracts.
b Estimated operating costs for existing computational science facilities.

performance computing. Funding for the activities recommended in this report would increase this base by $140M in additional resources for the first year, growing to an additional $545M per year in 5 years.

National Research Network. Current operating costs for the present collection of research–support networks operated by DARPA, NSF, DOE, and NASA is approximately $50M per year; the figure is uncertain because many subnetworks are funded by increments on research grants and contracts, rather than being centrally supported. Currently the interconnection of existing agencies' networks is planned within existing budgets. A significant increase in investment is needed to achieve the required capability. This investment could occur in three concurrent stages.

The *first stage* activity would involve an immediate upgrade to 1.5 Mbit/sec of the existing research–support networks. This would cost $15M over three years.

The *second stage* would expand upgraded network services (45Mbit/sec) to 200 to 300 research installations, using primarily fiber–optic trunk facilities. Development costs for this stage would be $5M per year of additional funding. Operation of the upgraded network would commence in three to five years, with operating costs of approximately $50M per year. Since the transition from the first stage to the second stage network could not be instantaneous, initially the full operating cost of the second stage network would necessitate additional funding; that requirement will diminish to the extent that the first stage network is phased out.

The goal of the *third stage* would be to deliver one to three Gbit/sec to selected research facilities, and 45 Mbit/sec to approximately 1000 research sites. Research and development costs for this project are estimated at $400M of new funds, spent over ten years; after ten years, operating costs would be about $200M per year unless some tariff relief is achieved.

Joint Research in Computational Science and Engineering. Current operating costs for existing computational science laboratory facilities is approximately $150M per year. Additional investment would be required to upgrade the existing facilities and/or to establish additional joint research activities, with government, industry, and university participation, to address approximately specific problem areas, including selected *grand challenges*. Many of these joint research efforts will involve multiple physical sites connected by the research network. The investment in these research activities supports pursuit of the grand challenges. This includes personnel to develop computational approaches in terms of theory, algorithms, and software, and the acquisition of modern computing equipment. Estimated Federal costs average $15M per year to establish and sustain each grand challenge. The joint research activities would be introduced at the rate of two per year. Overall investment will be approximately $30M per year initially, increasing to $150M per year in five years as new grand challenges are added.

Basic Research in Computer Science and High Performance Computing. Current Federal investment in advanced computer research is estimated at $300M in FY88. Over the past four years, investment in these areas has grown at 15% per year. The rate of increase appears to be declining, however, at a time when increased investment appears to be needed. Sufficient resources should continue to be allocated to take full advantage of the high performance computing opportunities that now exist including design and prototype development of systems capable of trillions of operations per second. A second important element is stable funding, which is required to preserve the long-term strength of the research community.

Other countries are also devoting considerable resources in this area. For example, the Japanese government supports two projects which directly address supercomputer development: The Fifth Generation Project and the Superspeed Project. Support for each of these is estimated to be in excess of $100M per year. In addition to this government support, Japanese industry is investing considerably more to develop high performance computers. Japanese government and industry are also investing amounts comparable to those recommended here to develop high bandwidth research networks.

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