

Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
2005-0336-F

FOIA MARKER

**This is not a textual record. This is used as an
administrative marker by the George Bush Presidential
Library Staff.**

Record Group/Collection: George H.W. Bush Presidential Records
Collection/Office of Origin: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files

OA/ID Number: 62045
Folder ID Number: 62045-004

Folder Title:
Physical Sciences: Space [3 of 3] [1991]

Stack:

Row:

Section:

Shelf:

Position:

0

0

0

0

"CORRESPONDENCE TRACKING"

TYPE: ACTION

DOCUMENT NUMBER: 9121047

FROM: WASSERBURG, G. J.: CALIFORNIA INSTITUTE OF TECHNOLOGY

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 04/09/91

SUBJECT: RE: A LETTER TO FRANK PRESS CONCERNING THE RECENT
REPORT ON THE SPACE STATION.

ASSIGNED TO: D. Allan Bromley

ACTION REQUIRED: IF APPROPRIATE

SENDER'S DUE DATE: OSTP DUE DATE: 04/23/91

DATE COMPLETED: -----

COPIES TO: Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/09/91

FILE: SPACE

p-Physical Sciences -

FAX 202/395-3261

9121047
RECEIVED

CALIFORNIA INSTITUTE OF TECHNOLOGY

91 APR 9 P3:41

DIVISION OF GEOLOGICAL AND PLANETARY SCIENCES 170-25

OFFICE OF THE
DIRECTOR

9 April, 1991

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
The White House
Old Executive Office Building #358
17th and Pennsylvania Avenue, N.W.
Washington, D.C. 20506

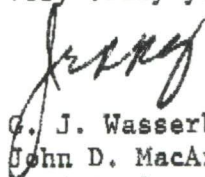
Dear Allan:

Here is a note I have written to Frank about the recent report on the Space Station. I think the report is flawed, although I am not a supporter of the Space Station for doing science, as it certainly cannot be justified by scientific goals. However, if we are going to require long-term piloted missions, then we must check out thoroughly those biomedical aspects related to this goal.

In addition, I think the earlier recommendations on the EOS are also flawed. It is tragic that an evolutionary program was not recommended instead of one enormous splurge whose quality does not justify the commitment, and which will freeze out the evolutionary and developmental aspects that are imperative for good science.

The blind copy of the letter to Frank is sent to you as a member of the NAS and because of your interest in the issues.

Very truly yours,



G. J. Wasserburg
John D. MacArthur Professor
of Geology and Geophysics

P.S. Have you thought of a way to shut off solar flares, or do we need a super-heavy lift capability for just the shielding?

GJW:kv
Attachment (1)

CALIFORNIA INSTITUTE OF TECHNOLOGY

DIVISION OF GEOLOGICAL AND PLANETARY SCIENCES 170-25

April 1, 1991

Dr. Frank Press
National Academy of Sciences
2101 Constitution Avenue
Washington, D.C. 20481

Dear Dr. Press:

At our last regional meeting there was some discussion of the role of the NAS regarding the NRC and the nature and quality of the NRC reports. In particular, concern was expressed about the adequate participation of NAS members on the appropriate committees and on their proper participation in the report review committee. In addition, there is, on my part, a most profound concern that the NAS present astute and balanced reports on selected important issues. These reports should reflect on previous NAS recommendations and when good judgement indicates change in their recommendations, the reasons for change should be appropriately explained. There is often a request that evaluations be made and reports with recommendations issued in a timely manner. However, the need for timeliness should not in any way weaken or prevent the exercise of proper and thorough procedures. The NAS should be responsive to requests from the government, and provide technically sound and wise advice, but it should not act as an instrument of tactical decision making or of instant advice on short range issues unless the NAS has defined a broader strategic level of evaluation and advice. It is clear that evaluation on specific programmatic issues can be given when there has been a study and report on the broader issues at hand. Certainly, excessive pressure to issue reports on a rapid time scale should be avoided whenever possible. Whatever the report may be, the report should reflect careful thought and analysis and should be crafted in a deliberate fashion to represent the considered NAS views for the issues at hand. NAS/NRC reports should properly reflect the careful analysis and dignity of the NAS.

In my view, this approach has not been carried forward in several reports that I have read. One such example was the contribution of EOS - US Global Change Program an assessment of FY90-91 Plans, Part II.

The most recent example of a difficulty is the release on 14 March 1991 of the Space Studies Board Position on *The Proposed Redesign of the Space Station*. It starts with a summary that appears to be dominated by the Augustine Committee report. It does not place a broad level of assessment of what the overall objectives of the space station may be and the extent to which some aspects of science, applied science or technology are its primary goals. The presentation then turns to the title "*Research Return on Taxpayers Investment*". The competence of the Board to address this issue is not evident nor is it a desirable judgement without a very broad view over many fields. It then turns in the next topic to Life Sciences Research and Microgravity Research. A critique is presented without having established what if any objectives should be met and on what time scale and how these objectives are related to the primary goals of the space station. It then concludes with a short statement on National Goals and their Achievement. However the analysis, or rather commentary, in these passages does not appear cogently argued. Indeed, it states that "most of whose goals could be achieved in both a more timely and more

PASADENA, CALIFORNIA 91125 TELEPHONE (818) 356-6139 FAX (818) 368-0935

THE WHITE HOUSE

WASHINGTON

April 26, 1991

Dear Jerry:

Many thanks for sending me a copy of your note to Frank Press about the recent report on the Space Station as well as the earlier recommendations on EOS.

I am in full agreement with your statement and have already had occasion to talk to Frank about both of these reports.

In the case of the EOS report, while the report itself was not too bad, the Executive Summary did not really reflect the report and the original version of the transmittal letter addressed to me from Frank and Bob White was so different from either the report or the Executive Summary, that I objected vigorously. In the end, both the Executive and the transmittal letter changed, but your comments still apply.

In the case of Lou Lanzerotti's report, I again share your point of view. I do not really argue all that much with Lou's Panel's conclusions, but I do argue vigorously with their premise. They took the statement supporting space science in the Augustine Report as justification for concluding that the only valid justification for the Space Station would be its science programs.

In a study that we did in my office for the Vice President we found, after considerable examination, that from our point of view the only valid justification for the Space Station is that of its being the first step in taking humans on an exploration foray away from the home planet. Once you make that decision then it becomes clear that the science that most needs doing as a prelude to the second step is life science, specifically directed toward better understanding of the effects of prolonged weightlessness on humans. We emphasized in our report the importance of having a human scale centrifuge eventually on the Space Station because we do not know yet how the human reacts to gravitational forces in the range between zero and 1g. There may well be thresholds or vast nonlinearities and it is vitally important for us to know whether providing point .1g, for example, can largely eliminate many of the negative effects of weightlessness.

We also concluded that although there may, as always, be major surprises in the microgravity arena, the best judgement we have been able to obtain thus far, both from national labs and universities and from the private sector folk who are thinking about these matters, suggests that microgravity research really does not in itself provide any adequate justification either for building the station or for special facilities on the station. We recommended that microgravity experiments be carried out during the several years during which the Station will be man-tended and under construction, but that once it becomes manned on a full-time basis, microgravity experiments can better be carried out on free-floating platforms with robotic handling.

The best comment I have heard yet on the cost effectiveness of the Space Station is one due to Richard Darman who pointed out that once could have said that "the Nina, Pinta, and Santa Maria were not a cost effective set of platforms for the study of motion sickness!"

Again, thanks for sending me your note. It is important that people like you make your feelings known to Frank because sometimes there is a tendency for the Academy to get a little off track.

With all best wishes,

Sincerely yours,



D. Allan Bromley
The Assistant to the President
for
Science and Technology

Professor G. J. Wasserburg
Division of Geological and Planetary Sciences 170-25
California Institute of Technology
Pasadena, California 91125

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9121059

FROM: RAVEN, Peter H.: NATIONAL ACADEMY OF SCIENCES

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 04/08/91

SUBJECT: THE SYMPOSIUM ON "ASTRONOMY AND ASTROPHYSICS IN THE
1990'S" DURING THE ACADEMY'S ANNUAL MEETING.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/10/91

FILE: SPACE

p-Physical Sciences -

NATIONAL ACADEMY OF SCIENCES

2101 Constitution Avenue, Washington, D.C. 20418

OFFICE OF THE HOME SECRETARY
(202) 334-2446

April 8, 1991

9121059
RECEIVED
91 APR 10 A10:01

OFFICE OF THE
DIRECTOR

Dr. D. Allan Bromley
Assistant to the President
for Science & Technology
Director, Office of Science & Technology
Old Executive Office Building, Room 360
Washington, D.C. 20506

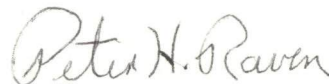
Dear Allan:

As you know, a symposium on "Astronomy and Astrophysics in the 1990s" will take place on Monday, April 29 during the Academy's annual meeting.

John Bahcall, chairman of the committee which produced the report *The Decade of Discovery for Astronomy and Astrophysics* will moderate the symposium and asked particularly that we bring it to your attention.

Additional material about the symposium is enclosed. I hope to see you at the annual meeting.

Sincerely,



Peter H. Raven
Home Secretary

Enclosure

SYMPOSIUM AT THE NATIONAL ACADEMY OF SCIENCES
2101 Constitution Avenue, N.W.
Washington, D.C. 20418
Monday, April 29, 1991 from 1:30 - 5:00 p.m.

ASTRONOMY AND ASTROPHYSICS IN THE 1990s

MODERATOR
John Bahcall
Professor of Astrophysics
Institute for Advanced Study
Princeton University

James W. Cronin
University Professor of Physics
Enrico Fermi Institute
University of Chicago
"Particle Astrophysics"

James R. Houck
Professor of Astronomy
Cornell University
"Space Astronomy in the Decade of Discovery"

Jeremiah Ostriker
Chairman
Department of Astrophysical Sciences
Director
Princeton University Observatory
"Large Scale Structure in the Universe"

Sidney Wolff
Director
National Optical Astronomy Observatories
"The AASC Report: The Ground-based Program"

The symposium is open to the public at no charge. Please use the entrance at 2100 C Street. Parking is not available. Public parking is located at Columbia Plaza on 23rd Street. The nearest metro stop is Foggy Bottom, located at 23rd and H Streets.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9121143

FROM: THOMPSON, James R. Jr.: NASA

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/29/91

SUBJECT: THE STATUS OF THE EARTH OBSERVING SYSTEM ENGINEERING
REVIEW ADVISORY COMMITTEE.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong
Nancy Maynard

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/17/91

FILE: SPACE

p-Physical Sciences -



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

March 29, 1991

OFFICE OF THE
DIRECTOR

91 APR 17 4:05

RECEIVED

Honorable D. Allan Bromley
Assistant to the President for
Science and Technology
Executive Office of the President
Washington, DC 20506

Allan
Dear Dr. Bromley:

I want to advise you on the status of the Earth Observing System (EOS) Engineering Review Advisory Committee. The first meeting of the Committee is tentatively planned for May 1991.

The Chairman, Dr. Ed Frieman, has requested that we add Dr. V. Ramanathan of the Scripps Institution of Oceanography as a member of the Committee. Dr. Ramanathan, a renowned Earth scientist, has published extensively and received numerous awards for his research in atmospheric studies. I have enclosed a copy of his resume for your information. I believe that he will be an asset to the Committee. We plan to send Dr. Ramanathan a confirmation package in the next several days.

I will forward additional information concerning the Committee to you as it becomes available.

Sincerely,

James R. Thompson, Jr.
Deputy Administrator

Enclosure

VITA

V. RAMANATHAN

PERSONAL: Born: 24 November 1944 (Madras, India); Citizenship: USA

EDUCATION:

B.E., 1965 Annamalai University, India (Mechanical Engineering)
M.S., 1970 Indian Institute of Science, India (Heat Transfer)
Ph.D., 1973 State University of New York at Stony Brook (Planetary Atmospheres)

RESEARCH POSITIONS:

1965-1967 Engineer, Shri-Ram Refrigeration Industries, Hyderabad, India.
1974-1976 National Research Council Post-doctoral Fellow and Visiting Scientist, Langley
Research Center, NASA, Hampton, VA;
1976-1982 Research Scientist, National Center for Atmospheric Research (NCAR), Boulder,
CO.
1982-1986 Senior Scientist and Leader, Cloud-Climate Interactions Group, NCAR
1979-date Principal Investigator, NASA Earth Radiation Budget Experiment Science Team.
1985-1988 Affiliate Professor, Colorado State University, Fort Collins, CO.
1988 Visiting Professor, Catholique Universite of Louvain, Belgium
1986-1990 Professor, Department of Geophysical Sciences, University of Chicago.
1990-date Professor, California Space Institute, University of California,
San Diego

RESEARCH INTERESTS:

Climate Dynamics, Radiative Transfer, The Greenhouse Effect, Clouds,
Satellite Radiation Measurements, and Global Climate Models.

HONORS:

Special Achievement Award, NASA, 1975.
Outstanding Publication Award, NCAR, 1981.
Distinguished Alumnus Award, SUNY, Stony Brook, 1984.
Fellow, American Meteorological Society
Fellow, American Association for the Advancement of Science
Medal for Exceptional Scientific Achievement, NASA, 1989.

RELATED EXPERIENCE:

Associate Editor, *Journal of Geophysical Research*, 1988-date.
Member, AAAS Atmospheric & Hydrospheric Sciences Nominating Committee, 1988.
Member, Space and Earth Science Advisory Committee, NASA 1987-1988.
Chairman, Appointments Committee, University of Chicago, 1986-1988.
Member of the International Association of Meteorology and Atmospheric Physics (IAMAP) Subcommittee, 1986-date.
Member, Climate Research Committee, National Research Council, 1984-1986.
Member, ISCCP Panel, National Research Council, 1984-1988.
Member, Committee on Earth Sciences, National Academy of Sciences, 1982-1984.
Member, International Radiation Commission, 1981-date.
Member, Committee on Radiation & Climate Variations, American Meteorological Society 1982-date.
Associate Editor, *Journal of Atmospheric Sciences*, 1979-1985.
Associate Editor, *Journal of Applied Meteorology*, 1982-1985.
Member, Panel on Climate Effects, Committee on Impacts of Stratospheric Change, NAS Assembly on Mathematical and Physical Science, February 1978.
Member, Panel on the Middle Atmosphere Program, Committee on Solar Terrestrial Research, NAS-NRC, February 1978.

CURRENT GRANTS:

NASA: Principal Investigator; ERBE Satellite experiment, 1979-date
NASA: Co-investigator, CERES Experiment on EOS platforms, 1989- date.
NSF: Cloud-Climate feedbacks, 1986-date

COURSES TAUGHT:

Radiative Transfer, Climate Dynamics, Clouds.

PRINCIPAL PUBLICATIONS

Contributions in Books

- Ramanathan, V., 1989: "The Radiative and Climatic Consequences of the Changing Atmospheric Composition of Trace Gases," in *The Changing Atmosphere*, F.S. Rowland and I.S.A. Isaksen, eds. (New York: John Wiley & Sons, Ltd., 1988), pp. 159-186.
- Ramanathan, V., 1989: "Trace Gas Effects on Climate: A Review," in *Carbon Dioxide and Other Greenhouse Gases: Climatic and Associated Impacts*, R. Fantechi and A. Ghazi, eds. (Boston: Kluwer Academic Publishers, 1989), pp. 152-158.
- Ramanathan, V., 1983: Coupling through radiative and chemical processes. Chapter in *Solar Variability, Weather and Climate. Studies in Geophysics*, Geophysics Research Board. National Academy Press, 83-91.
- Ramanathan, V., 1982: Commentary on climatic effects of minor atmospheric constituents. *Carbon Dioxide Review*, 1982, Edited by Clark, pp. 278-283.
- Ramanathan, V., 1980: "Climatic Effects of Anthropogenic Trace Gases," in *Interactions of Energy and Climate*, W. Bach, T. Pankrath and J. Williams, eds. (D. Reidel Publishing Co, 1980), pp. 269-80.

Reviewed Papers

- 6. Prasad, K.K., and V. Ramanathan, 1972: Heat transfer by free convection from a longitudinally vibrating vertical plate. *Int'l. J. Heat Mass. Transfer*, 15, 1213-1233.
- 7. Cess, R.D., and V. Ramanathan, 1972: Radiative transfer in the atmosphere of Mars and that of Venus above the cloud deck. *J. Quant. Apect. Rad. Trans.*, 12, 933-945.
- 8. Cess, R. D., and V. Ramanathan, 1973: The applicability of an approximate expression for radiative heating. *J. Quant. Spect. Rad. Trans.*, 13, 79-81.
- 9. Ramanathan, V. and R.D. Cess, 1974: Radiative transfer within the mesospheres of Mars and Venus. *Astrophys. J.*, 188, 407-416.
- 0. Ramanathan, V., 1975: Greenhouse effect due to chlorofluorocarbons: Climatic implications. *Science*, 190, 50-51.
- 1. Ramanathan, V. and R.D. Cess, 1975: An analysis of the strong zonal circulation within the stratosphere of Venus. *Icarus*, 25, 89-103.
- 2. Ramanathan, V., 1976: Atmospheric fluorocarbons: Possible effects of a large increase on the global climate. *Environmental Conservation*, 3, 90.
- 3. Ramanathan, V., 1976: Radiative transfer within the troposphere and stratosphere: A simplified radiative-convective model. *J. Atmos. Sci.*, 33, 1330-1346.
- 4. Ramanathan, V., L.D. Collins and R.E. Roughton, 1976: Sensitivity of atmospheric and surface temperature to

15. Augustsson, T., and V. Ramanathan, 1977: A radiative-convective model study of the CO₂-climate problem. *J. Atmos. Sci.*, 34, 448-451.
16. Ramanathan, V., 1977: Interactions between ice albedo, lapse-rate, and cloud-top feedback: An analysis of the nonlinear response of a GCM-climate model. *J. Atmos. Sci.*, 34, 1885-1897.
17. Ramanathan, V. 1977: Troposphere-stratosphere feedback mechanism: Stratospheric warming and its effect on the polar energy budget and the tropospheric circulation. *J. Atmos. Sci.*, 34, 439-447.
18. Ramanathan, V., and W.L. Grose, 1977: A general circulation model study of the radiative-dynamic coupling within the stratosphere. *Contributions to Atmospheric Physics-Beitrage zur Physik der Atmosphäre*, 50, 55-70.
19. Cess, R.D., and V. Ramanathan, 1978: Averaging of infrared cloud opacities for climate modeling. *J. Atmos. Sci.*, 35, 919-922.
20. Chen, T.C., and V. Ramanathan, 1978: A numerical simulation of seasonal stratospheric climate: Part II. Energetics. *J. Atmos. Sci.*, 35, 615-633.
21. Ramanathan, V., and J.A. Coakley, Jr., 1978: Climate modeling through radiative-convective models. *Rev. Geophys. Space Phys.*, 16, 465-490.
22. Ramanathan, V., and W.L. Grose, 1978: A numerical simulation of seasonal stratospheric climate: Part I. Zonal temperature and winds. *J. Atmos. Sci.*, 35, 600-614.
23. Ghazi, A., V. Ramanathan and R.E. Dickinson, 1979: Acceleration of upper atmospheric radiative damping: Observational evidence. *Geophys. Res. Lett.*, 6, 437-440.
24. Owen, T., R.D. Cess and V. Ramanathan, 1979: Early earth: An enhanced carbon-dioxide greenhouse to compensate for reduced solar luminosity. *Nature*, 277, 640-642.
25. Ramanathan, V., and R.E. Dickinson, 1979: The role of stratospheric ozone in the zonal and seasonal radiative energy balance of the earth-troposphere system. *J. Atmos. Sci.*, 36, 1084-1104.
26. Ramanathan, V., M.S. Lian and R. D. Cess, 1979: Increased atmospheric CO₂ Zonal and seasonal estimates of the effect on the radiation energy balance and surface temperature. *J. Geophys. Res.*, 84, 4949-4958.
27. Cess, R.D., V. Ramanathan and T. Owen, 1980: The Martian paleoclimate and enhanced atmospheric carbon dioxide. *Icarus*, 41, 159-165.
28. Donner, L. and V. Ramanathan, 1980: Methane and nitrous oxide: Their effects on the terrestrial climate. *J. Atmos. Sci.*, 37, 119-124.
29. Fishman, J., V. Ramanathan, P.J. Crutzen and S.C. Liu, 1980: Tropospheric ozone and climate. *Nature*, 282, 818-820.
30. Hunt, G.E., V. Ramanathan and R. M. Chervin, 1980: On the role of clouds in the general circulation of the atmosphere. *Quart. J. Roy. Meteor. Soc.*, 106, 213-215.
31. Madden, R.A., and V. Ramanathan, 1980: Detecting climate change due to increasing CO₂ in the atmosphere. *Science*, 209, 763-768.
32. Ramanathan, V., 1980: Climatic effects of ozone change: A review. *Low Latitude Aeronomic Processes, Advances in Space Exploration, COSPAR Symposium Series B*, 223-236.
33. Ramanathan, V., 1981: Climatic effects of stratosphere. Paper presented at the First Conference on Climate Variations, San Diego, CA, 19-23 January, sponsored by AMS.
34. Ramanathan, V., 1981: The role of ocean-atmosphere interactions in the CO₂-climate problems. *J. Atmos. Sci.*, 38.

918-930.

35. Briegleb, B. and V. Ramanathan, 1982: Spectral and diurnal variations in clear sky planetary albedo. *J. Appl. Meteor.*, 21, 1160-1171.
36. Kiehl, J.T., and V. Ramanathan, 1982: Radiative heating due to increased CO_2 : the role of H_2O continuum absorption. *J. Atmos. Sci.*, 39, 2923-2926.
37. Pitcher, E.G., R.C. Malone, V. Ramanathan, M.L. Blackmon, K. Pure and W. Bourke, 1983: January and July simulations with a spectral general circulation model. *J. Atmos. Sci.*, 40, 580-604.
38. Ramanathan, V., E.J. Pitcher, R.C. Malone and M.L. Blackmon, 1983: The response of a spectral general circulation model to refinements in radiative processes. *J. Atmos. Sci.*, 40, 605-630.
39. Kiehl, J.T., and V. Ramanathan, 1983: CO_2 radiative parameterization used in climate models Comparison with narrow band models and with laboratory data. *J. Geophys. Res.*, 88, 5191-5202.
40. Lal, M., and V. Ramanathan, 1984: The effects of moist convection and water vapor radiative processes on climate sensitivity. *J. Atmos. Sci.*, 41, 2238-2249.
1. Ramanathan, V., R.J. Cicerone, H.B. Singh and J.T. Kiehl, 1985: Trace gas trends and their potential role in climate change. *J. Geophys. Res.*, 90, 5547-5566.
2. Charlock, T.P. and V. Ramanathan, 1985: The albedo field and cloud radiative forcing produced by a general circulation model with internally generated cloud optics. *J. Atmos. Sci.*, 42, 1405-1429.
3. Wiscombe, W.J., and V. Ramanathan, 1985: The role of radiation and other nascent subfields in atmospheric science. *Bull. Amer. Meteor. Soc.*, 66, 1278-1287.
4. Briegleb, B.P., P. Minnis, V. Ramanathan, and G. Harrison, 1986: Comparison of regional clear-sky albedos inferred from satellite observations and model calculations. *J. Climate and Appl. Meteor.*, 25, 214-226.
5. Hartmann, D.L., V. Ramanathan, A. Berroir and G.E. Hunt, 1986: Earth radiation budget data and climate research. *Rev. of Geophys. and Space Physics*, 24, 439-468.
6. Ramanathan V., and P. Downey, 1986: A non-isothermal emissivity and absorptivity formulation for water vapor. *J. Geophys. Res.* 91, 8649-8666.
7. Albrecht, B.A., B. Boville and V. Ramanathan, 1986: The effects of cumulus moisture transports on the simulation of climate with a general circulation model. *J. Atmos. Sci.*, 43, 2444-2462.
8. Ramanathan, V., 1987: The role of earth radiation budget studies in climate and general circulation research. *J. Geophys. Res.* 92, 4075-4095.
9. Ramanathan, V., L. Callis, R. Cess, J. Hansen, I. Isaksen, W. Kuhn, A. Lacis, F. Luther, J. Mahlman, R. Reck, and M. Schlesinger, 1987: Climate-chemical interactions and effects of changing atmospheric trace gases, *Rev. of Geophys.*, 25, 1441-1482.
10. Ramanathan, V. 1987: Atmospheric General Circulation and its Low Frequency Variance: Radiative Influences, *J. Meteorol. Soc. of Japan*, special volume, 1512-1576.
11. Cess, R.D., E.F. Harrison, P. Minnis, G.L. Potter, and V. Ramanathan, 1987: Diurnal Variability of the planetary albedo: An appraisal with satellite measurements and general circulation models, *JCAM*, 1:3, 233-239.
12. Ramanathan, V., 1988: The Greenhouse Theory of Climate Change: A Test by an Inadvertant Global Experiment, *Science*, 240, 293-299.
13. Ramanathan, V., R.D. Cess, E.F. Harrison, P. Minnis, B.R. Barkstrom, E. Ahmad, and D. Hartmann, 1989: Cloud-radiative Forcing and Climate: Results from the Earth Radiation Budget Experiment. *Science*, 246, 1529-1535.

- * 54. Ramaswamy, V. and V. Ramanathan, 1989: Solar Absorption by Cirrus Clouds and the Maintenance of Upper Troposphere Thermal Structure. *J. Atmos. Sci.*, 46:14, 2293-2310.
- * 55. Ramanathan, V., E.F. Harrison and B.R. Barksurom, 1989: Climate and the Earth's Radiation Budget, *Physics Today*, 42:5, 22-33.
- 56. Kiehl, J.T., and V. Ramanathan, 1990: Comparison of Cloud Forcing Derived From the Earth Radiation Budget Experiment with the NCAR Community Climate Model, *J. Geophys Res.*, In Press.
- * 57. Raval, A., and V. Ramanathan, 1989: Observational Determination of the Greenhouse Effect, *Nature*, 342:758-761.
- 58. Harrison, E.F., P. Minnis, B.R. Barksurom, V. Ramanathan, R.D. Cess, and G.G. Gibson, 1990: Seasonal Variation of Cloud Radiative Forcing Derived From The Earth Radiation Budget Experiment, *Accepted by the Journal of Geophysical Research*.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9121013

FROM: THOMPSON, James R.: NASA

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/29/91

SUBJECT: LETTER TO ROBERT E. GRADY CONCERNING THE STATUS OF
THE EARTH OBSERVING SYSTEM ENGINEERING REVIEW
ADVISORY COMMITTEE.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong
Nancy Maynard

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/05/91

FILE: SPACE

p-physical Sciences-



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

9121013

RECEIVED

91 APR 5

March 29, 1991

OFFICE OF THE
DIRECTOR

Mr. Robert E. Grady
Associate Director
Office of Management and Budget
Washington, DC 20503

Dear Bob:

I want to advise you on the status of the Earth Observing System (EOS) Engineering Review Advisory Committee. The first meeting of the Committee is tentatively planned for May 1991.

The Chairman, Dr. Ed Frieman, has requested that we add Dr. V. Ramanathan of the Scripps Institution of Oceanography as a member of the Committee. Dr. Ramanathan, a renowned Earth scientist, has published extensively and received numerous awards for his research in atmospheric studies. I have enclosed a copy of his resume for your information. I believe that he will be an asset to the Committee. We plan to send Dr. Ramanathan a confirmation package in the next several days.

I will forward additional information concerning the Committee to you as it becomes available.

Sincerely,

James R. Thompson, Jr.
Deputy Administrator

Enclosure

VITA

V. RAMANATHAN

PERSONAL: Born: 24 November 1944 (Madras, India); Citizenship: USA

EDUCATION:

B.E., 1965 Annamalai University, India (Mechanical Engineering)
M.S., 1970 Indian Institute of Science, India (Heat Transfer)
Ph.D., 1973 State University of New York at Stony Brook (Planetary Atmospheres)

RESEARCH POSITIONS:

1965-1967 Engineer, Shri-Ram Refrigeration Industries, Hyderabad, India.
1974-1976 National Research Council Post-doctoral Fellow and Visiting Scientist, Langley Research Center, NASA, Hampton, VA;
1976-1982 Research Scientist, National Center for Atmospheric Research (NCAR), Boulder, CO.
1982-1986 Senior Scientist and Leader, Cloud-Climate Interactions Group, NCAR
1979-date Principal Investigator, NASA Earth Radiation Budget Experiment Science Team.
1985-1988 Affiliate Professor, Colorado State University, Fort Collins, CO.
1988 Visiting Professor, Catholique Universite of Louvain, Belgium
1986-1990 Professor, Department of Geophysical Sciences, University of Chicago.
1990-date Professor, California Space Institute, University of California, San Diego

RESEARCH INTERESTS:

Climate Dynamics, Radiative Transfer, The Greenhouse Effect, Clouds, Satellite Radiation Measurements, and Global Climate Models.

HONORS:

Special Achievement Award, NASA, 1975.
Outstanding Publication Award, NCAR, 1981.
Distinguished Alumnus Award, SUNY, Stony Brook, 1984.
Fellow, American Meteorological Society
Fellow, American Association for the Advancement of Science
Medal for Exceptional Scientific Achievement, NASA, 1989.

RELATED EXPERIENCE:

Associate Editor, *Journal of Geophysical Research*, 1988-date.
Member, AAAS Atmospheric & Hydrospheric Sciences Nominating Committee, 1988.
Member, Space and Earth Science Advisory Committee, NASA 1987-1988.
Chairman, Appointments Committee, University of Chicago, 1986-1988.
Member of the International Association of Meteorology and Atmospheric Physics (IAMAP) Subcommittee, 1986-date.
Member, Climate Research Committee, National Research Council, 1984-1986.
Member, ISCCP Panel, National Research Council, 1984-1988.
Member, Committee on Earth Sciences, National Academy of Sciences, 1982-1984.
Member, International Radiation Commission, 1981-date.
Member, Committee on Radiation & Climate Variations, American Meteorological Society 1982-date.
Associate Editor, *Journal of Atmospheric Sciences*, 1979-1985.
Associate Editor, *Journal of Applied Meteorology*, 1982-1985.
Member, Panel on Climate Effects, Committee on Impacts of Stratospheric Change, NAS Assembly on Mathematical and Physical Science, February 1978.
Member, Panel on the Middle Atmosphere Program, Committee on Solar Terrestrial Research, NAS-NRC, February 1978.

CURRENT GRANTS:

NASA: Principal Investigator, ERBE Satellite experiment, 1979-date
NASA: Co-investigator, CERES Experiment on EOS platforms, 1989- date.
NSF: Cloud-Climate feedbacks, 1986-date

COURSES TAUGHT:

Radiative Transfer, Climate Dynamics, Clouds.

PRINCIPAL PUBLICATIONS

Contributions in Books

- Ramanathan, V., 1989: "The Radiative and Climatic Consequences of the Changing Atmospheric Composition of Trace Gases," in *The Changing Atmosphere*, F.S. Rowland and I.S.A. Isaksen, eds. (New York: John Wiley & Sons, Ltd., 1988), pp. 159-186.
- Ramanathan, V., 1989: "Trace Gas Effects on Climate: A Review," in *Carbon Dioxide and Other Greenhouse Gases: Climatic and Associated Impacts*, R. Fantechi and A. Ghazi, eds. (Boston: Kluwer Academic Publishers, 1989), pp. 152-158.
- Ramanathan, V., 1983: Coupling through radiative and chemical processes. Chapter in *Solar Variability, Weather and Climate. Studies in Geophysics*, Geophysics Research Board. National Academy Press, 83-91.
- Ramanathan, V., 1982: Commentary on climatic effects of minor atmospheric constituents. *Carbon Dioxide Review*, 1982, Edited by Clark, pp. 278-283.
- Ramanathan, V., 1980: "Climatic Effects of Anthropogenic Trace Gases," in *Interactions of Energy and Climate*, W. Bach, T. Pankrath and J. Williams, eds. (D. Reidel Publishing Co. 1980), pp. 269-80.

Reviewed Papers

6. Prasad, K.K., and V. Ramanathan, 1972: Heat transfer by free convection from a longitudinally vibrating vertical plate. *Int'l. J. Heat Mass. Transfer*, 15, 1213-1233.
7. Cess, R.D., and V. Ramanathan, 1972: Radiative transfer in the atmosphere of Mars and that of Venus above the cloud deck. *J. Quant. Spect. Rad. Trans.*, 12, 933-945.
8. Cess, R. D., and V. Ramanathan, 1973: The applicability of an approximate expression for radiative heating. *J. Quant. Spect. Rad. Trans.*, 13, 79-81.
9. Ramanathan, V. and R.D. Cess, 1974: Radiative transfer within the mesospheres of Mars and Venus. *Astrophys. J.*, 188, 407-416.
0. Ramanathan, V., 1975: Greenhouse effect due to chlorofluorocarbons: Climatic implications, *Science*, 190, 50-51.
1. Ramanathan, V. and R.D. Cess, 1975: An analysis of the strong zonal circulation within the stratosphere of Venus. *Icarus*, 25, 89-103.
2. Ramanathan, V., 1976: Atmospheric fluorocarbons: Possible effects of a large increase on the global climate. *Environmental Conservation*, 3, 90.
3. Ramanathan, V., 1976: Radiative transfer within the troposphere and stratosphere: A simplified radiative-convective model. *J. Atmos. Sci.*, 33, 1330-1346.
4. Ramanathan, V., L.D. Collins and R.E. Poughner, 1976: Sensitivity of atmospheric and surface temperature to

15. Augustsson, T., and V. Ramanathan, 1977: A radiative-convective model study of the CO₂-climate problem. *J. Atmos. Sci.*, 34, 448-451.
16. Ramanathan, V., 1977: Interactions between ice albedo, lapse-rate, and cloud-top feedback: An analysis of the nonlinear response of a GCM-climate model. *J. Atmos. Sci.*, 34, 1885-1897.
17. Ramanathan, V. 1977: Troposphere-stratosphere feedback mechanism: Stratospheric warming and its effect on the polar energy budget and the tropospheric circulation. *J. Atmos. Sci.*, 34, 439-447.
18. Ramanathan, V., and W.L. Grose, 1977: A general circulation model study of the radiative-dynamic coupling within the stratosphere. *Contributions to Atmospheric Physics-Beitrage zur Physik der Atmosphere*, 50, 55-70.
19. Cess, R.D., and V. Ramanathan, 1978: Averaging of infrared cloud opacities for climate modeling. *J. Atmos. Sci.*, 35, 919-922.
20. Chen, T.C., and V. Ramanathan, 1978: A numerical simulation of seasonal stratospheric climate: Part II. Energetics. *J. Atmos. Sci.*, 35, 615-633.
21. Ramanathan, V., and J.A. Coakley, Jr., 1978: Climate modeling through radiative-convective models. *Rev. Geophys. Space Phys.*, 16, 465-490.
22. Ramanathan, V., and W.L. Grose, 1978: A numerical simulation of seasonal stratospheric climate: Part I. Zonal temperature and winds. *J. Atmos. Sci.*, 35, 600-614.
23. Ghazi, A., V. Ramanathan and R.E. Dickinson, 1979: Acceleration of upper atmospheric radiative damping: Observational evidence. *Geophys. Res. Lett.*, 6, 437-440.
24. Owen, T., R.D. Cess and V. Ramanathan, 1979: Early earth: An enhanced carbon-dioxide greenhouse to compensate for reduced solar luminosity. *Nature*, 277, 640-642.
25. Ramanathan, V., and R.E. Dickinson, 1979: The role of stratospheric ozone in the zonal and seasonal radiative energy balance of the earth-troposphere system. *J. Atmos. Sci.*, 36, 1084-1104.
26. Ramanathan, V., M.S. Lian and R. D. Cess, 1979: Increased atmospheric CO₂ Zonal and seasonal estimates of the effect on the radiation energy balance and surface temperature. *J. Geophys. Res.*, 84, 4949-4958.
27. Cess, R.D., V. Ramanathan and T. Owen, 1980: The Martian paleoclimate and enhanced atmospheric carbon dioxide. *Icarus*, 41, 159-165.
28. Donner, L. and V. Ramanathan, 1980: Methane and nitrous oxide: Their effects on the terrestrial climate. *J. Atmos. Sci.*, 37, 119-124.
29. Fishman, J., V. Ramanathan, P.J. Crutzen and S.C. Liu, 1980: Tropospheric ozone and climate. *Nature*, 282, 818-820.
30. Hunt, G.E., V. Ramanathan and R. M. Chervin, 1980: On the role of clouds in the general circulation of the atmosphere. *Quart. J. Roy. Meteor. Soc.*, 106, 213-215.
31. Madden, R.A., and V. Ramanathan, 1980: Detecting climate change due to increasing CO₂ in the atmosphere. *Science*, 209, 763-768.
32. Ramanathan, V., 1980: Climatic effects of ozone change: A review. *Low Latitude Aeronomical Processes, Advances in Space Exploration, COSPAR Symposium Series B*, 223-236.
33. Ramanathan, V., 1981: Climatic effects of stratosphere. Paper presented at the First Conference on Climate Variations, San Diego, CA, 19-23 January, sponsored by AMS.
34. Ramanathan, V., 1981: The role of ocean-atmosphere interactions in the CO₂-climate problems. *J. Atmos. Sci.*, 38.

918-930.

35. Briegleb, B. and V. Ramanathan, 1982: Spectral and diurnal variations in clear sky planetary albedo. *J. Appl. Meteor.*, 21, 1160-1171.
36. Kiehl, J.T., and V. Ramanathan, 1982: Radiative heating due to increased CO_2 : the role of H_2O continuum absorption. *J. Atmos. Sci.*, 39, 2923-2926.
37. Pitcher, E.G., R.C. Malone, V. Ramanathan, M.L. Blackmon, K. Pure and W. Bourke, 1983: January and July simulations with a spectral general circulation model. *J. Atmos. Sci.*, 40, 580-604.
38. Ramanathan, V., E.J. Pitcher, R.C. Malone and M.L. Blackmon, 1983: The response of a spectral general circulation model to refinements in radiative processes. *J. Atmos. Sci.*, 40, 605-630.
39. Kiehl, J.T., and V. Ramanathan, 1983: CO_2 radiative parameterization used in climate models Comparison with narrow band models and with laboratory data. *J. Geophys. Res.*, 88, 5191-5202.
40. Lal, M., and V. Ramanathan, 1984: The effects of moist convection and water vapor radiative processes on climate sensitivity. *J. Atmos. Sci.*, 41, 2238-2249.
1. Ramanathan, V., R.J. Cicerone, H.B. Singh and J.T. Kiehl, 1985: Trace gas trends and their potential role in climate change. *J. Geophys. Res.*, 90, 5547-5566.
2. Charlock, T.P. and V. Ramanathan, 1985: The albedo field and cloud radiative forcing produced by a general circulation model with internally generated cloud optics. *J. Atmos. Sci.*, 42, 1405-1429.
3. Wiscombe, W.J., and V. Ramanathan, 1985: The role of radiation and other nascent subfields in atmospheric science. *Bull. Amer. Meteor. Soc.*, 66, 1278-1287.
4. Briegleb, B.P., P. Minnis, V. Ramanathan, and G. Harrison, 1986: Comparison of regional clear-sky albedos inferred from satellite observations and model calculations. *J. Climate and Appl. Meteor.*, 25, 214-226.
- Hartmann, D.L., V. Ramanathan, A. Berroir and G.E. Hunt, 1986: Earth radiation budget data and climate research. *Rev. of Geophys. and Space Physics.* 24, 439-468.
- Ramanathan V., and P. Downey, 1986: A non-isothermal emissivity and absorptivity formulation for water vapor. *J. Geophys. Res.* 91, 8649-8666.
- Albrecht, B.A., B. Boville and V. Ramanathan, 1986: The effects of cumulus moisture transports on the simulation of climate with a general circulation model. *J. Atmos. Sci.*, 43, 2444-2462.
- Ramanathan, V., 1987: The role of earth radiation budget studies in climate and general circulation research. *J. Geophys. Res.* 92, 4075-4095.
- Ramanathan, V., L. Callis, R. Cess, J. Hansen, I. Isaksen, W. Kuhn, A. Lacis, F. Luther, J. Mahlman, R. Reck, and M. Schlesinger, 1987: Climate-chemical interactions and effects of changing atmospheric trace gases, *Rev. of Geophys.*, 25, 1441-1482.
- Ramanathan, V. 1987: Atmospheric General Circulation and its Low Frequency Variance: Radiative Influences, *J. Meteorol. Soc. of Japan.*, special volume, 1512-1576.
- Cess, R.D., E.F. Harrison, P. Minnis, G.L. Potter, and V. Ramanathan, 1987: Diurnal Variability of the planetary albedo: An appraisal with satellite measurements and general circulation models, *JCAM.*, 1:3, 233-239.
- Ramanathan, V., 1988: The Greenhouse Theory of Climate Change: A Test by an Inadvertent Global Experiment, *Science*, 240, 293-299.
- Ramanathan, V., R.D. Cess, E.F. Harrison, P. Minnis, B.R. Barkstrom, E. Ahmad, and D. Hartmann, 1989: Cloud-radiative Forcing and Climate: Results from the Earth Radiation Budget Experiment, *J. Geophys. Res.*, 94, 933-955.

- * 54. Ramaswamy, V. and V. Ramanathan, 1989: Solar Absorption by Cirrus Clouds and the Maintenance of Upper Troposphere Thermal Structure. *J. Atmos. Sci.*, 46:14, 2293-2310.
- * 55. Ramanathan, V., E.F. Harrison and B.R. Barksrom, 1989: Climate and the Earth's Radiation Budget, *Physics Today*, 42:5, 22-33.
- 56. Kiehl, J.T., and V. Ramanathan, 1990: Comparison of Cloud Forcing Derived From the Earth Radiation Budget Experiment with the NCAR Community Climate Model, *J. Geophys Res.*, In Press.
- * 57. Raval, A., and V. Ramanathan, 1989: Observational Determination of the Greenhouse Effect, *Nature*, 342:758-761.
- 58. Harrison, E.F., P. Minnis, B.R. Barksrom, V. Ramanathan, R.D. Cess, and G.G. Gibson, 1990: Seasonal Variation of Cloud Radiative Forcing Derived From The Earth Radiation Budget Experiment, *Accepted by the Journal of Geophysical Research*.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9121056

FROM: LANZEROTTI, Louis J.: NAITONAL RESEARCH COUNCIL

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/29/91

SUBJECT: SPACE STUDIES BOARD POSITION ON THE PROPOSED
REDESIGN OF SPACE STATION FREEDOM.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Steve Olson
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 04/10/91

FILE: SPACE

p-Physical Sciences -

9121052

NATIONAL RESEARCH COUNCIL

COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

2101 Constitution Avenue Washington, D.C. 20418-0001

RECEIVED

SPACE STUDIES BOARD

91 APR 10 10:00

March 29, 1991

OFFICE OF THE
DIRECTOR

Office Location:
Milton Harris Building
Room 584
2001 Wisconsin Avenue, N.W.
(202) 334-3477
Fax: (202) 334-2791

The Honorable D. Allan Bromley
Assistant to the President for
Science and Technology
Old EOB, Suite 358
17th St. and Pennsylvania Ave., N.W.
Washington, D.C. 20506

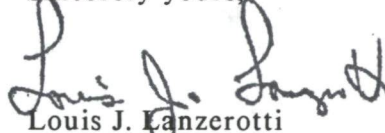
Dear Mr. Bromley:

In its capacity as the National Research Council's principal standing advisory body concerning the civil space research program, the Space Studies Board recently released the enclosed position on the currently proposed space station. The position was forwarded to NASA's Administrator, Admiral Richard Truly, and the Chairman of the National Space Council, Vice President Dan Quayle, on March 14, 1991.

Also enclosed you will find the original issue of our new Board newsletter. Our intention is to issue it approximately quarterly to keep members of the space policy and space research communities up to date on our Board's activities.

If you have any questions about the background for the Board's position or the contents of the position itself, or any suggestions for the newsletter, please contact the Space Studies Board at 202/334-3477.

Sincerely yours,



Louis J. Lanzerotti
Chairman

LJL/mg

SPACE STUDIES BOARD POSITION

ON

PROPOSED REDESIGN OF SPACE STATION FREEDOM

SUMMARY

The United States has contemplated for many years the construction of a space station that would further a variety of national goals, one of which is space science and applications. The recent report of the presidentially appointed Advisory Committee on the Future of the U.S. Space Program, chaired by Norman Augustine, recommended that the development of a U.S. space station with research facilities must give top priority to life sciences research, with microgravity research assuming a significant but secondary role.¹ The Board notes that this recommendation is fully consistent with the 1983 Space Studies Board position on the space station, as well as with the 1988 National Academy of Sciences/National Academy of Engineering report to then newly-elected President Bush.^{2,3} *In the judgment of the Board, Space Station Freedom, at the present stage of redesign, does not meet the basic research requirements of the two principal scientific disciplines for which it is intended: (1) life sciences research necessary to support the national objective of long-term human exploration of space, and (2) microgravity research and applications.* This conclusion as to the station's research capabilities is based upon an assessment of its redesign as of March 1991.⁴ Attachments 1 and 2 summarize the research requirements for space biology and medicine and for microgravity research and their relationship to the redesigned space station.

The Space Studies Board's membership is not constituted such that it can provide an engineering judgment on the feasibility of the redesign, and therefore has not done so.

RESEARCH RETURN ON TAXPAYER INVESTMENT

The Space Studies Board considered the quantity and quality of research that might be conducted on the proposed redesigned space station in the context of the level of investment that will be required to bring it to completion. The Board believes that neither the quantity nor the quality of research that can be conducted on the proposed station merits the projected investment. As redesigned, a maximum of \$2.6 billion per year would be expended on the station to achieve an initial crew-tended capability by the mid-1990s, not including associated Space Transportation System and user costs.⁵ Additional funding at a comparable rate of expenditure would be required to achieve a permanently occupied capability late in the decade. In the initial, crew-tended configuration, the redesigned station would be devoted primarily to microgravity research. Life sciences research unique to the space station would not begin until the end of the decade, when the permanently occupied configuration would be established. For comparison, the 1991 NASA budget allocates roughly \$102 million to microgravity research. In other words, during each of the next five years, the amount of funding devoted to space station construction for microgravity research would be approximately 20 times the level of the current research program for this discipline. In

addition, the **monthly** cost of constructing the redesigned station would approach the **annual** total funding devoted to both NASA's life sciences and microgravity science and applications divisions during the current fiscal year.

SPACE RESEARCH REQUIREMENTS, OPPORTUNITIES, AND ALTERNATIVES

Life Sciences Research

The Augustine Committee recently concluded that the primary objective of a space station should be life sciences research.¹ The Space Studies Board strongly endorses the position that a space-based laboratory is required to study the physiological consequences of long-term space flight.^{7,8} The Board notes that many of the fundamental problems in life sciences research involve a long period of time for their pursuit and solution. In its present form, the redesigned space station does not provide the facilities required for such research. (See Attachment 1.)

Microgravity Research

In the judgment of the Board, the limited microgravity research that could be conducted on the redesigned space station as currently proposed does not merit the investment. If such funds were made available, the research community would likely choose to spend them in a very different way. (See Attachment 2.) The Board believes specifically that more research progress could be achieved in a shorter period of time and at a fraction of the cost through an expanded program of Spacelab missions and of free-flyer experiments.^{6,8,9}

NATIONAL GOALS AND THEIR ACHIEVEMENT

In conclusion, the SSB recognizes that there are national considerations for building a space station other than scientific research. Included among these are the possibilities of enhancing international prestige, stimulating the nation's educational achievement, stimulating the U.S. technology base, and supporting a long-term human space exploration initiative.

In the judgment of the Board, the proposed redesign of Space Station Freedom does not meet the stated national goal of enabling the life sciences research necessary to support extended human space exploration, nor does it meet the stated needs of the microgravity research community--most of whose goals could be achieved in both a more timely and more cost-effective manner by alternative means. Continued development of Space Station Freedom, as currently redesigned, cannot be supported on scientific grounds. If the present station redesign is implemented, this major national investment must be justified on the basis of considerations other than research in these two disciplines.

ATTACHMENT 1

SPACE BIOLOGY AND MEDICINE RESEARCH REQUIREMENTS

Requirements for conducting space biology and medicine research are described in detail in the 1987 report, *A Strategy for Space Biology and Medical Science for the 1980s and 1990s*.⁷ The major goals established in that report for this area of research are:

- a. "To describe and understand human adaptation to the space environment and the readaptation upon return to Earth."
- b. "To use the knowledge so obtained to devise procedures that will improve the health, safety, comfort, and performance of the astronauts. Specifically, we must improve our understanding of the microgravity induced alterations in physiologic and psychological processes as well as effects of radiation before long duration human exploration can be safely and effectively pursued."

Critical Requirements for Conducting Space Biology and Medicine Research

The Board's 1987 report⁷ emphasizes that a space station is **pivotal** to the conduct of life sciences research, and it documents the following as critical requirements for a space station:

1. A dedicated life sciences laboratory with adequate scientific crew to conduct research.
2. A variable speed centrifuge of sufficient radius to accommodate small primates.
3. Sufficient numbers of experimental subjects (humans, plants and animals) to address the stated scientific goals.
4. Sufficient laboratory resources, i.e., power, equipment, space, and atmosphere, to support the above research requirements.

The Space Studies Board's Committee on Space Biology and Medicine, and the Board itself wish to emphatically emphasize that the above requirements are absolutely fundamental to the acquisition of the data necessary to determine the feasibility of long-term human space exploration.

Inadequacy of the Redesigned Space Station Freedom for Space Biology and Medicine Research Requirements

The Committee on Space Biology and Medicine and the Space Studies Board conclude that Space Station Freedom, in its present redesigned form, will be inadequate to meet the requirements for space biology and medicine research described above because of the following:

1. The plan to share limited power among multiple users in all laboratory modules suggests that there will be insufficient power to conduct the volume of long-term biological experiments required to support a human space exploration initiative.
2. Plans for the size and location of a centrifuge and of animal-holding facilities are insufficiently defined for proper evaluation. As emphasized in the Board's 1987 strategy report⁷, an adequate centrifuge is essential to provide a 1-g control for 0-g experiments and also to explore the adequacy of artificial gravity for long-duration spaceflight.
3. The proposed crew size is insufficient to conduct the requisite experiments in a reasonable time period.
4. The absence of a dedicated life sciences laboratory will prohibit some experiments and will severely restrict most others, prolonging the acquisition of data required to answer fundamental questions related to the feasibility of long-duration human space exploration.

ATTACHMENT 2

MICROGRAVITY RESEARCH REQUIREMENTS

The National Research Council, as well as several NASA advisory committees, has published reports over the years that specifically address the minimum research requirements for this field of space research.^{6,8,9}

The Space Studies Board's Committee on Microgravity Research has advised the Board that, unlike research in the field of space biology and medicine, only a limited amount of the desired research in microgravity, at least over the next decade, can best be accomplished with a space station. The use of crew-tended free-flyers, drop towers, extended duration Spacelabs, and so forth, offer adequate, and in fact more viable, opportunities for the research needs in many cases. There are, however, important experiments requiring measurements and human observation and interaction over extended periods of time. The space station is a means to provide this capability. *If plans proceed to conduct microgravity research on the redesigned Space Station Freedom, the Board and its Committee on Microgravity Research recommend that adequate provisions be made for supporting only those microgravity research questions that can best be addressed using a space station.*

The following minimum facility requirements for microgravity research aboard a space station are based on the conclusions and recommendations described in the cited reports and on recent briefings presented to the Committee on Microgravity Research and the Space Studies Board.⁴

Critical Requirements for Conducting Microgravity Research on a Space Station

1. Adequate power, research volume, and support space.
2. Skilled on-board scientific personnel in sufficient numbers to carry out experiments and to diagnose and correct malfunctions.
3. Suitable acceleration environment and adequate monitoring.
4. Affordable de-integration and re-integration of experiments on orbit.
5. Capability to integrate advanced techniques and instrumentation as these become available.
6. Fast turnaround for specimens that must be characterized on Earth.

Inadequacy of the Redesigned Space Station Freedom for Microgravity Research Needs

The redesigned Space Station Freedom would be inadequate to meet the requirements of microgravity science and applications because it lacks the following:

1. A low, quiescent acceleration environment unhampered by crew activities, docking maneuvers, and other system activities necessary to sustain a permanently occupied presence.

2. A crew that would spend sufficient time working with the experiment equipment (See Attachment 1, item 3.).
3. Sufficient power, data-handling capabilities, and research volume (see Attachment 1, item 1).
4. The flexibility to upgrade systems; this deficiency is especially disconcerting in the area of computers, in which obsolescence is extremely rapid.

Other Issues

During the crew-tended phase, NASA plans to fly Spacelab experiment hardware on the Space Station Freedom because other, newer hardware will not be available. Most of this Spacelab hardware will require manual intervention and therefore will be operable only when people are present. Unfortunately, the crew-tended phase is a time when significant acceleration disturbances will exist due to concurrent hardware integration and assembly and construction activities. Therefore, the man-tended phase will not be suitable for many microgravity experiments. Only a limited number of experiments could be run during the free-flying mode between shuttle visits during the crew-tended phase.

If the bulk of the microgravity research program planned for Freedom were removed, the station would then be devoted almost exclusively to life sciences research. The benefits of this action would be that (a) the g-level on the station would not have to be strongly controlled, thus resulting in significant cost savings, (b) some low-gravity experiments (e.g., fluids handling, fire safety) could still be done on the space station, and (c) the bulk of the microgravity program could be conducted using independent, more cost-effective facilities.

ENDNOTES

1. *Report of the Advisory Committee on the Future of the U.S. Space Program*, Superintendent of Documents (GPO) December, 1990.
2. Space Science Board Assessment of the Scientific Value of a Space Station and letter to NASA Administrator James Beggs, September 9, 1983. See also Space Studies Board, Testimony to U.S. Senate Subcommittee on Science, Technology and Space, May 10, 1990.
3. *Toward a New Era in Space--Realigning Policies to New Realities--Recommendations for President-Elect George Bush*, Committee on Space Policy, NAS/NAE (NAP) 1988.
4. Briefing to Committee on Microgravity Research, William Taylor, Chief Scientist, Space Station Freedom, January 10, 1991. Briefing to Committee on Space Biology and Medicine, William Taylor, Chief Scientist, Space Station Freedom, February 8, 1991. Briefing to Space Studies Board, William Raney, Special Assistant, Space Station Freedom, and John-David Bartoe, Deputy Director, Space Station Freedom Operations and Utilization, February 28, 1991.
5. Conference Report 101-900, HUD and Independent Agencies, FY 1991.
6. *Microgravity Science and Applications--Report on a Workshop*, Panel on Microgravity Science and Applications, Solid State Sciences Committee, Board on Physics and Astronomy (NAP) 1986. *Review of Microgravity Science and Applications Flight Programs*, Committee To Review the Microgravity Science and Applications Flight Program, USRA, January-March, 1987. Space Studies Board Workshop on Microgravity Research, NAS Beckman Center, January 16-17, 1989.
7. *A Strategy for Space Biology and Medical Science for the 1980s and 1990s* (NAP) 1987. *Space Studies Board Assessment: Space Biology and Medicine Research--1990* (in press). Space Studies Board/Committee on Space Biology and Medicine, letter to Andrew Stofan, Associate Administrator, Office of Space Station, NASA Headquarters, July 21, 1987. Space Studies Board/Committee on Space Biology and Medicine, Testimony to the U.S. Senate Subcommittee on HUD Appropriations, May 1, 1987.
8. Space Studies Board letter to Joseph Alexander, Assistant Associate Administrator, Office of Space Science and Applications, NASA Headquarters, December 12, 1990. *Space Station Summer Study Report*, SESAC Task Force on Scientific Uses of a Space Station, NASA, March, 21, 1985. *Space Station Summer Study Report*, SESAC Task Force on Scientific Uses of a Space Station, NASA, March, 1986.
9. *Materials Processing in Space*, Committee on Scientific and Technological Aspects of Materials Processing in Space, Space Applications Board, (NAS) 1978. *Industrial Applications of the Microgravity Environment*, Space Applications Board (NAP) 1988.

SPACE STUDIES BOARD

MEMBERS

Louis J. Lanzerotti, *Chairman*, Distinguished Member of the Technical Staff, AT&T Bell Laboratories
Philip Abelson, Science Advisor, American Association for the Advancement of Science
Joseph A. Burns, Professor of Astronomy, Cornell University
John R. Carruthers, Manager, Components Research, INTEL
Andrea K. Dupree, Senior Scientist, Harvard-Smithsonian Institution Center for Astrophysics
John Dutton, Dean, College of Earth and Mineral Sciences, Pennsylvania State University
Larry Esposito, Associate Professor, University of Colorado
James P. Ferris, Professor, Department of Chemistry, Rensselaer Polytechnic Institute
Herbert Friedman, Consultant, Naval Research Laboratory
Richard L. Garwin, Advisor to the Director of Research, IBM Corporation
Riccardo Giacconi, Director, Space Telescope Science Institute
Noel W. Hinners, Vice President for Strategic Planning, Martin Marietta Corporation
James R. Houck, Professor of Astronomy, Cornell University
David A. Landgrebe, Professor of Electrical Engineering, Purdue University
Elliott C. Levinthal, Professor of Mechanical Engineering, Stanford University
William J. Merrell, Jr., President, Texas A&M University, Galveston
Richard K. Moore, Professor, Remote Sensing Labs, University of Kansas
Robert H. Moser, Vice President for Medical Affairs, NutraSweet Company
Norman F. Ness, President, Bartol Research Institute, University of Delaware
Marcia Neugebauer, Senior Research Scientist, Jet Propulsion Laboratory
Sally K. Ride, Professor/Director, California Space Institute, University of California, San Diego
Robert F. Sekerka, Dean, Mellon College of Science, Carnegie Mellon University
Mark Settle, Manager, The New Opportunities Group, ARCO Oil and Gas Company
L. Dennis Smith, Executive Vice Chancellor, University of California, Irvine
Byron D. Tapley, Director, Center for Space Research
Arthur B.C. Walker, Professor of Applied Physics, Stanford University

Marc S. Allen
Staff Director

COMMITTEE ON SPACE BIOLOGY AND MEDICINE

MEMBERS

L. Dennis Smith, *Chairman*, Executive Vice Chancellor, University of California, Irvine
Robert M. Berne, Alumni Professor of Physiology, University of Virginia
Peter Dews, Professor of Psychology and Psychobiology, Harvard Medical School
R.J. Michael Fry, Head of Cancer Section, Biology Division, Oak Ridge National Laboratory
Edward J. Goetzl, Professor of Rheumatic and Connective Tissue Diseases, University of California Medical Center, San Francisco
Robert Helmreich, Professor of Psychology and Director, NASA/UT Aerospace Crew Research Project/The University of Texas, Austin
Barry W. Peterson, Professor of Physiology, Northwestern University
Clinton T. Rubin, Associate Professor/Director of Musculo-skeletal Research Laboratory, State University of New York at Stony Brook
Alan L. Schiller, Professor and Chairman Pathology, Mt. Sinai Medical Center
Tom Scott, Professor of Biology, University of North Carolina, Chapel Hill
William Thompson, University Professor of Botany and Genetics, North Carolina State University
Fred W. Turek, Chairman, Department of Neurobiology and Physiology, Northwestern University

Joyce M. Purcell
Executive Secretary

COMMITTEE ON MICROGRAVITY RESEARCH

MEMBERS

Robert F. Sekerka, *Chairman*, Dean, Mellon College of Science, Carnegie Mellon University
Robert A. Brown, Head, Department of Chemical Engineering, Massachusetts Institute of Technology

Franklin D. Lemkey, Senior Consultant Scientist, United Technologies Research Center

William A. Sirignano, Dean, School of Engineering, University of California, Irvine

Thomas A. Steitz, Investigator/Professor of Molecular Biophysics and Chemistry,
The Howard Hughes Medical Institute/Yale University

John R. Carruthers, Manager, Components Research, INTEL

Joyce M. Purcell
Executive Secretary

THE SSBULLETIN

A Newsletter of the Space Studies Board

NATIONAL RESEARCH COUNCIL

March 1991, Vol. 1, No. 1

Chairman's Message: Fostering a Space Research Dialogue

This is the inaugural issue of what we hope will become a regular newsletter from the Space Studies Board (SSB) of the National Research Council. The staff and the members of the SSB intend this newsletter to be a vehicle to inform the space research community and interested scientists, engineers, and policy makers of the activities of the Board and its constituent committees. We also intend, when appropriate, to use the newsletter as a source of information concerning space research and policy matters in the national and international arenas.

It is opportune to commence this newsletter inasmuch as the SSB has assumed a considerably broader research and policy purview over the last few years. It is a direct descendent of the Space Science Board, an advisory entity founded at the very beginning of the U.S. space era, and which guided, with careful analyses and research recommendations, the U.S. space science program for three decades.

The majority of the Board's study activities are conducted through its standing discipline committees and its working groups. The space research environment is in a process of rapid change and development. As a result, the SSB is addressing a number of high priority policy matters that affect the health and the vitality of space research in the U.S. The potential number of such matters that the Board could address is quite large. Thus, the Board has had to determine, through its deliberations, those that it believes hold the most promise for significantly influencing the space research environment and agenda. These policy matters will be discussed in

future issues of this newsletter.

Board and committee members perform their advisory responsibilities for the U.S. space program under the auspices of the National Research Council. However, our effectiveness as a Board and as members of the individual discipline and policy committees will be more limited than desired if we do not have comments from, and discussions with, members of the research community at large. Hence, members of the Board and the staff, who are listed at the end of this newsletter, encourage communications from the research and policy communities on all matters related to space research as well as on those matters contained in these newsletters.

After some Notes by Staff Director Marc Allen, this inaugural issue contains a brief history of the Board and a snapshot of it today. In addition, the text of recent SSB testimony to a special hearing of the House Science, Space and Technology Committee is presented. I hope that readers will find this newsletter interesting and that it will help further a dialogue between you and the Board.

Louis Lanzerotti
Chairman

Staff Director's Notes

Responding to Board Chairman Louis Lanzerotti's desire to produce and distribute this newsletter on a regular basis, (Notes continued on page 2)

(Notes continued from page 1)

we plan to issue a new edition quarterly. The space research world is a fast-moving world today, and we expect it to be a challenge to make this newsletter both punctual and timely.

In the reports area, several discipline assessments are in final stages of preparation, including status surveys on planetary exploration, space biology and medicine, solar and space physics and earth studies. A new assessment of the EOS program, including treatment of the payload selection for EOS-A, is also nearing completion. All of these should be available by early summer.

Many of you are following with interest the Board's participation in the national debate on the proposed space station. We will include updates on our contributions in further issues.

Note that a list of the present membership of the SSB is attached, along with a list of present committee chairs.

Marc Allen
Staff Director

Space Studies Board History and Charter

Chartered by an Act of Congress signed by President Abraham Lincoln in 1863, the National Academy of Sciences (NAS) was created to advise the federal government on scientific and technological matters. The current President of the NAS is Dr. Frank Press, who also serves as Chairman of the National Research Council (NRC). The Academy complex also includes the National Academy of Engineering and the Institute of Medicine. Presidents of the NAE and IOM are, respectively, Dr. Robert White and Dr. Samuel Thier. The Academies are **private, not governmental** organizations and do not receive direct federal appropriations for their work. However, studies undertaken for the government by the Academy complex are

usually funded through appropriations made available to federal agencies. The majority of the studies carried out by the Academy complex are at the request of government agencies. The National Research Council is the working arm of the National Academy of Sciences and the National Academy of Engineering carrying out most of the studies done in their names. The committees, boards, task groups, etc. that perform work for the Academies are constituted of members, in the main, from the scientific and engineering communities. They serve on a voluntary basis and are appointed to terms of service by the NRC Chair.

Preceding the formation of NASA, the Space Science Board (now called the Space Studies Board, or SSB) was established by the National Academy of Sciences in 1958. The Board serves as the Academies' primary advisory body concerning the U.S. civil space research program. Thus, NASA is served by a variety of advisory bodies, both internal -- operating under the direct control of the agency through the NASA Advisory Council -- and external, such as the National Research Council's SSB. In a statement chartering the Board, National Academy of Sciences President Detlev W. Bronk outlined the purpose and purview of the new body.

We have talked of the main task of the Board in three parts -- the immediate program, the long-range program, and the international aspects of both. In all three we shall look to the Board to be the focus of the interests and responsibilities of the Academy-Research Council in space science; to establish necessary relationships with civilian science and with governmental scientific activities, particularly the proposed new Space Agency, the National Science Foundation, and the

(History continued on page 3)

(History continued from page 2)

Advanced Research Projects Agency; to represent the Academy-Research Council in our international relations in this field on behalf of American science and scientists; to seek ways to stimulate needed research; to promote necessary coordination of scientific effort, and to provide such advice and recommendations to appropriate individuals and agencies with regard to space science as may, in the Board's judgment be desirable.

The Board is intended to be an advisory, consultative, correlating, evaluating body and not an operating agency in the field of space science. It should avoid responsibility as a Board for the conduct of **programs of space research and for the formulation of budgets relative thereto.** [emphasis added] Advice to agencies, properly responsible for these matters, on the other hand, would be within its purview to provide.

The spirit and guiding principles articulated in the charter remain intact; the purview and responsibilities of the Board have evolved over time, however, corresponding to the needs and maturing of the nation's civil space program. As recently as 1988, the Board underwent a major reorganization in response to a recognition of the need to broaden its advisory purview to federal agencies other than NASA, for example, the National Science Foundation, the National Institutes of Health and the National Oceanic and Atmospheric Administration. While this broader advisory purview was recognized as

necessary from the Board's inception in 1958, NASA has historically represented the major beneficiary of our advice over the last 30 years.

A Picture of the Space Studies Board

The Chairman of the SSB is Louis J. Lanzerotti of AT&T Bell Laboratories. He has served as Chairman of the Board since 1988. The Board is currently made up of 26 members representing the major space research areas: (i) astronomy and astrophysics, (ii) solar and space physics, (iii) space biology and medicine, (iv) lunar and planetary exploration, (v) earth sciences and (vi) microgravity research, and, in addition, individuals from more general backgrounds. Members serve terms of two to three years and are appointed and approved by the NRC Chair. The Board meets three to four times per year to provide oversight and direction for the work of its committees and to provide advice to NASA and other agencies on issues in space research. The Board provides its advice in a variety of ways --- in response to specific requests, testimony to Congress and self-generated letters and reports. All are subject to review and approval by the NRC. The Board also serves as the U.S. representative to the Committee on Space Research under the International Council of Scientific Unions.

The SSB presently has six discipline committees, two interdisciplinary committees, and one task group, established to carry out the Board's program. Unlike many other entities of the Academies, the SSB has established standing discipline committees. Rather than going out of existence upon completion of a particular task, as is more typical in the institution, the committees exist on a standing basis. The six committees represent the major space research areas listed above. In addition to providing ongoing advice concerning their designated areas, each committee (with the exception of microgravity research) has published a

(History continued on page 4)

(History continued from page 3)

research strategy for its respective field. These research strategies address a 10 to 15 year period and provide a set of recommendations concerning the baseline level of effort necessary to maintain the long-term health and vigor of the various fields. They are based exclusively on science, and maintain the distinction between the Board's competence in scientific research and NASA's responsibility for mission planning. For the most part, these strategies have formed the basis of NASA's science and applications program as it exists today. Virtually every science and applications mission that is currently manifested or recently launched has its roots in one of the discipline strategies that was produced by the SSB. As noted in the Board's 1990 testimony to the Senate Subcommittee on Science, Technology and Space on this point, "I say this not to heap praise on the Space Studies Board, but to emphasize that the strength of a science and applications program is directly dependent on fundamental and well articulated goals and objectives." Examples of published research strategies are: *A Strategy for Space Biology and Medical Science for the 1980's and 1990's* (NAP, 1987) and *Strategy for the Detection and Study of Other Planetary Systems and Extrasolar Planetary Materials: 1990-2000* (NAP, 1990). Committee letters and reports are subject to approval by the parent body, the SSB, as well as by the NRC. Membership of the discipline committees averages about 10 persons.

As part of the 1988 reorganization, the Board took on several new tasks that are currently underway. The Board formed a Task Group on Priorities in Space Research and charged the group with developing a consensus and rationale for making priority choices among space research initiatives and, subsequently, developing a methodology for doing so. This two phase study is being chaired by John A. Dutton of Pennsylvania State University and represents the Board's attempt to provide a voice on some of the broad, critical issues

facing the U.S. space research program today. A report on Phase I of this study is targeted for publication in mid-1991.

Another of the new tasks of the SSB has been the formation of a Joint Committee on Technology Development. A first for the Board, this joint committee with the NRC's Aeronautics and Space Engineering Board (ASEB) will assist NASA's Offices of Space Science and Applications and Aeronautics, Exploration, and Technology in: developing and assessing science requirements for advanced technology development; in facilitating cooperative activities between the two NASA Offices; and in exploring ways in which the scientific and engineering communities could work together more closely. The committee is jointly chaired by David Landgrebe of Purdue University from the SSB and John McElroy of the University of Texas, Arlington, from the ASEB.

In addition to these committees, there is a Board Steering Group on Human Exploration. This steering group is completing a study on scientific research required to undertake piloted exploration of the solar system, and is initiating a second study on science that might uniquely be enabled by such a program.

In carrying out its advisory responsibilities, the SSB has a wide range of interactions... not only with NASA and its internal advisory committees but with other federal agencies such as NOAA, Congress, the National Space Council, and the Offices of Management and Budget and Science and Technology Policy, among others. The aim of the SSB is two-fold: (1) To serve as a representative and voice for the space research community and (2) To provide objective advice and counsel to NASA, other agencies and offices with interest in the civil space program, and to the nation at large.

Joyce Purcell
Senior Program Officer

SSB Testimony to House Committee

The following testimony was delivered to the House Committee on Science, Space, and Technology on behalf of the SSB by Board Member Dr. Norman Ness on January 29, 1991.

Mr. Chairman, members of the Committee, thank you for inviting the Space Studies Board to testify on the recently released Report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Mr. Norman Augustine. Louis J. Lanzerotti, Chair of the Space Studies Board, is unable to be here because of a prior commitment. I am presenting this statement of the Board on his behalf. As many of you know, Dr. Lanzerotti served as a member of the Advisory Committee.

The Space Studies Board was established in 1958 by the National Academy of Sciences to provide guidance to NASA and other agencies concerned with civil space research. Over the years, the Board has prepared and released a large number of reports and research strategies intended to promote the success and vitality of the Nation's civil space program. The Board's recommendations are based on focused discussions among prominent researchers organized by discipline areas in the Board's standing committees and task groups. These committees and task groups have addressed, over the years, a broad sweep of space science and applications disciplines, including astronomy and astrophysics, space biology and medicine, microgravity research, solar and space physics, earth studies, and planetary and lunar exploration.

We have been asked today to provide our assessment of the Augustine Report and to comment on its implementation. The Report covers an immense territory of technical, programmatic, and institutional concerns; it was prepared by a committee of distinguished scientists, engineers, industry executives, and politicians, and is based on

testimony by nearly 400 experts in space science, technology, and management. I will confine my remarks to a selection of topics that have been previously addressed by the Space Studies Board and by related special study groups convened by the Academy in recent years. Today's remarks will be related to (1) the priority of space research in the civil space program; (2) the role of a manned space station; (3) supporting theoretical and laboratory work and university participation; and (4) launch systems. The full implications of the Augustine Committee's Report are currently being evaluated by the Board, and will be the subject of additional discussion at our next meeting at the end of February. As I present the views of the Board, I will indicate a few areas that we expect to study further.

Space Science: Primary Goal of the Civil Space Program

The first concern noted in the Augustine Report is the deleterious effect of a lack of consensus in the civil space program. The National Research Council shares this concern, and clearly expressed the importance of shared national space goals in recommendations prepared for then President-elect Bush in 1988 (*Toward a New Era in Space*). The Board supports the Augustine Committee's statement of broad goals, and especially its assignment of top priority to space science. In its report, *Space Science in the 21st Century*, the Board proposed that the advance of science and its applications be assigned at least equal importance in America's space program as any other goal, such as the capability of expanding man's presence into space. The *21st Century* report recommends that other related activities, such as the development of space technology, should be carried out so as to maximize scientific return, and states the view that beneficial applications of space technology are most likely to flourish if science is made the principal object of the civilian space program.

(Testimony continued on page 6)

(Testimony continued from page 5)

Giving space research top priority in the civil space program has the important ramification that its financial support must be assured. To address this concern, the Augustine Committee's Recommendation #1 provides that space science should be assured a fixed minimum percentage of NASA's total budget to ensure stable funding. This is fully consistent with the NRC's recommendation in *Toward a New Era in Space* that a space science program be configured with a base program of balanced investigation, with major new enterprises funded separately as special initiatives. Two major issues arising from this overall approach are the prioritization of research objectives within the base program, and whether or not the nominal 20% portion recommended by the Augustine Committee is enough to adequately support space science as civil space's number one priority. A related topic is the important one of ensuring the most efficient use of these resources, as urged in the Committee's report. The Board is studying these questions now.

Role of a Manned Space Station

I would like to turn now to a second area of vital importance to the space research community: the role of a manned space station in space research. While the Augustine Committee concluded that microgravity research could benefit from human presence in space, it also stated that only a long-term program in life sciences could fully justify the construction of a space station. The scientific utility of a space station has been a concern of the Space Studies Board since 1983. In a statement to the NASA Administrator that year, the Board questioned the scientific need for a manned station before the beginning of the next (21st) century, while acknowledging a "special relationship" between the proposed station and space biological and medical research. In its report *Toward a New Era in Space*, the NRC recommended a shift away from microgravity research and "space

manufacturing" and toward space biology and medicine as drivers for the space station program. This is fully consistent with the Augustine Report's conclusions. In our Board's report, *A Strategy for Space Biology and Medical Science for the 1980s and 1990s*, we appealed specifically for a station design emphasizing life sciences research. Based on this discipline's dual requirements for continuous access and manned intervention, the Board recommended that there be a dedicated Life Sciences Laboratory on the Space Station, and that a variable force centrifuge of the largest possible dimensions be designed, built and included in the initial operating configuration of this Life Sciences Laboratory.

While Space Station Freedom's design remains in a state of flux at the present time, existing proposed configurations appear to diverge from these recommendations. The Board plans to assess the results of the Congressionally-mandated 90-day redesign once the results of this activity are available. The usability of the re-designed station for microgravity research between Orbiter visits during the station's man-tended phase is another topic we will be discussing.

Research and Analysis and the Universities

Mr. Chairman, the third area I wish to discuss today is the very important one of the status of research and analysis (R&A) funding and the role of the universities in our civil space effort. The Augustine Committee expressed the view that R&A programs, along with several other supporting programs, should be assigned the same importance as flight hardware programs themselves. On the same page, the Augustine Report urges that universities and other non-NASA Center organizations be tapped increasingly as "primes" for space research. The Board concurs strongly in these recommendations. The Board's 21st

(Testimony continued on page 7)

(Testimony continued from page 6)

Century study focused on major space undertakings, but asserts that, if these undertakings are to succeed, they must be built on a solid foundation of supporting research and technology, and on small-scale exploratory projects such as the Explorer and suborbital (rocket- and balloon-borne) programs. Supporting research must include stable funding for vigorous theoretical and laboratory studies, which provide the framework for understanding data obtained from scientific missions. The Board's research strategy for exploration of the outer planets, for example, contends that proper support of laboratory and theoretical studies is an integral part of any program of planetary exploration. This support must be sufficiently stable to maintain these activities at a professional level and to encourage participation of young investigators.

Launch Systems

Mr. Chairman, my final topic for today is launch systems. The Augustine Committee recommends deferral of a fifth Orbiter, and supports an immediate start of development of an "unmanned, but man-rateable," heavy lift launch vehicle. While the NRC's recently published report, *Human Exploration of Space: A Review of NASA's 90-Day Study and Alternatives*, clearly supports the development of a modern launch system with heavy lift capability, the Space Studies Board has tended to be more concerned with assured access to space on vehicles appropriate to each research mission. If space research is to have the top priority within the future civil space program, it must influence the development of infrastructure, particularly space transportation. The Board believes that launch systems, delivery mechanisms, space platforms, and other such developments should never be looked upon as ends in themselves. Rather they should be treated as tools to support well-defined objectives. Where space research is concerned, the key desiderata for advanced launch systems are

reliability (because payloads are costly to lose), a capacity for rapid processing (to ensure the timeliness of launches), low cost (allowing access to space for a wider community of users), and diversity and redundancy (so that failure of one element of the launch infrastructure does not shut down the nation's entire launch capability). These space science community concerns should be fully considered in launch system development planning.

In closing my statement, I would like to emphasize that omission from these remarks of the Mission to Planet Earth and the Mission from Planet Earth should not suggest that the Board attaches low importance to them. On the contrary, we are now completing two reports in the earth studies area, one an assessment of the state of the discipline, and the other an assessment of the Earth Observing System program. Our Committee on Human Exploration is initiating a broad study of the role of science investigations in a future manned exploration program. The Board looks forward to the opportunity to share the results of these important activities with you at a future date.

Thank you. I'll be happy to answer any questions you might have.

Members of the Space Studies Board

LOUIS J. LANZEROTTI, CHAIRMAN
AT&T Bell Laboratories
Murray Hill, NJ

Philip Abelson
American Association for the Advancement of Science
Washington, DC

Joseph A. Burns
Cornell University
Ithaca, NY

John R. Carruthers
INTEL
Santa Clara, CA

(Members continued on page 8)

(Members continued from page 7)

Andrea K. Dupree
Harvard-Smithsonian Institution
Cambridge, MA

John A. Dutton
Pennsylvania State University
University Park, PA

Larry Esposito
University of Colorado
Boulder, CO

James P. Ferris
Rensselaer Polytechnic Institute
Troy, NY

Herbert Friedman
Naval Research Laboratory
Washington, DC

Richard L. Garwin
IBM Corporation
Yorktown Heights, NY

Riccardo Giacconi
Space Telescope Science Institute
Baltimore, MD

Noel W. Hinners
Martin Marietta Civil Space & Communications Company
Bethesda, MD

James R. Houck
Cornell University
Ithaca, NY

David A. Landgrebe
Purdue University
West Lafayette, IN

Elliott C. Levinthal
Stanford University
Stanford, CA

William J. Merrell, Jr.
Texas A&M University
Galveston, TX

Richard K. Moore
University of Kansas
Lawrence, KS

Robert H. Moser
The NutraSweet Company
Deerfield, IL

Norman F. Ness
University of Delaware
Newark, DE

Marcia Neugebauer
Jet Propulsion Laboratory
Pasadena, CA

Sally K. Ride
University of CA, San Diego
La Jolla, CA

Robert F. Sekerka
Carnegie Mellon University
Pittsburgh, PA

Mark Settle
ARCO Oil and Gas Company
Plano, Texas

L. Dennis Smith
University of California
Irvine, CA

Byron D. Tapley
University of Texas
Austin, TX

Arthur B.C. Walker
Stanford University
Stanford, CA

Space Studies Board Committee Chairs

John A. Dutton
Task Group on Priorities in Space Research-Phase I & II

Larry Esposito
Committee on Planetary and Lunar Exploration

Noel Hinners
Steering Committee on Human Exploration

David A. Landgrebe
Joint Committee on Technology for Space Science and
Applications

Marcia Neugebauer
Committee on Solar and Space Physics

Robert F. Sekerka
Committee on Microgravity Research

L. Dennis Smith
Committee on Space Biology and Medicine

Byron D. Tapley
Committee on Earth Studies

Vacant
Committee on Space Astronomy and Astrophysics

**Space Studies Board
Staff**

Marc S. Allen
Staff Director

Joyce M. Purcell
Senior Program Officer

Betty C. Guyot
Staff Associate

Carmela J. Chamberlain
Administrative Secretary

Richard C. Hart
Deputy Staff Director

Paul Uhler
Senior Program Officer

Altonia L. Bell
Administrative Secretary

Melanie M. Green
Administrative Secretary

Dean P. Kastel
Consultant to the Board

**PLEASE CHECK THE MAILING LABEL ON THIS PACKAGE.
IF CHANGES/CORRECTIONS ARE NEEDED, PLEASE ADVISE US AT:**

**Space Studies Board
National Academy of Sciences
Harris Building, Room 584
2101 Constitution Ave., NW
Washington, DC 20418**

**(tel) 202-334-3477
(fax) 202-334-2791**

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120828

FROM: GRAY, Leven B.: NASA

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/15/91

SUBJECT: CORRECTION TO THE FEBRUARY-APRIL 91 QUARTERLY
REPORTS, DUE TO AN ADDITION OF A NEW DEVELOPMENTAL
TEST OBJECTIVE (DTO 640).

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong
Michelle Van Cleave

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 03/21/91

FILE: SPACE

p-physical Sciences-

Withdrawal/Redaction Sheet

(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01. Letter w/ attachment	To: Allan Bromley From: Leven Gray Re: Correction to quarterly report (2 pp.)	3/15/91	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files
WHORM Cat.:
File Location: Physical Sciences: Space [3 of 3] [1991]

Date Closed:	4/1/2010	OA/ID Number:	62045-004
FOIA/SYS Case #:	2005-0336-F	Appeal Case #:	
Re-review Case #:		Appeal Disposition:	
P-2/P-5 Review Case #:		Disposition Date:	
AR Case #:		MR Case #:	
AR Disposition:		MR Disposition:	
AR Disposition Date:		MR Disposition Date:	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

Freedom of Information Act - [5 U.S.C. 552(b)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [(a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120814

FROM: TRULY, Richard H.: NASA

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/15/91

SUBJECT: AN INITIAL RESPONSE TO THE NATIONAL RESEARCH
COUNCIL'S PAPER ON LIFE SCIENCES AND MATERIALS
SCIENCE CAPABILITIES ABOARD THE REDESIGNED SPACE
STATION.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong
Life Sciences

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 03/20/91

FILE: SPACE

p-Physical Sciences -



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

9120914

RECEIVED

91 MAR 20 March 15 1991 9:36

OFFICE OF THE
DIRECTOR

The Honorable D. Allan Bromley
Assistant to the President
for Science and Technology and
Director, Office of Science and
Technology Policy
Executive Office of the President
Washington, DC 20506

Dear Dr. *Allan* Bromley:

As I promised on the telephone this morning, we developed the enclosed material as an initial response to the National Research Council's paper on life sciences and materials science capabilities aboard the redesigned Space Station.

Our aim was to satisfy congressional budget restraints, honor international commitments and maintain the long-term capability to meet user requirements. We believe the Station redesign does this.

Sincerely,

Richard H. Truly
Richard H. Truly
Administrator

Enclosure

NASA COMMENTS ON THE SPACE STUDIES BOARD REPORT

The basic premise of the Space Station Freedom restructuring was that the Congressionally mandated constraints on budget runout and the International Agreements with Europe, Japan, and Canada, would not be violated.

Having done that, the basic design, timing of Permanent Manned Capability, and priorities for science, applied research, and technology utilization of the Station were effectively determined.

The Space Studies Board concerns would require that NASA violate one or both of the basic premises in order to effect the changes implied by their recommendations. NASA does not unilaterally possess the authority, nor does it believe it is appropriate, to take such action.

NASA believes that the restructured Space Station, during its evolution, will meet the requirements of the principal scientific research for which it is intended, and that it will provide for world-class research in microgravity and life science.

The Space Studies Board listed a number of specific criticisms of the restructured Space Station. In most cases these criticisms are an inaccurate reflection of the Station's current or planned capabilities. The attached comments address specific points made by the Boards' subcommittee reports.

SPACE BIOLOGY AND MEDICINE RESEARCH REQUIREMENTS

The Committee on Space Biology and Medicine and the Space Studies Board conclude that Space Station Freedom, in its present redesigned form, will be inadequate to meet the requirements for space biology and medicine research described above because of the following:

- 1. The plan to share limited power among multiple users in all laboratory modules suggests that there will be insufficient power to conduct the volume of long-term biological experiments required to support a human space exploration initiative.*
 - An analysis of the life sciences power requirements indicates that the life sciences share of the OSSA projected 65% allocation allows the full utilization of the proposed life sciences experiment hardware during all phases of operation.
 - At PMC and beyond, power equates to more than the power provided to three simultaneous dedicated Spacelab module missions, such as SLS-1.
- 2. Plans for the size and location of a centrifuge and of animal-holding facilities are insufficiently defined for proper evaluation. As emphasized in the Boards 1987 strategy report, an adequate centrifuge is essential to provide a 1-g control for 0-g experiments and also to explore the adequacy of artificial gravity for long-duration spaceflight.*
 - The Space Station Freedom Program Requirement Definition (PRD) document has accepted a baseline requirement for a 2.5 meter centrifuge and the associated animal holding facilities on the Station. Options for specific location and accommodations are still being evaluated.
 - The Japanese module has both the proper plumbing and space for a 1.8 meter centrifuge.

3. *The proposed crew size is insufficient to conduct the requisite experiments in a reasonable time period.*

- The reduction to an initial crew size of four from the eight previously baselined will necessarily extend the time required to develop appropriate statistics on areas related to long-term exposure to the space environment.
- The inherent capability to restore crew size to eight after PMC has been retained in the restructured Space Station and its implementation is paced only by budget availability.

4. *The absence of a dedicated life sciences laboratory will prohibit some experiments and will severely restrict most others, prolonging the acquisition of data required to answer fundamental questions related to the feasibility of long-duration human space exploration.*

- We are unaware of any validated science rationale which can only be met by a dedicated laboratory for life sciences.
- We are aware of proximity requirements for selected life sciences suites of instruments and those requirements are being met.

MICROGRAVITY RESEARCH REQUIREMENTS

The redesigned Space Station Freedom would be inadequate to meet the requirements of microgravity science and applications because it lacks the following:

- 1. A low, quiescent acceleration environment unhampered by crew activities, docking maneuvers, and other system activities necessary to sustain a permanently occupied presence.*
 - The National Academy of Sciences Report of the Committee on a Commercially Developed Space Facility, 1989, found ". . . that over 85 per cent of the proposed [*microgravity sciences*] experiments could be accommodated in a 16-day mission, and that a 28-day mission would accommodate virtually all of the remainder. Experiments or processes needing on-orbit duration greater than presently available include such things as biotechnology research with living cells and crystal growth."
 - During the Man Tended phase of Space Station utilization, periods of up to 45 days will be available and provide a quiescent microgravity acceleration environment unhampered by crew activities and docking maneuvers.
 - Post-PMC, the baselined Station specification for the restructured Station will provide a microgravity environment for periods of up to 30 days free of significant disturbances .
 - The Space Station program has baselined a U.S. Laboratory Acceleration Mapping System which allows for monitoring and will facilitate control of the acceleration environment. Additionally, the Station has committed to implementing a vibro-acoustic control plan.

2. *A crew that would spend sufficient time working with the experiment equipment.*

- During Man Tended phase utilization flights a dedicated payload crew of up to four will be available to operate with experiments.
- Inherent capability to restore crew size to eight after PMC has been retained in the restructured Space Station and its implementation is paced only by budget availability.
- However, even beyond PMC when a crew of eight could be available, dedicated experiment crew time will still be one of Space Station's most precious resources.

3. *Sufficient power, data-handling capabilities, and research volume.*

- An analysis of the microgravity sciences power requirements indicates that the microgravity sciences share of the projected OSSA 65% allocation allows the full utilization of the proposed microgravity sciences experiment hardware.
- As a minimum, the data handling and down link capabilities of the restructured station equals or exceeds the current Spacelab capability.
- The inherent capability to restore a 300 mbps data handling system after PMC has been retained in the restructured Space Station, is still a high priority, and its implementation is paced only by budget availability.
- However, on-orbit data storage and processing for user payloads remain unresolved issues which are subjects of continuing study.
- The inherent capability to restore the Station to the full volume of user laboratory racks previously baselined has been retained in the restructured Space Station in the form U.S. Laboratory B (which offers 12 additional U.S. user payload racks) and its implementation is paced only by budget availability.

4. *The flexibility to upgrade systems; this deficiency is especially disconcerting in the area of computers, in which obsolescence is extremely rapid.*

- Current station design has incorporated state of the art data standards (e.g., Fiber Distributed Data Interface - FDDI). This basic fiber optic system is capable of handling higher data rates with future upgrades in terminating hardware, data handling and computational systems.
- Modularity of experiment and infrastructure systems will be applied to both payload and station design/utilization.

Other Issues

"During the crew-tended phase, NASA plans to fly Spacelab experiment hardware on the Space Station Freedom because other, newer hardware will not be available. Most of this Spacelab hardware will require manual intervention and therefore will be operable only when people are present."

- During the initial man tended phase of Space Station (1997 - 98), NASA plans to fly hardware developed for Spacelab to support peer-reviewed science investigations that continue into this timeframe. The transition to station is evolutionary, as is the science performed in space. Accommodating this class of hardware on the restructured Station during the initial utilization period precludes discontinuities in the science program were NASA to stand down to retool for the new spacecraft.

"Unfortunately, the crew-tended phase is a time when significant acceleration disturbances will exist due to concurrent hardware integration and assembly and construction activities. Therefore, the man-tended phase will not be suitable for many microgravity experiments."

- The concept of utilization flights during the assembly sequence of Space Station was to ensure that the science, applied research, and technology activities during the man tended phase were distinct and isolated from the construction and verification activities. This promotes efficiencies in utilization during the assembly period, while providing continued research in space as we transition from Spacelab to Space Station.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120761

FROM: PRESS, Frank: NATIONAL RESEARCH COUNCIL

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/14/91

SUBJECT: A POSITION PAPER PREPARED BY THE NRC'S SPACE STUDIES
BOARD ON THE RECENT REDESIGN OF SPACE STATION
FREEDOM.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Karl Erb
Dr. Phillips

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 03/15/91

FILE: *p-Physical Sciences -*
SPACE

91 20761

NATIONAL RESEARCH COUNCIL

RECEIVED

2101 CONSTITUTION AVENUE WASHINGTON, D. C. 20418

91 MAR 15 10:08

OFFICE OF THE CHAIRMAN

March 14, 1991

OFFICE OF THE
DIRECTOR

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
Old Executive Office Building
17th Street & Pennsylvania Avenue NW
Washington DC 20506

Dear Allan:

I am forwarding a position paper prepared by the National Research Council's Space Studies Board on the recent redesign of Space Station Freedom—specifically, the suitability of that redesign for space research. The Board evaluated the results of this redesign effort, as presented by NASA space station officials, in the context of published Board research recommendations. The evaluation was conducted by the Board and its discipline committees in microgravity research and space biology and medicine. The enclosed cover letter addressed to Admiral Truly provides a brief history of the evolution of the statement.

We look forward to the opportunity to discuss this report with members of the OSTP, OMB, and Space Council staffs tomorrow morning.

Yours sincerely,



Frank Press
Chairman

Enclosures

SPACE STUDIES BOARD POSITION

ON

PROPOSED REDESIGN OF SPACE STATION FREEDOM

SUMMARY

The United States has contemplated for many years the construction of a space station that would further a variety of national goals, one of which is space science and applications. The recent report of the presidentially appointed Advisory Committee on the Future of the U.S. Space Program, chaired by Norman Augustine, recommended that the development of a U.S. space station with research facilities must give top priority to life sciences research, with microgravity research assuming a significant but secondary role.¹ The Board notes that this recommendation is fully consistent with the 1983 Space Studies Board position on the space station, as well as with the 1988 National Academy of Sciences/National Academy of Engineering report to then newly-elected President Bush.^{2,3} *In the judgment of the Board, Space Station Freedom, at the present stage of redesign, does not meet the basic research requirements of the two principal scientific disciplines for which it is intended: (1) life sciences research necessary to support the national objective of long-term human exploration of space, and (2) microgravity research and applications.* This conclusion as to the station's research capabilities is based upon an assessment of its redesign as of March 1991.⁴ Attachments 1 and 2 summarize the research requirements for space biology and medicine and for microgravity research and their relationship to the redesigned space station.

The Space Studies Board's membership is not constituted such that it can provide an engineering judgment on the feasibility of the redesign, and therefore has not done so.

RESEARCH RETURN ON TAXPAYER INVESTMENT

The Space Studies Board considered the quantity and quality of research that might be conducted on the proposed redesigned space station in the context of the level of investment that will be required to bring it to completion. The Board believes that neither the quantity nor the quality of research that can be conducted on the proposed station merits the projected investment. As redesigned, a maximum of \$2.6 billion per year would be expended on the station to achieve an initial crew-tended capability by the mid-1990s, not including associated Space Transportation System and user costs.⁵ Additional funding at a comparable rate of expenditure would be required to achieve a permanently occupied capability late in the decade. In the initial, crew-tended configuration, the redesigned station would be devoted primarily to microgravity research. Life sciences research unique to the space station would not begin until the end of the decade, when the permanently occupied configuration would be established. For comparison, the 1991 NASA budget allocates roughly \$102 million to microgravity research. In other words, during each of the next five years, the amount of funding devoted to space station construction for microgravity research would be approximately 20 times the level of the current research program for this discipline. In addition, the monthly cost of constructing the redesigned station would approach the annual total funding devoted to both NASA's life sciences and microgravity science and applications divisions during the current fiscal year.

SPACE RESEARCH REQUIREMENTS, OPPORTUNITIES, AND ALTERNATIVES

Life Sciences Research

The Augustine Committee recently concluded that the primary objective of a space station should be life sciences research.¹ The Space Studies Board strongly endorses the position that a space-based laboratory is required to study the physiological consequences of long-term space flight.^{7,8} The Board notes that many of the fundamental problems in life sciences research involve a long period of time for their pursuit and solution. In its present form, the redesigned space station does not provide the facilities required for such research. (See Attachment 1.)

Microgravity Research

In the judgment of the Board, the limited microgravity research that could be conducted on the redesigned space station as currently proposed does not merit the investment. If such funds were made available, the research community would likely choose to spend them in a very different way. (See Attachment 2.) The Board believes specifically that more research progress could be achieved in a shorter period of time and at a fraction of the cost through an expanded program of Spacelab missions and of free-flyer experiments.^{6,8,9}

NATIONAL GOALS AND THEIR ACHIEVEMENT

In conclusion, the SSB recognizes that there are national considerations for building a space station other than scientific research. Included among these are the possibilities of enhancing international prestige, stimulating the nation's educational achievement, stimulating the U.S. technology base, and supporting a long-term human space exploration initiative.

In the judgment of the Board, the proposed redesign of Space Station Freedom does not meet the stated national goal of enabling the life sciences research necessary to support extended human space exploration, nor does it meet the stated needs of the microgravity research community--most of whose goals could be achieved in both a more timely and more cost-effective manner by alternative means. Continued development of Space Station Freedom, as currently redesigned, cannot be supported on scientific grounds. If the present station redesign is implemented, this major national investment must be justified on the basis of considerations other than research in these two disciplines.

ATTACHMENT 1

SPACE BIOLOGY AND MEDICINE RESEARCH REQUIREMENTS

Requirements for conducting space biology and medicine research are described in detail in the 1987 report, *A Strategy for Space Biology and Medical Science for the 1980s and 1990s*.⁷ The major goals established in that report for this area of research are:

- a. "To describe and understand human adaptation to the space environment and the readaptation upon return to Earth."
- b. "To use the knowledge so obtained to devise procedures that will improve the health, safety, comfort, and performance of the astronauts. Specifically, we must improve our understanding of the microgravity induced alterations in physiologic and psychological processes as well as effects of radiation before long duration human exploration can be safely and effectively pursued."

Critical Requirements for Conducting Space Biology and Medicine Research

The Board's 1987 report⁷ emphasizes that a space station is **pivotal** to the conduct of life sciences research, and it documents the following as critical requirements for a space station:

1. A dedicated life sciences laboratory with adequate scientific crew to conduct research.
2. A variable speed centrifuge of sufficient radius to accommodate small primates.
3. Sufficient numbers of experimental subjects (humans, plants and animals) to address the stated scientific goals.
4. Sufficient laboratory resources, i.e., power, equipment, space, and atmosphere, to support the above research requirements.

The Space Studies Board's Committee on Space Biology and Medicine, and the Board itself wish to emphatically emphasize that the above requirements are absolutely fundamental to the acquisition of the data necessary to determine the feasibility of long-term human space exploration.

Inadequacy of the Redesigned Space Station Freedom for Space Biology and Medicine Research Requirements

The Committee on Space Biology and Medicine and the Space Studies Board conclude that Space Station Freedom, in its present redesigned form, will be inadequate to meet the requirements for space biology and medicine research described above because of the following:

1. The plan to share limited power among multiple users in all laboratory modules suggests that there will be insufficient power to conduct the volume of long-term biological experiments required to support a human space exploration initiative.
2. Plans for the size and location of a centrifuge and of animal-holding facilities are insufficiently defined for proper evaluation. As emphasized in the Board's 1987 strategy report⁷, an adequate centrifuge is essential to provide a 1-g control for 0-g experiments and also to explore the adequacy of artificial gravity for long-duration spaceflight.
3. The proposed crew size is insufficient to conduct the requisite experiments in a reasonable time period.
4. The absence of a dedicated life sciences laboratory will prohibit some experiments and will severely restrict most others, prolonging the acquisition of data required to answer fundamental questions related to the feasibility of long-duration human space exploration.

ATTACHMENT 2

MICROGRAVITY RESEARCH REQUIREMENTS

The National Research Council, as well as several NASA advisory committees, has published reports over the years that specifically address the minimum research requirements for this field of space research.^{6,8,9}

The Space Studies Board's Committee on Microgravity Research has advised the Board that, unlike research in the field of space biology and medicine, only a limited amount of the desired research in microgravity, at least over the next decade, can best be accomplished with a space station. The use of crew-tended free-flyers, drop towers, extended duration Spacelabs, and so forth, offer adequate, and in fact more viable, opportunities for the research needs in many cases. There are, however, important experiments requiring measurements and human observation and interaction over extended periods of time. The space station is a means to provide this capability. *If plans proceed to conduct microgravity research on the redesigned Space Station Freedom, the Board and its Committee on Microgravity Research recommend that adequate provisions be made for supporting only those microgravity research questions that can best be addressed using a space station.*

The following minimum facility requirements for microgravity research aboard a space station are based on the conclusions and recommendations described in the cited reports and on recent briefings presented to the Committee on Microgravity Research and the Space Studies Board.⁴

Critical Requirements for Conducting Microgravity Research on a Space Station

1. Adequate power, research volume, and support space.
2. Skilled on-board scientific personnel in sufficient numbers to carry out experiments and to diagnose and correct malfunctions.
3. Suitable acceleration environment and adequate monitoring.
4. Affordable de-integration and re-integration of experiments on orbit.
5. Capability to integrate advanced techniques and instrumentation as these become available.
6. Fast turnaround for specimens that must be characterized on Earth.

Inadequacy of the Redesigned Space Station Freedom for Microgravity Research Needs

The redesigned Space Station Freedom would be inadequate to meet the requirements of microgravity science and applications because it lacks the following:

1. A low, quiescent acceleration environment unhampered by crew activities, docking maneuvers, and other system activities necessary to sustain a permanently occupied presence.

2. A crew that would spend sufficient time working with the experiment equipment (See Attachment 1, item 3.).
3. Sufficient power, data-handling capabilities, and research volume (see Attachment 1, item 1).
4. The flexibility to upgrade systems; this deficiency is especially disconcerting in the area of computers, in which obsolescence is extremely rapid.

Other Issues

During the crew-tended phase, NASA plans to fly Spacelab experiment hardware on the Space Station Freedom because other, newer hardware will not be available. Most of this Spacelab hardware will require manual intervention and therefore will be operable only when people are present. Unfortunately, the crew-tended phase is a time when significant acceleration disturbances will exist due to concurrent hardware integration and assembly and construction activities. Therefore, the man-tended phase will not be suitable for many microgravity experiments. Only a limited number of experiments could be run during the free-flying mode between shuttle visits during the crew-tended phase.

If the bulk of the microgravity research program planned for Freedom were removed, the station would then be devoted almost exclusively to life sciences research. The benefits of this action would be that (a) the g-level on the station would not have to be strongly controlled, thus resulting in significant cost savings, (b) some low-gravity experiments (e.g., fluids handling, fire safety) could still be done on the space station, and (c) the bulk of the microgravity program could be conducted using independent, more cost-effective facilities.

ENDNOTES

1. *Report of the Advisory Committee on the Future of the U.S. Space Program*, Superintendent of Documents (GPO) December, 1990.
2. Space Science Board Assessment of the Scientific Value of a Space Station and letter to NASA Administrator James Beggs, September 9, 1983. See also Space Studies Board, Testimony to U.S. Senate Subcommittee on Science, Technology and Space, May 10, 1990.
3. *Toward a New Era in Space--Realigning Policies to New Realities--Recommendations for President-Elect George Bush*, Committee on Space Policy, NAS/NAE (NAP) 1988.
4. Briefing to Committee on Microgravity Research, William Taylor, Chief Scientist, Space Station Freedom, January 10, 1991. Briefing to Committee on Space Biology and Medicine, William Taylor, Chief Scientist, Space Station Freedom, February 8, 1991. Briefing to Space Studies Board, William Raney, Special Assistant, Space Station Freedom, and John-David Bartoe, Deputy Director, Space Station Freedom Operations and Utilization, February 28, 1991.
5. Conference Report 101-900, HUD and Independent Agencies, FY 1991.
6. *Microgravity Science and Applications--Report on a Workshop*, Panel on Microgravity Science and Applications, Solid State Sciences Committee, Board on Physics and Astronomy (NAP) 1986. *Review of Microgravity Science and Applications Flight Programs*, Committee To Review the Microgravity Science and Applications Flight Program, USRA, January-March, 1987. Space Studies Board Workshop on Microgravity Research, NAS Beckman Center, January 16-17, 1989.
7. *A Strategy for Space Biology and Medical Science for the 1980s and 1990s* (NAP) 1987. *Space Studies Board Assessment: Space Biology and Medicine Research--1990* (in press). Space Studies Board/Committee on Space Biology and Medicine, letter to Andrew Stofan, Associate Administrator, Office of Space Station, NASA Headquarters, July 21, 1987. Space Studies Board/Committee on Space Biology and Medicine, Testimony to the U.S. Senate Subcommittee on HUD Appropriations, May 1, 1987.
8. Space Studies Board letter to Joseph Alexander, Assistant Associate Administrator, Office of Space Science and Applications, NASA Headquarters, December 12, 1990. *Space Station Summer Study Report*, SESAC Task Force on Scientific Uses of a Space Station, NASA, March, 21, 1985. *Space Station Summer Study Report*, SESAC Task Force on Scientific Uses of a Space Station, NASA, March, 1986.
9. *Materials Processing in Space*, Committee on Scientific and Technological Aspects of Materials Processing in Space, Space Applications Board, (NAS) 1978. *Industrial Applications of the Microgravity Environment*, Space Applications Board (NAP) 1988.

SPACE STUDIES BOARD

MEMBERS

Louis J. Lanzerotti, *Chairman*, Distinguished Member of the Technical Staff, AT&T Bell Laboratories
Philip Abelson, Science Advisor, American Association for the Advancement of Science
Joseph A. Burns, Professor of Astronomy, Cornell University
John R. Carruthers, Manager, Components Research, INTEL
Andrea K. Dupree, Senior Scientist, Harvard-Smithsonian Institution Center for Astrophysics
John Dutton, Dean, College of Earth and Mineral Sciences, Pennsylvania State University
Larry Esposito, Associate Professor, University of Colorado
James P. Ferris, Professor, Department of Chemistry, Rensselaer Polytechnic Institute
Herbert Friedman, Consultant, Naval Research Laboratory
Richard L. Garwin, Advisor to the Director of Research, IBM Corporation
Riccardo Giacconi, Director, Space Telescope Science Institute
Noel W. Hinners, Vice President for Strategic Planning, Martin Marietta Corporation
James R. Houck, Professor of Astronomy, Cornell University
David A. Landgrebe, Professor of Electrical Engineering, Purdue University
Elliott C. Levinthal, Professor of Mechanical Engineering, Stanford University
William J. Merrell, Jr., President, Texas A&M University, Galveston
Richard K. Moore, Professor, Remote Sensing Labs, University of Kansas
Robert H. Moser, Vice President for Medical Affairs, NutraSweet Company
Norman F. Ness, President, Bartol Research Institute, University of Delaware
Marcia Neugebauer, Senior Research Scientist, Jet Propulsion Laboratory
Sally K. Ride, Professor/Director, California Space Institute, University of California, San Diego
Robert F. Sekerka, Dean, Mellon College of Science, Carnegie Mellon University
Mark Settle, Manager, The New Opportunities Group, ARCO Oil and Gas Company
L. Dennis Smith, Executive Vice Chancellor, University of California, Irvine
Byron D. Tapley, Director, Center for Space Research
Arthur B.C. Walker, Professor of Applied Physics, Stanford University

Marc S. Allen
Staff Director

COMMITTEE ON SPACE BIOLOGY AND MEDICINE

MEMBERS

L. Dennis Smith, *Chairman*, Executive Vice Chancellor, University of California, Irvine
Robert M. Berne, Alumni Professor of Physiology, University of Virginia
Peter Dews, Professor of Psychology and Psychobiology, Harvard Medical School
R.J. Michael Fry, Head of Cancer Section, Biology Division, Oak Ridge National Laboratory
Edward J. Goetzel, Professor of Rheumatic and Connective Tissue Diseases, University of California Medical Center, San Francisco
Robert Helmreich, Professor of Psychology and Director, NASA/UT Aerospace Crew Research Project/The University of Texas, Austin
Barry W. Peterson, Professor of Physiology, Northwestern University
Clinton T. Rubin, Associate Professor/Director of Musculo-skeletal Research Laboratory, State University of New York at Stony Brook
Alan L. Schiller, Professor and Chairman Pathology, Mt. Sinai Medical Center
Tom Scott, Professor of Biology, University of North Carolina, Chapel Hill
William Thompson, University Professor of Botany and Genetics, North Carolina State University
Fred W. Turek, Chairman, Department of Neurobiology and Physiology, Northwestern University

Joyce M. Purcell
Executive Secretary

COMMITTEE ON MICROGRAVITY RESEARCH

MEMBERS

Robert F. Sekerka, *Chairman*, Dean, Mellon College of Science, Carnegie Mellon University
Robert A. Brown, Head, Department of Chemical Engineering, Massachusetts Institute of Technology

Franklin D. Lemkey, Senior Consultant Scientist, United Technologies Research Center

William A. Sirignano, Dean, School of Engineering, University of California, Irvine

Thomas A. Steitz, Investigator/Professor of Molecular Biophysics and Chemistry,
The Howard Hughes Medical Institute/Yale University

John R. Carruthers, Manager, Components Research, INTEL

Joyce M. Purcell
Executive Secretary

NATIONAL RESEARCH COUNCIL
COMMISSION ON PHYSICAL SCIENCES, MATHEMATICS, AND APPLICATIONS

2101 Constitution Avenue Washington, D.C. 20418-0001

SPACE STUDIES BOARD

Office Location:
Milton Harris Building
Room 584
2001 Wisconsin Avenue, N.W.
(202) 334-3477
Fax: (202) 334-2791

March 14, 1991

Rear Admiral Richard H. Truly (Ret.)
Administrator
National Aeronautics and Space Administration
Code A
Washington, D.C. 20546

Dear Admiral Truly:

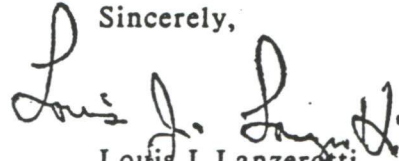
As you know, the research utilization of a manned U.S. space station has been a subject of considerable interest to the Space Studies Board since the inception of the program. In a letter to Mr. Beggs in 1983, the Board expressed reservations about the national requirement for a manned station for supporting space science, other than life science. Since that time, station planning and design have evolved rapidly.

Beginning in late 1990, and particularly after the release of the Augustine Report and its recommendations for development of a U.S. space station, two of the Board's discipline committees have become increasingly concerned about the research capabilities of the station as redesigned under the Congressional mandate. In addition, the Board itself has expressed concern as to whether the redesigned station will adequately support the research required to make important national decisions about long term human spaceflight. The Committee on Microgravity Research and the Committee on Space Biology and Medicine were briefed by space station officials on redesign ground rules and guidelines on January 10 and February 8 of this year, respectively. On February 28, the full Board was briefed on the preliminary results of the redesign study, with the chairmen and several key members of the two committees in attendance. The briefing officials from the space station office were most generous with their time and very frank in their discussions. We thank them for their efforts. Based on this briefing and on known research requirements cited in the attached assessment, the consensus of the Board was that the inadequacy of the redesign in its present state for research was sufficiently grave that a formal Board statement expressing these views to you was in order. Please note that the Board did not formulate and does not express any opinion on the engineering feasibility of the present redesign, nor does the Board address possible reasons other than space research for proceeding with the redesigned station.

Admiral Truly
March 14, 1991
Page 2

Enclosed is the assessment that resulted from the deliberations of the full Board, reflecting the participation of the two discipline committees. I will be happy to discuss with you any questions you might have about the Board's conclusions or the supporting rationale. We all share a common commitment to a vigorous and forward-looking national civil space research program.

Sincerely,



Louis J. Lanzerotti
Chairman

Enclosure

cc: The Vice President J. Danforth Quayle, Chairman, The National Space
Council
M. Albrecht
D.A. Bromley
R. Grady

cc (Enclosure only): Chairs and Ranking Minority Members of Congressional
Authorizing and Appropriations Committees

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120759

FROM: MILLER, Jay

TO: DR. BROMLEY

- DATE OF
CORRESPONDENCE: 03/11/91

SUBJECT: LETTER TO PRESIDENT BUSH DATED 07/20/90 CONCERNING
SUPPORT FOR THE PRIVATE DEVELOPMENT OF NEWER
AEROSPACE TECHNOLOGIES.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Phillips
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 03/15/91

FILE: *p-physical Science-Space**
SPACE*TECHNOLOGY

2018

Dr. Bromley

3/11/91

If we really are committed to the betterment of our lives and our economy then it is time to end the subsidy of the aerospace pork barrel and support the private development of these newer technologies which will reduce costs by over a factor of 100, and open the market to untold new products and services.

George Bush
United States of America

Tex

20 July 1990
9120759

Dear President Bush:

Your concern for national space program priorities is timely and well founded. With the end of the cold war, the many costs and consequences of domestic 'white elephant' space projects are no longer justified. More importantly, routine low-cost access to space can no longer be denied to American enterprise if we are to meet the needs of global commerce in the 1990s and beyond.

91 MAY 15 AM 07

RECEIVED

As your own arithmetic must tell you, the Moon and Mars are not options for a national program which has yet to manufacture low-cost reusable space transport systems. As long as the Shuttle and Space Station programs are continued, no progress will be made and no money will be available for other programs.

Fortunately, even NASA/DoD contractor studies confirm, the cost to build replacement space transport systems would total only \$1-2 Billion. That is, less than the cost of 1 Shuttle flight!

These new reusable space transport systems are called Single-Stage-To-Orbit (SSTO) or Phoenix, and ElectroMagnetic Launch (EML). The Phoenix passengerliner concept was patented and buried 25 years ago by NASA. The EML cargo launcher concept was tested 50 years ago by the Navy. The technology is roughly equivalent to the particle accelerators in operation all over the world today (SLAC, Fermi, etc.).

The aerospace industry says Phoenix and EML will each cost \$1 Billion to build. The business plans of the entrepreneur promoters say the costs will be under \$500 Million each. Either way, I am sure you will agree, all impediments should be removed so that we can begin to build them today.

NASA need not be a scapegoat. The White House and Congress share the responsibility for the history of micromanagement, and the future of opportunity. The new space transport systems should be developed by the nation, not by NASA. NASA, or a new agency, may then continue the mission of pushing back the frontiers of the universe, instead of being mired in politics.

What you decide to do about the institutional future of space science and technology is your responsibility, not mine. My special interest is in assuring that business opportunities such as space power, hotels, manufacturing, communications, etc., are allowed to happen in the traditional environment of a commercial marketplace.

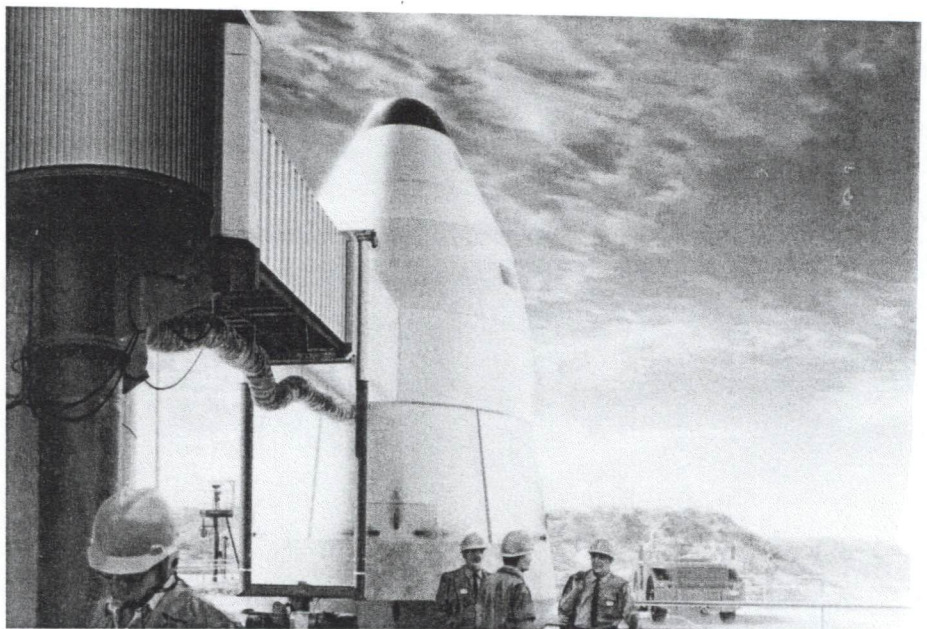
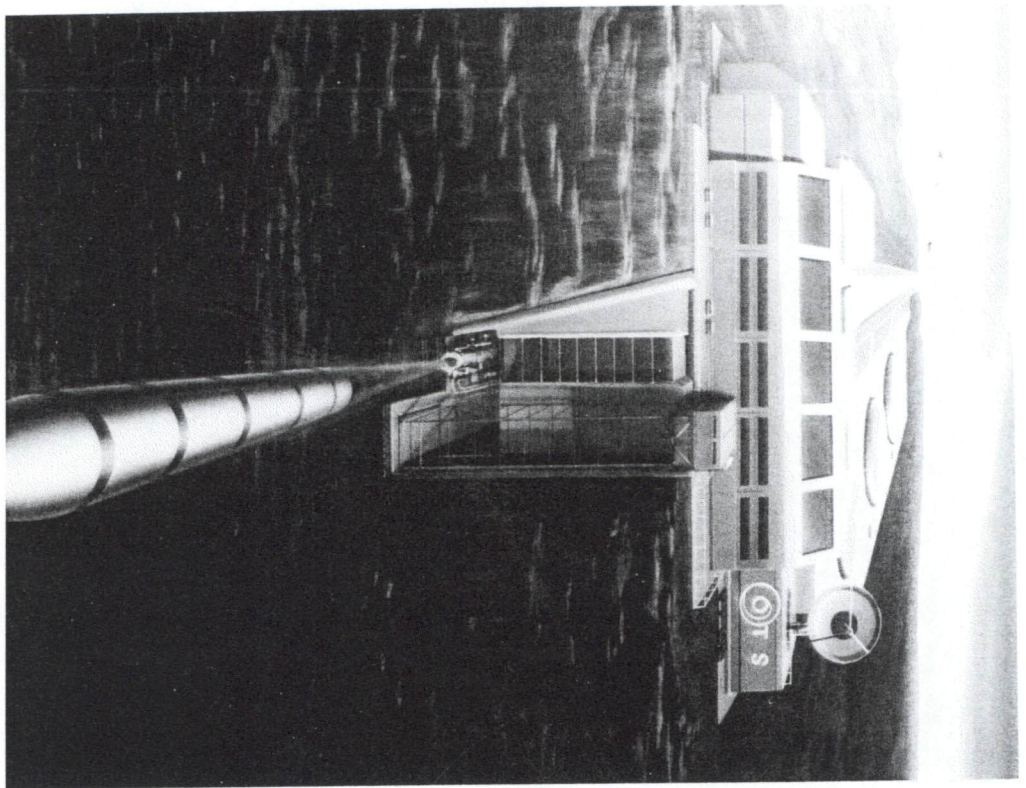
It is unfortunate that I should have to write you with this information and analysis which should be at the fingertips of your staff. If we were still a nation which valued the entrepreneur and the market as much as the bureaucrat and the status quo, then you would have a hundred such letters as this, and a dozen similar staff analyses.

Yours truly,

Jay Miller

P.S. Your proposal for a reduced tax burden for long term capital gains, for investors and businesses large & small, is an important contribution. Sidestepping the debate of whether you recently said "increased tax rates" or "increased tax revenues," I look forward to a successful reduction of the capital gains tax this year.

cc: Dan Quayle, Vice President
Samuel Skinner, Department of Transportation
Robert Mosbacher, Department of Commerce
Nicholas Brady, Treasury Department
James Watkins, Department of Energy
Richard Truly, National Aeronautics & Space Administration
Richard Cheney, Department of Defense
Ernest Hollings, Senate Commerce, Science & Trans. Committee
Robert Roe, House Space, Science & Technology Committee
Gary Hudson, Pacific American Launch Systems, Inc.
Bruce Roth, Orbital Transport Services, Inc.



Bush Library Photocopy
Preservation

Total development cost
 $\leq \$500$ million
Recurring cost
 $\leq \$100$ per pound
payload delivered to orbit
lifetime = 10,000 launches
Private sector concept
by Bruce Roth
OTS, Inc.

Single Stage To Orbit
Total development cost
 $\leq \$500$ million
Recurring costs
 $\leq \$250$ per pound delivered
to orbit (payload)
Lifetime = 500 flights

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120664

FROM: KNAUSS, John A.: NATIONAL OCEANIC & ATMOSPHERIC ADMINISTRATION

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 03/04/91

SUBJECT: AUTOGRAPHED COPY OF TOM VAN SANT'S PHOTO, "THE EARTH
FROM SPACE: A SATELLITE VIEW OF THE WORLD."

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED: -----

COPIES TO: D. Allan Bromley

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 03/07/91

FILE: ENVIRONMENT **SPACE**

*P-Physical Sciences-Space **

35703



92066-1
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
The Under Secretary
for Oceans and Atmosphere
Washington, D.C. 20230
202-877-3436

March 4, 1991

RECEIVED

To: D. Allan Bromley
Assistant to the President for
Science and Technology

91 MAR 7 12:08

From: John A. Knauss

OFFICE OF THE
DIRECTOR

Attached is an autographed copy of Tom Van Sant's photo, "The Earth from Space: A Satellite View of the World;" it is most interesting. I hope you enjoy it.

Attachment

The Van Sant
GeoSphere™

THE GEOSPHERE PROJECT

Earth scientists and educators face an unprecedented challenge in communicating the complex issues of global change and Earth resource management. The purpose of the GeoSphere Project is to make such issues understandable through visualization of global databases and models of the Earth.

THE INSTRUMENT

The GeoSphere is the first visually accurate, three-dimensional model of Earth. Because the surface of the sphere is composed of satellite imagery, the GeoSphere is a replica of the Earth as it appears when seen from space. The first GeoSphere prototype uses advanced computer technology to control rotation, lighting, audio, projection and informational programming. Interior fiber optics provide a view of city lights as seen from space. The GeoSphere is now being used for display and as a set for filming global issues.

THE IMAGE

The surface of the sphere is a composite of high resolution pictures taken by the NOAA TIROS satellites. These pictures, collectively termed the GeoSphere Image, comprise the first satellite view of the world. This task, requiring a one year effort, was completed on April 15, 1990 by Tom Van Sant, with technical direction by Lloyd Van Warren. Assistance was provided by Eyes on Earth, NOAA, NASA, Stardent Computer Corporation and the National Geographic Society:-

THE ATMOSPHERE

A transparent spherical shell, rotatable and removable, will enclose the GeoSphere. This will represent the Earth's atmosphere and is designed to receive projections of the "live" weather as transmitted by the Earth's weather satellites.

THE GLOBAL DATABASES

Global databases gathered from around the world are being co-registered with the GeoSphere Image to form an integrated global geographic information system. The first global visualization application of the GeoSphere project was embodied in the Nov. 21, 1990 nation-wide airing of "After the Warming", a two hour program hosted by James Burke, produced by Maryland Public Television. The GeoSphere Image and databases were used extensively in global animations, composites, database overlays, zooms and flight simulations. The subjects included geological history, oceanography, atmospheric, human migration and settlement, industrialization, energy production and use, food production and distribution, atmospheric pollution, deforestation, species depletion, and the issue of global warming.

THE EARTH SITUATION ROOM

An Earth Situation Room network is the ultimate manifestation of the GeoSphere Project. Such electronically linked facilities will constitute a global clearing house, research center, and software and hardware interface for dissemination of global change and Earth resource management visualizations. It also comprises a center for tracking and visualizing topical news events of global concern. The focal point of the Earth Situation Room is the computer-controlled Van Sant GeoSphere with the whole earth surface resolved to 1 km.

THE APPLICATIONS

The GeoSphere Image is being published internationally in magazines, text books, atlases and posters. Home and school globes surfaced with the GeoSphere Image will soon be available, accompanied by clear attachable "accessories" with videos and compact disks representing geopolitical, historic and global change subjects derived from the global databases. Six and a half foot diameter GeoSpheres are being prepared for newsroom displays, museum exhibits and other public venues.



The Geosphere Project Presentation

National Geographic Society, Washington, D.C.

July 23, 1990

GeoSphere Image Statistics

Data Origin:	NOAA TYROS-N series satellites, AVHRR sensors
Image Resolution:	8640 pixels wide by 4320 pixels high.
Geographic Resolution:	4.6 kilometers per equatorial pixel.
Number of Pixels:	37.3 million
Storage Space:	150 Megabytes
Planes of Color:	24 bits, 8 each in red, green and blue (true color)
Project Time:	10 months, approx. 2400 man hours
Project Cost:	\$600,000

The full resolution GeoSphere Image is 8,640 pixels wide and 4,320 pixels high for a total of 37.3 million true color pixels. Displaying the image at its full spatial resolution would require 338 standard broadcast television sets arranged in 26 stacks, each 13 sets high¹. Each pixel in the image represents a region 4.6 kilometers wide at the equator².

The cloud-free image was created from six whole earth mosaics plus dozens of separate satellite scenes. The five bands of satellite data were used as well as a rivers/continents database and three elevation databases. Each of the satellite mosaics was itself a full 8,640 x 4,320 resolution image. The satellite sensor contributed in two visual bands, and three thermal bands.

The input mosaics from which the GeoSphere Image was created required five months of software development and non-interactive mosaicking time, and five months of additional software development and interactive compositing time on a Stardent GS1000 Graphics Supercomputer equipped with 128 Megabytes of RAM memory, 3 Gigabytes of hard disk memory and a 1280 x 1024 pixel monitor. It would take 198 IBM personal computers to equal this amount of computer memory. Backing up the Stardent hard disk would require 4,286 MacIntosh double sided diskettes. Displaying the entire image simultaneously would require 32 Stardent monitors. However, the whole image would fit nicely on a single frame of IMAX[®] format film.

Tom Van Sant is the Executive Director of The GeoSphere Project and producer and compositor of the GeoSphere Image.

Van Warren is the Technical Director of the GeoSphere Image.

12

¹ Assuming 512 x 250 lines of effective NTSC resolution.

² The equatorial circumference of the earth is 40,076 km divided into 8,640 parts



Eyes on Earth

Tom Van Sant Inc., 146 Entrada Drive, Santa Monica, CA 90402 USA Phone: (213) 459-4342 Fax: (213) 459-8299

8299

Los Angeles Times

SECTION



SUNDAY

DECEMBER 9, 1990

Santa Monica Artist Uses Science to Build a Better World

■ **Technology:** Tom Van Sant and a team of scientists create a remarkably detailed image of the Earth as it appears from space. The result may revolutionize the globe industry.

By HOWARD BLUME
TIMES STAFF WRITER

The globe on your bookshelf was never like the GeoSphere.

Instead of man-imposed borders and artificially colored countries, there's a picture-perfect, remarkably detailed, cloudless image of the Earth's land masses and oceans, pretty much as they appear from space.

As the globe rotates, light from an artificial sun throws some continents into shadows or "night," and then tiny optic fibers wink on to mark the light show of

the world's major cities after dark.

The image is a complex mosaic of thousands of satellite photos pieced together by a team of artists, computer experts and scientists under the direction of Santa Monica artist Tom Van Sant. He financed the project first with a \$30,000 grant from the National Aeronautics and Space Administration, then by using the proceeds from the sale of his Los Feliz home, then by stretching his credit to the breaking point.

Computer-graphics experts from the Jet Propulsion Laboratory in Pasadena joined Van Sant's team, mostly in their spare time, to create the technology that made the image possible. Before they were finished, they had not only invented methods for Van Sant to correct color distortions in satellite pictures but also devised a program that permitted Van Sant to see through the clouds that perpetually blanket parts of the Earth.

The "globe" the team produced could revolutionize

the globe industry when it enters the market, as early as next year, says Jon Hultman, an executive with Replogle Globes Inc., an Illinois-based firm and major globe manufacturer. Hultman is negotiating distribution rights to Van Sant's creation, which may be the biggest thing in globes since the 1950s, when bumps were placed on them to symbolize mountain chains.

For Van Sant, the project is more than the realization of an artistic dream. It's a necessity, he says, a potential cure for mankind's predilection for failing to treat the Earth as a fragile, organism-like entity.

"The Earth is like a person," he says. "You might not appreciate how much you would be affected if something happened to a small part of you, like your big toe. But everything is connected, interrelated." An untreated infection in one small place could imperil the entire organism, he says.

Van Sant says the GeoSphere can make this point forcefully. GeoSphere technology can go beyond creat-

Please see **GLOBE**, J10

Continued from J1
ing what its makers call a "reality image" of the Earth. The technology has the potential to generate computer pictures of the Earth, past and future.

Such projections already exist in the form of tables and charts, the dialect of scientists. The purpose of a three-dimensional globe is to translate scientific data into a picture that can be understood by policy-makers and ordinary people.

"If the World Bank is deciding whether to support dam building or a deforestation project in the Amazon, they are not now able to see all the ramifications of this decision," Van Sant says.

Ultimately, GeoSphere technology will be able to project "what the Amazon region looked like in 1972, 1982, and show what it looks like in 1990," Van Sant says. "With risk projection, we can show what the rain forests will look like in 2010 given the same rate of deforestation."

"Earth-resource studies and Earth sciences are no longer territory for scientific inquiry alone," he says. "They are essential ingredients in the formation of public policy."

It makes perfect sense for an artist to be heading a scientific project with that goal, Van Sant says. "Artists are tremendously needed in the world of technology, to be able to take these issues and communicate them effectively." Besides, he says, "I'm comfortable with large things."

Van Sant has crossed between art and science before. In 1980, he placed sunlight-reflecting mirrors in the Mojave Desert to overexpose picture panels in a satellite passing overhead. The overexposure created what appeared to be a drawing of a giant eye, about 2.5 kilometers across, or 100,000 times the size of a human eye.

And, he's used a stream of electrons to etch a microscopic eye, 100,000 times smaller than normal, into the side of a salt crystal.

Van Sant, 59, has also produced more traditional art—paintings, murals and sculptures—all across Southern California. The former Marine and Korean War veteran has supported himself as an artist since earning a master's degree in fine arts in 1957 from the Otis Art Institute in Los Angeles.

Van Sant has accepted virtually no commissions, however, since March, 1989, when an eye infection after a cornea transplant nearly blinded him.

"The only thing that could save my eyes was the administration of five different antibiotics in my eyes every half-hour for 10 days," he recalls. "That's a treatment that made everyone crazy, even the nurses. I emptied my mind of all thought and resided there for 10 days. When that period was over, the GeoSphere made a choice on me. Nothing else would reside in my mind."



ANACLETO RAIPING / Los Angeles Times

Tom Van Sant and JPL scientists used thousands of satellite photos and innovative computer programs to assemble the GeoSphere.

But single-mindedness was no substitute for technical expertise. That's why Van Sant called JPL's Van Warren, who had put together a cruder computer-assisted Earth mosaic on his own.

"I always wanted to see the Earth as it looked from space," Warren says. "We pay so much attention to other planets, why not pay attention to our own planet? It is what affects us most of the time."

JPL agreed to release Warren for four months to work with Van Sant, who used his own money to purchase a \$200,000 advanced graphics computer. Overall, the artist, who lives in a Santa Monica garage apartment with his 8-year-old son, estimates that he's invested about \$350,000 in the project.

For months, the GeoSphere team labored in a dark, creaky, converted garage in Pasadena. Between them, Van Sant and Warren painstakingly pored over about five years of satellite data and aerial photography bought or borrowed from government storage facilities. The goal was to find at least one cloud-free satellite picture of every section of land and water.

From these, Van Sant could use Warren's computer program to assemble a single mosaic-style picture of the Earth.

Some areas, such as parts of the Amazon, the Congo and southern New Zealand, were always covered with clouds. Enter JPL's Jim Knighton, who had purchased charts and tables, originally compiled by the CIA, describing various rivers and coastlines. Even before he met Van Sant, Knighton, who has now become the project's technical director, had been using computer graphics to convert these data into picture form.

The image remained seriously flawed, however, because the colors—coded by scientists concerned with such topics as surface temperature and infrared radiation—were wrong. Heavily forested areas, for instance, typically came out red instead of green. Van Sant says they looked like raw meat.

Leo Blume, another computer-graphics consultant who then worked for JPL, designed a program to correct the colors.

At every turn, Van Sant had to move forward with the mosaic only after his technical team created a computer medium within which he could work. It was as if da Vinci had to keep the "Mona Lisa" on hold while his colleagues struggled to invent the paintbrush.

The image that emerged is not quite a photo, though it looks like one. Surface features in perpetually cloud-covered areas were traced in through computer graphics and colored as they would appear. Green areas were made a little greener, to compensate for natural factors that convert green to a dull brown when viewed from space. Other surface features, such as rivers, were enhanced to make them more visible.

The team says its computer image, finished in April, is one of the largest and most complex ever assembled. It contains well over 37 million pixels. Each pixel is an individually controlled dot of color that makes up part of the image. And every pixel had about 15 sets of data behind it.

"Because of its sheer enormity," Warren says, "I did feel at times like a bricklayer."

The resolution enables Van Sant to show any object on the surface that's four kilometers—about 4,400 yards—or larger, although a person might need a powerful magnifying glass to see it.

Next, Van Sant would like to try for a one-kilometer resolution, which would require four times the amount of information and render objects as small as airports distinguishable.

In Van Sant's computer, the Earth appears on a monitor and will turn or rotate on command. The computer program can zoom in on any designated geographic location, such as the Nile River. Van Sant eventually hopes JPL's Knighton can package this software for home computers.

Van Sant says an inexpensive home globe for families and classrooms is also just around the corner. Ideally, that globe would include a variety of snap-on accessories, to show political boundaries, for instance.

In the meantime, Van Sant has lined up vendors to sell poster versions of his GeoSphere image. Just in time, Van Sant says, noting he's come near the end of his savings and credit. "The universe is looking after us," he said.

On Assignment

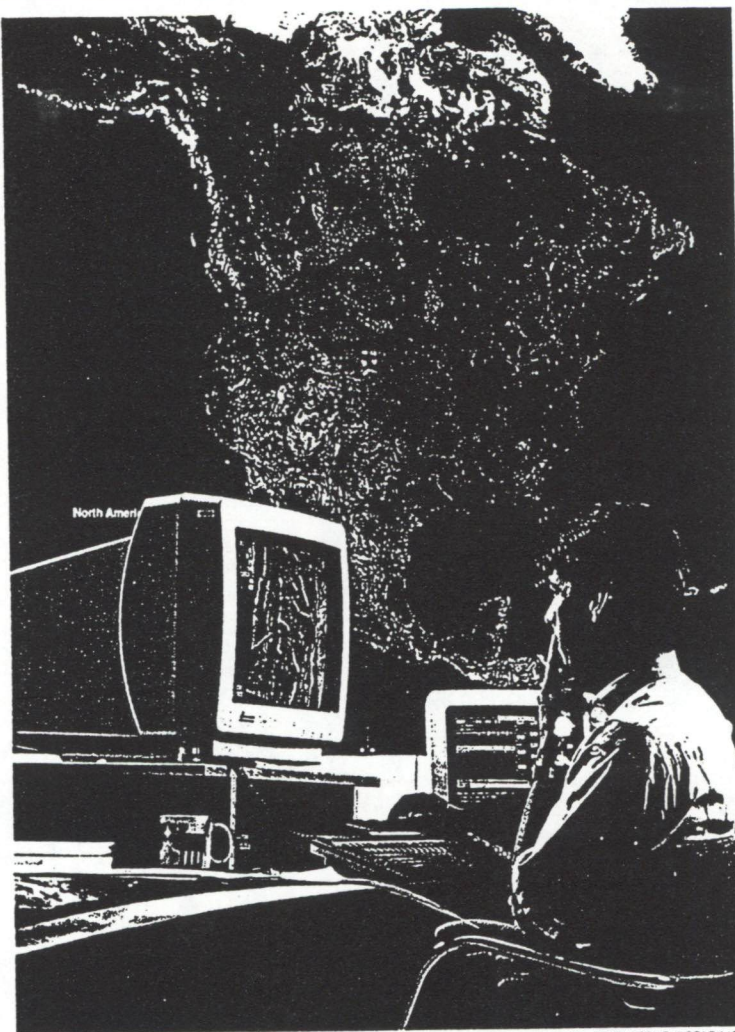
NATIONAL GEOGRAPHIC MAGAZINE

THERE'S HARDLY A CLOUD in the sky over North America after CHRIS CHIESA (right) selects 50 clear-weather satellite images of different regions to create the clearest ever mosaic of that continent for the new *National Geographic Atlas of the World*.

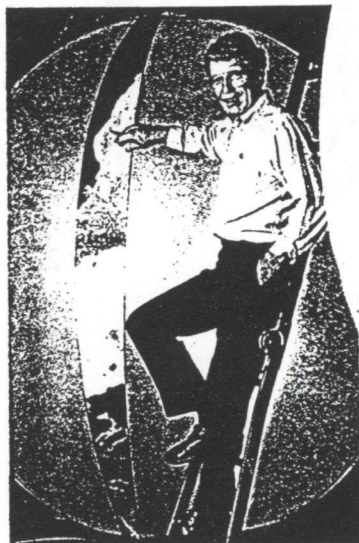
To produce this mosaic for the Society, Chris and his colleagues at the Environmental Research Institute of Michigan spent months writing software and reviewing hundreds of images recorded by NOAA weather satellites. Matching one swath of the continent to another for a single mosaic "was a lot like putting together a jigsaw puzzle," says Chris. Color variations were blended, leaving a seamless image rich in such details as land formations, settlement patterns, and vegetation (red). Each of the mosaic's 81 million picture elements, or pixels, represents one square kilometer of earth's surface.

Such high resolution makes for exciting science as well as vivid illustration. Concern about global issues of ozone depletion, deforestation, and climate change has galvanized science internationally. The U. S. alone plans to spend more than a billion dollars on earth-systems research next year.

Digital data bases are an essential tool in that effort. The seven



JOSEPH SOHM AND STEVE KELLER (BELOW LEFT); ANDREW SACKS, TONY STONE WORLDWIDE



continental mosaics assembled for the world atlas—a collaboration involving numerous private firms and government agencies here and abroad—form one such data base. National Geographic is helping to make the set available in computer-ready formats next year, at cost. For information, contact: Customer Services Section, Earth Resources Observation Systems Data Center, U. S. Geological Survey, Sioux Falls, SD 57198.

Changing people's perspective comes as naturally as running on wet sand to Santa Monica, California, artist TOM VAN SANT (left). Well-known for his public murals and sculpture, he now takes on projects of global proportions.

Also using satellite images, Tom and colleague Van Warren assembled a unique portrait of the planet (pages 127-9). It reveals colors so true to life and details so crisp that one can imagine zooming in to find a neighbor busy in the garden.

Here he applies earth's image, sectioned into 36 gores, to one of the fiberglass GeoSpheres he is designing. Surrounded by projectors in its own special "Earth Situation Room," the rotating GeoSphere will simulate global patterns—from weather and whale migrations to oil tanker routes. "The goal," he says, "is to change our consciousness from resource users to resource managers. There's no alternative."

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120607

FROM: STEPLER, Jack L.: LTV AEROSPACE AND DEFENSE COMPANY

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE:

SUBJECT: MICHAEL COLLINS LATEST BOOK, "MISSION TO MARS"

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS: Please note that the book has been signed by Mike Collins.

DATE RECEIVED: 03/01/91

FILE: SPACE

p-Physical Sciences -

THE WHITE HOUSE

WASHINGTON

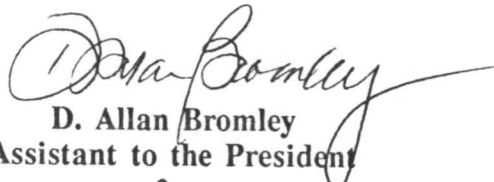
March 13, 1991

Dear Mr. Stempler:

Many thanks for sending me a copy of Mike Collins' new book **Mission to Mars**. This is not only an excellent book, but it is one that is of immediate use to me inasmuch as I am spending a significant amount of my time these days worrying about the space program.

Again, my thanks and all best wishes,

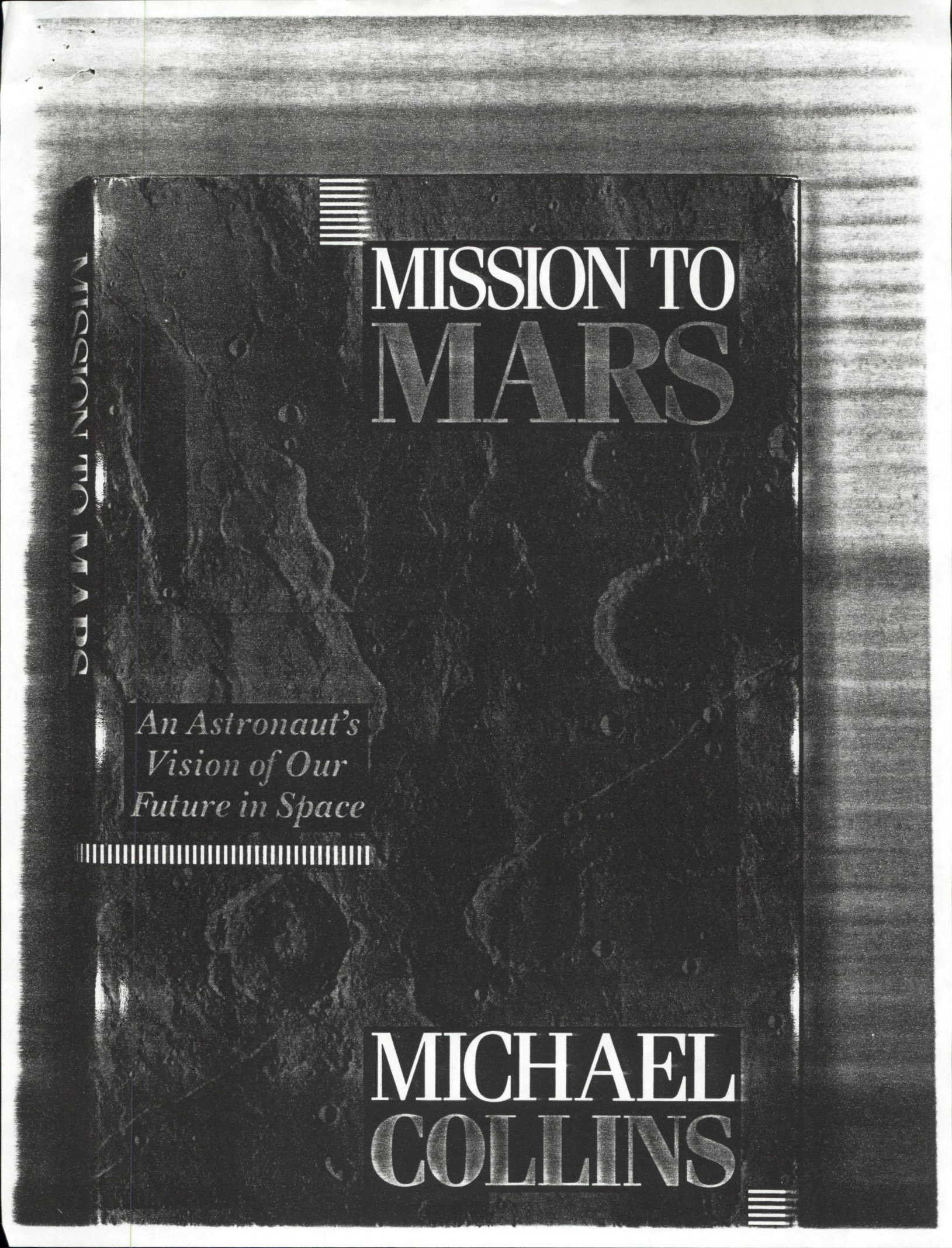
Sincerely yours,

A handwritten signature in dark ink, appearing to read "D. Allan Bromley", with a long, sweeping horizontal line extending to the right.

D. Allan Bromley
Assistant to the President
for
Science and Technology

Mr. Jack L. Stempler
Vice President, Washington Operations
LTV Aerospace and Defense Company
1725 Jefferson Davis Highway
Suite 900
Arlington, Virginia 22202

MISSION TO MARS



MISSION TO MARS

*An Astronaut's
Vision of Our
Future in Space*

MICHAEL COLLINS

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120524

FROM: DeGEORGE, Francis D.: DEPARTMENT OF COMMERCE

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 02/19/91

SUBJECT: REPORT, "NATIONAL STRATEGY FOR SATELLITE REMOTE
SENSING IS NEEDED".

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/25/91

FILE: SPACE

p-Physical Sciences -



9120524
UNITED STATES DEPARTMENT OF COMMERCE
The Inspector General
Washington, D.C. 20230

FEB 19 1991

RECEIVED

91 FEB 25 P 3:13

Honorable D. Allan Bromley
Assistant to the President for Science
and Technology
The White House
Washington, D.C. 20500

OFFICE OF THE
DIRECTOR

Dear Dr. Bromley:

Enclosed is our final report entitled "National Strategy for Satellite Remote Sensing is Needed." The report recommends that the Office of Management and Budget oversee a governmentwide study of environmental satellite programs. The crosscutting view provided by a governmentwide study would help identify opportunities for consolidating programs and avoid unwarranted duplication. Comments received on our September draft report from the Office of Management and Budget, the Department of Commerce, the National Aeronautics and Space Administration, and the Department of Defense indicated general concurrence with our position that a national strategy is needed.

We appreciate the cooperation provided to my staff during our review. If you have any questions, please call me on 377-4661.

Sincerely,

Francis D. DeGeorge

Enclosure

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120471

FROM: WELLIVER, A.D.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 02/11/91

SUBJECT: THE POSSIBLE RESTORATION OF THE AERONAUTICAL POLICY
REVIEW COMMITTEE.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong
Dr. Phillips

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/20/91

FILE: **AERONAUTICS**

p-Physical Sciences-Space

REPRODUCTION

RECEIVED

91 FEB 20 P 4: 24

OFFICE OF THE
DIRECTOR

February 11, 1991

BOEING

Dr. Alan Bromley
Science Advisor to the President
Office of Science & Technology Policy
Old Executive Office Building
Washington, D.C. 20506

Dear Dr. Bromley,

We are advised by AIAA that you intend to make a decision this month on possible restoration of the now-sunset Aeronautical Policy Review Committee. This letter is to express our interest and support for restoration of this committee.

Competition in both civil and military aeronautics is global and intense. Our competitors are trying new approaches to achieve parity and have stated a goal of dominating the market for aeronautical technologies and products. The previous Aeronautical Policy Review Committee provided the aeronautical community with a cohesive focus on important long-term goals and critical issues that transcended special interests. We believe the U.S. environment will be substantially strengthened with restoration of this body.

Sincerely,



A.D. Welliver

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120436

FROM: METTLER, RUBEN F.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 02/12/91

SUBJECT: THE ANNUAL SMITHSONIAN LECTURE ON SPACE

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/19/91

FILE: *p-Physical Sciences - Space*
SPACE POLICY



TRW Inc.

Ruben F. Mettler
One Space Park
Redondo Beach, CA 90278

9120436
RECEIVED

01 FEB 19 11:07

February 12, 1991

OFFICE OF THE
DIRECTOR

Dr. D. Allan Bromley
Special Assistant to the President
Office of Science and Technology Policy
17th and Pennsylvania Avenue, N.W.
Washington, D.C. 20506

Dear Allan:

Recently, I delivered the annual Smithsonian Lecture on Space. You may find the attached copy of interest.

On another subject - congratulations on your statement on research and development in the President's FY 1992 budget. It represents a significant step forward, even while leaving much yet to be done.

With best regards.

Sincerely,



Ruben F. Mettler

RFM/cmk

Enclosure

**NEW HORIZONS: AMERICAN SPACE POLICY IN A CHANGING
WORLD**

**Ruben F. Mettler
Retired Chairman and
Chief Executive Officer
TRW Inc.**

**Wernher von Braun Memorial Lecture
January 31, 1991
National Air and Space Museum
Smithsonian Institution
Washington, D.C.**

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120395

FROM: TRULY, RICHARD H.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 02/08/91

SUBJECT: ANNOUNCEMENT OF THE COMPETITION FOR THE SENIOR
EXECUTIVE SERVICE POSITION OF ASSOCIATE
ADMINISTRATOR FOR EXPLORATION.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: Alicia Dustira
D. Allan Bromley

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/13/91

FILE: *P-Physical Sciences-Space*
SPACE EXPLORATION

REDACTED

"CORRESPONDENCE TRACKING"

TYPE: ACTION

DOCUMENT NUMBER: 9120395

FROM: TRULY, RICHARD H.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 02/08/91

SUBJECT: ANNOUNCEMENT OF THE COMPETITION FOR THE SENIOR
EXECUTIVE SERVICE POSITION OF ASSOCIATE
ADMINISTRATOR FOR EXPLORATION.

ASSIGNED TO: D. Allan Bromley

ACTION REQUIRED: AS APPROPRIATE

SENDER'S DUE DATE: OSTP DUE DATE:

DATE COMPLETED: -----

COPIES TO:

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/13/91

FILE: SPACE EXPLORATION

*Send copies
to each AD
+ DAB*

*No further action
necessary so need
need for
pink*



National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

RECEIVED

91 FEB 13 AIO: 19

9120395
FEB 8 1991

The Honorable D. Allan Bromley
Assistant to the President
for Science and Technology and
Director, Office of Science and
Technology Policy
Executive Office of the President
Washington, DC 20506

OFFICE OF THE
DIRECTOR

Dear Dr. *Allan* Bromley:

The Report of the Advisory Committee on the Future of the U.S. Space Program suggested that NASA create an Office of Exploration. I have accepted that recommendation in the interest of providing a strong institutional capability for our implementation of the President's Space Exploration Initiative. Enclosed is the announcement of the competition for the Senior Executive Service position of Associate Administrator for Exploration. I would appreciate your making this announcement available to anyone whom you believe might be interested in the position.

Sincerely,

Richard H. Truly
Richard H. Truly
Administrator

Enclosure



National
Aeronautics and
Space
Administration

Senior Executive Service

Vacancy
Announcement

Washington, D.C.
20546

ISSUE DATE: February 13, 1991

CLOSING DATE: March 6, 1991

POSITION: Associate Administrator for Exploration

LOCATION: NASA Headquarters
Washington, DC

SALARY RANGE: \$87,000 - \$108,300

AREA OF CONSIDERATION: All Qualified Candidates

VACANCY ANNOUNCEMENT: HQA-005

DUTIES: The Associate Administrator for Exploration serves as the senior NASA official responsible for analysis, definition, implementation, and advocacy of preparatory mission activities for exploration of the solar system. The incumbent provides direction, integration, and oversight of NASA activities involving agency exploration goals, including program management, technical management, and fiscal management for all matters related to the office mission. Specific responsibilities include:

- Manage the study, selection, preparation for, and implementation of exploration architectures.

- Develop and present to the Administrator detailed plans, milestones, schedules, and financial resource requirements for the accomplishment of exploration objectives and activities. Responsible for establishing and allocating resources to meet approved objectives in accordance with delegated authority.

- Develop an advocacy for and advocate exploration objectives and activities in Administration, Congressional, international, and public forums.

- Participate with other NASA officials in developing overall NASA program objectives.

QUALIFICATION REQUIREMENTS: Candidates must demonstrate possession of responsible experience to perform the duties described above. Normally, this level of experience would have been gained at or above the GS-15 level or its equivalent. Candidates must demonstrate experience in the following managerial and technical areas.

MANAGERIAL QUALIFICATIONS:

1. Integration of Internal and External Program/Policy Issues -- This involves ensuring key national and agency-wide goals, priorities, values, and other issues are considered in making program decisions.
2. Organizational Representation and Liaison -- This focuses upon the external communications aspects of executive positions, including being a representative for the work unit and/or organization and coordinating with other work units and organizations.
3. Direction and Guidance of Programs, Projects, or Policy Development -- This involves activities related to establishing program-policy goals and the structure and processes necessary to carry them out.
4. Acquisition and Administration of Financial and Material Resources -- This concerns activities and procedures related to obtaining and allocating the financial and material resources necessary to support program and policy implementation.
5. Utilization of Human Resources -- This involves activities and processes for ensuring that people are appropriately employed, effectively and efficiently utilized, developed, and dealt with in a fair and equitable manner.
6. Review of Implementation and Results -- This involves activities and procedures for seeing that programs and policies are being implemented, adjusted as necessary, and that the appropriate results are being achieved.

TECHNICAL QUALIFICATIONS:

1. Formal education in an appropriate field of engineering, physical science, or mathematics at or above the bachelor degree level.
2. Comprehensive knowledge of, and demonstrated experience in the theories, principles, practices, and techniques of managing and directing multi-disciplinary scientific and technical programs engaged in space flight.
3. Detailed knowledge and demonstrated experience in the development of long range strategies within a governmental process.

4. Knowledge of, and demonstrated experience in, the planning and implementation of advanced studies to define key prerequisites in the areas of technology, life science research, robotic precursor missions, and Earth-to-Orbit transportation capabilities in order to accomplish human exploration programs.

5. Experience in effectively communicating program information, facts, research results, and recommendations in clear, concise, and logical terms to top executive level management, national and international technical/scientific organizations, external advisory groups, and congressional bodies.

EVALUATION METHOD: Applicants will be evaluated by an Executive Resources Panel based on the managerial and technical qualification requirements stated in this announcement and eligible candidates will be placed in qualified and highly qualified categories. Interviews and qualification and suitability inquiries may be requested. The highly qualified will be referred to the appropriate official who will recommend selections.

NASA is an equal opportunity employer, and all applicants will be considered with regard to race, color, religion, sex, national origin, political affiliation, marital status, physical handicap, membership in an employee organization, or other non-merit reason.

This announcement is for a career appointment to a position in the NASA Senior Executive Service (SES). Persons entering the SES for the first time are subject to a one-year probationary period. A financial disclosure statement will be used to avoid conflicting situations in employment through advice and counseling.

HOW TO APPLY: Applicants must submit a Standard Form 171 (available at Federal Personnel Offices or Federal Job Information Centers). In addition, the applicant must submit a brief summary which describes the relationship of the applicant's experience, knowledge, skill, and ability to each of the managerial and technical qualification requirements stated above (this should include examples to show level of accomplishment and degree of responsibility). Names and current addresses of responsible management officials who have knowledge of your background must be provided so that performance vouchers may be obtained, if necessary.

To ensure consideration, applications should be received by March 6, 1991, and are to be sent to: NASA Headquarters, DP/Bonnie Acoven, 400 Maryland Avenue, SW, Washington, DC 20546. For additional information contact Ms. Acoven on (202) 453-8478.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120321

FROM: MEREDITH, LES

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 01/30/91

SUBJECT: AGU'S REVIEW OF THE REPORT OF THE ADVISORY COMMITTEE
ON THE FUTURE OF THE U.S. SPACE PROGRAM.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Dr. Wong

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 02/01/91

FILE: SPACE

p-physical Sciences-Space



9120321
American Geophysical Union

RECEIVED

2000 Florida Avenue, N.W.
Washington, D.C. 20009
Phone (202) 462-6900
TWX 710-822-9300
FAX 202-328-0566

91 FEB 1 P 4:10

OFFICE OF THE
DIRECTOR

January 30, 1991

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Old Executive Office Building
17th Street and Pennsylvania Ave., N.W.
Washington, D.C. 20506

Dear Dr. Bromley:

AGU has reviewed the Report of the Advisory Committee on the Future of the U.S. Space Program at the request of the House Committee on Science, Space, and Technology. Our views on this potentially important document are being forwarded for your information. Please let me know if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Les Meredith".

Les Meredith

LHM:djs

Enclosure

Statement for the
House Committee on Science, Space, and Technology

Submitted by A. F. Spilhaus, Jr. on behalf of the
American Geophysical Union

Review of the Report of the Advisory Committee on the Future of the U.S. Space Program.

In this statement we address the recommendations in the Report of the Advisory Committee on the Future of the U.S. Space Program, chaired by Augustine, that relate specifically to the NASA science program. As an organization composed entirely of research scientists, this is the area in which we are expert. We prefer to leave non-scientific aspects of the program, i.e. management, engineering and technology, to others.

The recommendations in the full report that directly relate to the NASA science program are numbers 1, 2, 3, 4, and 6. Our comments on each of these five recommendations follows.

Recommendation 1: "That the civil space science program should have first priority for NASA resources, and continue to be funded at approximately the same percentage of the NASA budget as at present (about 20 percent)."

The scientific results of the space program have contributed enormously to our understanding of Earth, of our environment in space, and of the nature of the universe in which we live. Studies of the internal structure of the Earth have been driven by magnetic, geodetic and imaging missions. Our ability to gain a synoptic picture of the global properties of the ocean and atmosphere is essential to unlocking what the future holds for man on the planet. Studies of the properties of interplanetary space, the history of the Moon and planets, the structure of solar flares, the evolution of stars, and the origin of the universe all contribute materially to our understanding of Earth and to our ability to live here and ultimately to roam in and use the space around us. The record of accomplishment and the new windows it has opened fully justify making NASA's science program of highest priority in the Agency. Space science should continue to receive at least 20% of the NASA budget.

Recommendation 2: "That, with respect to program content, the existing strategic plan for science and applications research proposed by NASA with input from the science community be funded and executed."

While the existing strategic plan fits the existing scientific imperatives, it is important to recognize that scientific and technological advances in the future will demand revisiting this plan on a regular basis. This need for flexibility is, in fact, reflected in the next Recommendation of the report.

Recommendation 3: "That the multi-decade set of projects known as Mission to Planet Earth be conducted as a continually evolving program rather than as a mission whose design is frozen in time. A combination of different size spacecraft appears to be most appropriate to meet the needs of simultaneity, accuracy, continuity and robustness...."

We strongly support a Mission to Planet Earth as a major objective of NASA. The importance to this program, which we have already stressed in other forums, of the Earth probes, international cooperation, data continuity, having satellites in multiple orbits, and having continuing programmatic flexibility are all mentioned in the report. These properties of the program are not just niceties but are absolutely required if the program is going to meet its scientific objectives.

Also needed is the ready availability to Mission to Planet Earth of data from Landsat and NOAA environmental satellites. These data are needed for studying problems ranging from mineral location, through climate change and the protective ozone shield, to our variable space radiation environment. If a commercial entity is given responsibility for such satellites then the question of the availability and cost to the research community of the data needs to be addressed.

The specific objectives of Mission to Planet Earth are unclear from the Augustine Report. We believe that it should be aimed at understanding Earth as a global system, as recommended by the National Academy of Sciences report, Space Science in the Twenty-First Century: Imperatives for the Decades 1995 to 2015, and not be limited to global climate change. The scope of Mission to Planet Earth is a fundamental issue that needs resolution.

In our testimony on the NASA budget last year we supported the EOS program as an addition to the space science program. The recommendation in the Augustine report to make Mission to Planet Earth, of which EOS is the major part, separately funded from the space science program is fully consistent with our position and we strongly endorse it.

Recommendation 4: "That the Mission from Planet Earth be established with the long-term goal of human exploration of Mars, underpinned by an effort to produce significant advances in space transportation and space life sciences."

While Mission from Planet Earth might be justified on the basis of man's exploration of new frontiers, the program has not been well enough defined to make possible a meaningful scientific assessment. We think that such an assessment is needed and have set up a committee to do so as soon as sufficient definition is available. My personal opinion is that the massive costs may well doom Mission from Planet Earth to a fate similar to that of the current space station program.

Recommendation 6: "That NASA, in concert with its international partners, reconfigure and reschedule the Space Station Freedom with only two missions in mind: first, life sciences experimentation (including the accrual of operational experience on very long duration human activities in space) and, second, microgravity research and applications...."

We do not believe that the space station can be justified on the basis of science related to understanding Earth better, AGU's area of expertise. We are very pleased that the Augustine report not only supports our position but broadens it to all areas of physical space science. We, of course, strongly support this conclusion. The justification they present for a modified space station, however, is far from clear to me. I believe it needs quantification and further study to determine whether the proposed space station levels of expenditure will provide an appropriate return.

I appreciate very much this opportunity to delineate for you how the recommendations in the Augustine Report fit with the long-term direction that we would like to see for Earth and space science. In the areas of our expertise, we generally support the directions they've set and commend all the participants.

A. F. Spilhaus, Jr.
January 24, 1991

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120289

FROM: DUPREE, ANDREA K.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 01/24/92

SUBJECT: THANK YOU FOR ADDRESSING THE AMERICAN ASTRONOMICAL
SOCIETY'S 177TH MEETING

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Steve Olson
Thomas Ratchford

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 01/28/91

FILE: *p-Physical Science-Space*
~~THANK YOU-ASTRONOMY/ED~~

CONFIDENTIAL

9120289



Harvard-Smithsonian Center for Astrophysics

60 Garden Street, Cambridge, MA 02138

(617) 495-7000
Telex # 921428



January 24, 1991

Dr. D. Allan Bromley
Science Advisor to the President
The White House
Washington, D.C. 20501

Dear Dr. Bromley:

On behalf of the American Astronomical Society, I thank you for coming to Philadelphia to address our 177th Meeting last week.

Your remarks about priorities in astronomy, and the role of science education were particularly well-received. We especially appreciate your willingness to field questions and remain for some discussion afterwards.

Contemporary astronomy and astrophysics remain one of the most challenging and exciting fields of scientific endeavor. I know that our members want to contribute their capabilities and enthusiasm to increase the technical capabilities and scientific interest in our country.

It was a pleasure to meet you.

Sincerely,

Andrea K. Dupree
Chairman, Committee on
Astronomy and Public Policy

DIRECTOR
OFFICE OF THE

91 JAN 28 PM 12:51

RECEIVED

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120247

FROM: TENNANT, SAMUEL M.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 01/21/91

SUBJECT: TRUSTEES ELECTED AT THE DECEMBER 8, 1990 AEROSPACE
CORPORATION BOARD OF TRUSTEES MEETING.

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Michelle Van Cleave

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 01/24/91

FILE: *p-Physical Sciences-Space*
BROMLEY-ELECTION OF TRUSTEE

CONFIDENTIAL - SECURITY INFORMATION

9120247

THE AEROSPACE CORPORATION



Post Office Box 92957, Los Angeles, California 90009-2957, Telephone: (213) 336-5872

Samuel M. Tennant
President
and
Chief Executive Officer

January 21, 1991

Dr. D. Allan Bromley
Science Advisor to the President & Director
Office of Science and Technology Policy
Old Executive Office Building
Washington, DC 20506

Dear Dr. Bromley:

I am pleased to inform you that The Aerospace Corporation Board of Trustees elected the following Trustees at its December 8, 1990 meeting: The Honorable John N. Erlenborn; Dr. George E. R. Kinnear II; Jeffrey H. Smith, Esq.; and Dr. Albert D. Wheelon. In addition, General Russell E. Dougherty has returned as a Board member after the required one year absence. In other changes affecting the Board of Trustees, Mr. Jack Edwards, Mr. Togo D. West, Jr., and Dr. Lew Allen, Jr. have resigned.

At its meeting, the Board also elected Dr. Rodney C. Gibson a Vice President, replacing Jerome L. Wittels who retired.

Sincerely,

Samuel M. Tennant

RECEIVED

JAN 24 P 3 37

OFFICE OF
DIRECTOR

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120111

FROM: TRULY, RICHARD

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 01/14/91

SUBJECT: COBE AND ASTRO-1 MISSION DISCOVERIES

ASSIGNED TO: D. Allan Bromley

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO:

WHITE HOUSE TRACKING #:

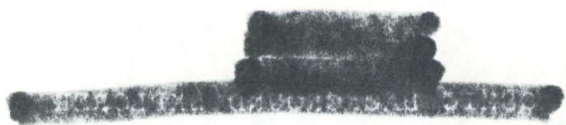
CONTACT PERSON:

REMARKS:

DATE RECEIVED: 01/22/91

FILE: COSMIC BACKGROUND EXPLORER

P-Physical Sciences - Space





National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JAN 14 1991

Honorable D. Allan Bromley
Assistant to the President
for Science and Technology and
Director, Office of Science and
Technology Policy
Executive Office of the President
Washington, DC 20506

Dear Dr. *Allan* Bromley:

I thought you would be interested in a preview of the latest discoveries made by the Cosmic Background Explorer (COBE) and Astro-1 missions as captured in the enclosed images and summarized in the accompanying captions and news release. The COBE science discoveries were made public on Monday, January 14, 1991.

Both COBE and Astro-1 will be highlighted this week, along with the Hubble Space Telescope (HST) and Roentgen Satellite (ROSAT), at the annual meeting of the American Astronomical Society (AAS) in Philadelphia. I was very impressed by these results and thought you would appreciate an advanced copy of the images in light of your scheduled talk at the AAS meeting.

Sincerely,

Richard H. Truly
Richard H. Truly
Administrator

Enclosures

RECEIVED
91 JAN 22 11:04
DIRECTOR

NASA News

National Aeronautics and
Space Administration

Washington, D.C. 20546
AC 202 453-8400

Paula Cleggett-Haleim
Headquarters, Washington, D.C.
(Phone: 202/453-1549)

For Release

January 14, 1991
Noon

Randee Exler
Goddard Space Flight Center, Md.
(Phone: 301/286-7277)

RELEASE: 91-6

COBE MAPS INTERSTELLAR MATERIAL IN MILKY WAY GALAXY

For the first time, astronomers have mapped the distribution of nitrogen throughout our galaxy. The new observations were taken by an instrument on NASA's Cosmic Background Explorer, the Far Infrared Absolute Spectrophotometer.

This all-sky survey, along with additional maps of carbon and dust, provides quantitative information that may enable scientists to understand better the heating and cooling processes that take place throughout the Milky Way. These accomplishments were reported today at the American Astronomical Society meeting in Philadelphia by members of the COBE science team.

COBE scientists presented images that show the locations in the galaxy of ionized nitrogen. The nitrogen map of the Milky Way is at the wavelength of 205 micrometers and is the first detection of this important spectral line. The carbon map was produced at 158 micrometers and the dust map at 205 micrometer wavelengths.

"Before COBE, it was not possible to map the whole galaxy in this way, although these atomic emissions are the dominant way in which the interstellar gas cools," said COBE Project Scientist Dr. John C. Mather, who added that COBE's unique capabilities permit these all-sky measurements unencumbered by atmospheric and instrument emission. Five months of data were used to produce the maps.

- more -

The data were analyzed at the Goddard Space Flight Center. The scientific team includes members at Massachusetts Institute of Technology, Cambridge, Mass.; General Research Corp., Danvers, Mass.; Princeton University, N.J.; University of California at Los Angeles, and the Jet Propulsion Laboratory, Pasadena, Calif., as well as the Goddard Space Flight Center. Scientists at General Sciences Corp., Laurel, Md., Applied Research Corp., Landover, Md.; Universities Space Research Association, Greenbelt, Md., and Systems Technologies Corp., Lanham, Md., support the reduction and analysis of the data.

This research is supported by NASA's Astrophysics Division of the Office of Space Science and Applications.

- end -

NASA news releases and other NASA information are available electronically on CompuServe and GENie, the General Electric Network for Information Exchange. For information on CompuServe, call 1-800-848-8199 and ask for representative 176. For information on GENie, call 1-800-638-9636.

"CORRESPONDENCE TRACKING"

TYPE: INFORMATION

DOCUMENT NUMBER: 9120091

FROM: WELDON, VIRGINIA V.

TO: DR. BROMLEY

DATE OF
CORRESPONDENCE: 01/07/91

SUBJECT: COMMENTS ON SYNOPSIS OF SPEECH AT THE NASA
CONFERENCE

ASSIGNED TO:

ACTION REQUIRED:

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO: D. Allan Bromley
Nancy Maynard
Dr. Phillips

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 01/17/91

FILE: *Space*
BROMLEY

P- Physical Sciences - Space



Monsanto

VIRGINIA V. WELDON, M.D.
Vice President
Public Policy

Monsanto Company
800 N. Lindbergh Boulevard
St. Louis, Missouri 63167
Phone: (314) 694-3901

January 7, 1991

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology, and
Director, OSTP
Old Executive Office Building, Room 358
17th Street & Pennsylvania Avenue, NW
Washington, DC 20506

Dear Allan:

It was with great interest that I read a synopsis of your speech at a conference sponsored by the National Aeronautics and Space Administration in which you outlined President Bush's initiatives for helping U.S. businesses stay competitive. Basic to commercializing any new technology is a sound, credible, scientifically based regulatory system. The Administration's commitment to funding basic research in our universities has created a foundation for technological development second to none in the biological sciences.

American industry will be hamstrung if we cannot bring our products to market in this country. This does not mean, however, a regulatory system which is either lenient or sacrifices a quality review to expedite regulatory oversight.

In the area of biotechnology it is essential that the scoping documents for regulation of biotechnology products be published by the relevant agencies, and that there be timely publication of these documents so that the regulatory road map is clear to all.

I hope you had a wonderful holiday season and my best wishes for the new year.

Sincerely,

Virginia

9120091

"CORRESPONDENCE TRACKING"

TYPE: ACTION

DOCUMENT NUMBER: 9120225

FROM: STONE, EDWARD C.

TO: DR.J BROMLEY

DATE OF
CORRESPONDENCE: 01/03/91

SUBJECT: FIRST LIGHT IMAGE ON THE KECK TELESCOPE

ASSIGNED TO: D. Allan Bromley

ACTION REQUIRED: AS NECESSARY

SENDER'S DUE DATE:

OSTP DUE DATE:

DATE COMPLETED:

COPIES TO:

WHITE HOUSE TRACKING #:

CONTACT PERSON:

REMARKS:

DATE RECEIVED: 01/19/91

FILE: **ASTRONOMY**

Physical Sciences - Space

THE WHITE HOUSE

WASHINGTON

February 22, 1991

Dear Ed:

Congratulations on achieving first light on the Keck Telescope! This marks a very major achievement and I would ask that you pass on my congratulations to all those involved in a major step forward in the development of astronomical instrumentation.

I thoroughly enjoyed my visit to Mauna Kea and its observatories and deeply appreciate your spending the entire day showing me around. I must say that the day gave me a totally new understanding of what is available in the way of instrumentation for modern astronomy, both optical and infrared, and quite apart from all of that, the view from the mountain top is absolutely spectacular!

I too am sorry that I am unable to be at CalTech on March 22 to speak to the EUREKA Conference, but it turns out that it may just be possible that I will be at CalTech on June 14 at this year's commencement, and if so, I would certainly like to take you up on your offer visit JPL.

With warmest best wishes,

Sincerely yours,



D. Allan Bromley
Assistant to the President
for
Science and Technology

Professor Edward C. Stone
Chairman
California Association for Research
in Astronomy
1201 East California Boulevard
Pasadena, California 91125

9120225

California Association for Research in Astronomy

Edward C. Stone
Chairman



January 3, 1991

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology Policy
Old Executive Office Building, Room 360
Office of Science and Technology Policy
Washington, D.C. 20500

Dear Allan:

One week after your recent visit to Mauna Kea and the Keck Observatory, we achieved first light on the Keck Telescope. On behalf of the California Association for Research in Astronomy, or CARA, as the partnership between Caltech and the University of California is called, I am pleased to send you a copy of the first light image of the spiral galaxy NGC 1232.

CARA was formed by Caltech and the University of California to build and operate the Keck Observatory. A \$70M grant to Caltech from the W. M. Keck Foundation provided major funding for the \$94M project; UC will provide the annual operating costs of approximately \$4M and is funding development of the optical spectrometers and infrared cameras.

The first light image demonstrates that the innovative segmented-mirror technology used on the Keck Telescope works; a computer actively controls the positions of the nine segments to ≤ 25 nm rms, so that the separate images are accurately merged into one. Although only one-quarter of the thirty-six hexagonal segments comprising the 10-meter mirror had been installed, it was already equal in size to the world's largest effective optical telescope, the 200-inch Hale Telescope at Caltech's Palomar Observatory.

With the installation of all thirty-six segments during 1991, the 10-meter Keck Telescope will allow UC and Caltech astronomers to undertake unequaled spectroscopic studies of galaxies as they were three billion years after the Big Bang. University of Hawaii astronomers will also receive observing time in exchange for providing the excellent site on Mauna Kea.

Dr. D. Allan Bromley
January 3, 1991
Page 2

As I mentioned to you in Hawaii, we would like to build a second Keck Telescope 85 meters from the first. This would allow the development of infrared and optical interferometry for faint sources and would increase the light collecting power of the Keck Observatory so that galaxies in the first one to two billion years after the Big Bang could be studied.

I have had several discussions with the Keck Foundation about major funding for a second telescope, and Len Fisk has indicated his interest in NASA's participation in the Keck Observatory. In exchange for one-sixth the cost of the dual observatory, NASA would have access to one-sixth of the observing time on the two telescopes for use by the national astronomy community in support of both current and future space astronomy missions.

With the first light image demonstrating the feasibility of the segmented mirror technology, the prospects for a second telescope appear bright and I'm sure that Len Fisk would be pleased to discuss NASA's participation with you. I think you will agree that the opportunity for a three-way collaboration among NASA and two of the nation's leading universities, one private and one public, is particularly attractive. If you would like more information about the Keck Observatory, please give me a call at (818) 354-3405.

Finally, I understand from Tom Tombrello that you are unable to be at Caltech on March 22, 1991, to speak to the EUREKA Conference. Since you mentioned that you hadn't been to the Jet Propulsion Laboratory recently, as the new director I would have liked to invite you to visit while in Pasadena. I know that Tom Everhart was looking forward to showing you around the Caltech Campus as well. We would have no problem keeping your interest fully engaged for at least a couple of days, so please let us know what your schedule allows.

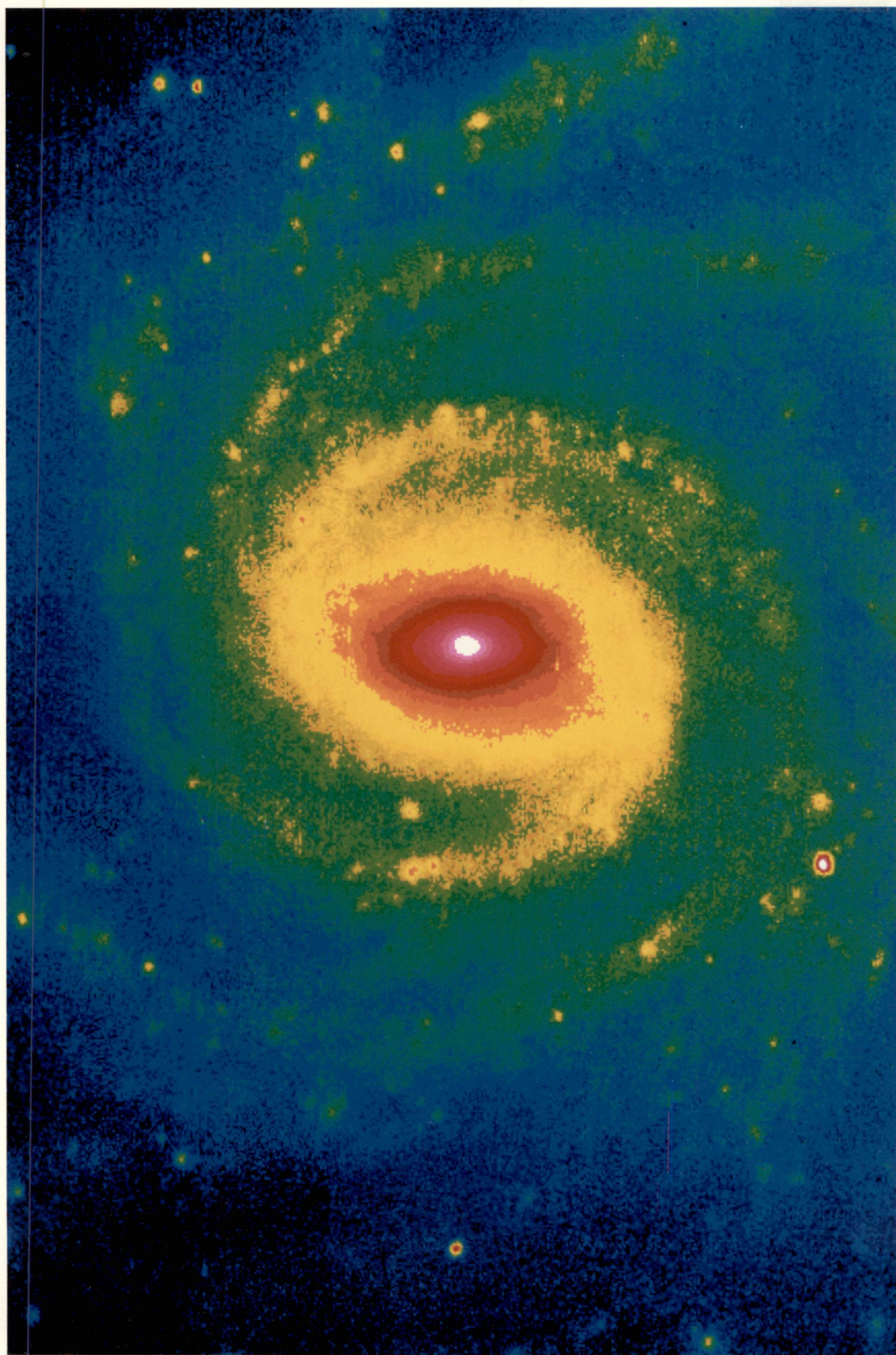
With best wishes for the New Year and looking forward to seeing you some time in the very near future.

Sincerely,



Edward C. Stone

Copies: Dr. Thomas E. Everhart, President, Caltech
Dr. Lennard A. Fisk, Associate Administrator, NASA



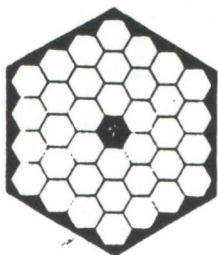


PHOTO CAPTION

Dec. 4, 1990

K-1 Color

The first celestial photograph taken with the partially completed Keck Telescope in Hawaii is a mosaic of four successive exposures of the galaxy NGC 1232, also known as Arp 41. The images were taken the night of Nov. 24, 1990, using nine of the telescope's eventual 36 mirrors. With nine mirrors, the light-collecting area of the Keck Telescope equals that of the famed 200-inch Hale Telescope at the Palomar Observatory. When completed in late 1991, the Keck Telescope will be the world's largest with a mirror 33 feet (10 meters) in diameter.

This color-enhanced photograph displays more detail than possible with the black and white version. Blue represents the faintest regions, while white represents the brightest region of the galaxy.

NGC 1232 is a normal spiral galaxy (Type Sc), which may be similar to our own Milky Way. It is located in the constellation Eridanus ("The River"). NGC 1232 is approximately 65 million light years away (a light year is 5.88 trillion miles). The visible diameter of NGC 1232 is about 100,000 light years. Bright spots in the spiral arms are compact star-forming regions. The images that make up this mosaic were obtained with a charge-coupled device (CCD) engineering test camera located at the telescope's prime focus.

The Keck Telescope is housed in the W.M. Keck Observatory on Mauna Kea on the Big Island of Hawaii. The telescope and observatory are being built and will be operated by the California Association for Research in Astronomy (CARA), a partnership of the California Institute of Technology and the University of California.

[PHOTO CREDIT: California Association for Research in Astronomy/CARA]

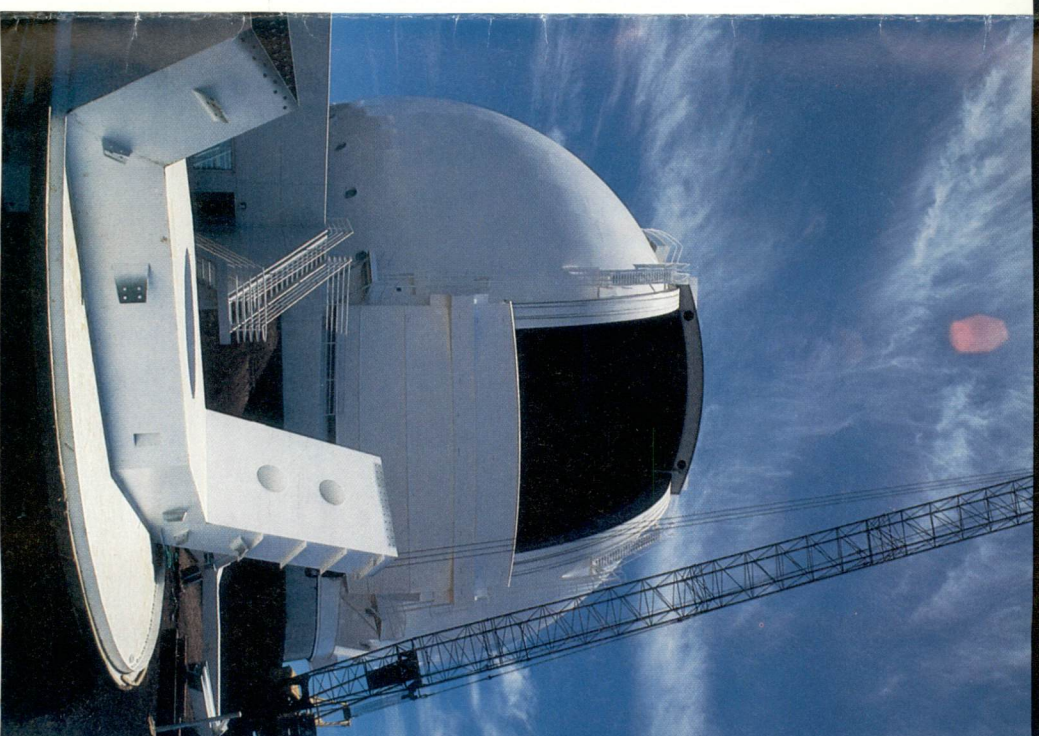
W. M. KECK OBSERVATORY

Like buried treasures, the outposts of the universe have beckoned to the adventurous from immemorial times.

—George Ellery Hale, 1868-1938

W.M. Keck Telescope data

Observatory location	Mauna Kea, Hawaii
Headquarters location	Kamuela, Hawaii
Owners and operators	California Institute of Technology and the University of California California Association for Research in Astronomy
Project management	Research in Astronomy W.M. Keck Foundation
Major Donor	
Primary mirror design	Segmented
Number of segments	36
Segment shape	Hexagonal
Segment diameter	1.8 meters (6 feet)
Segment thickness	75 millimeters (3 inches)
Segment weight	880 pounds
Segment material	Zerodur™ (low-expansion glass-ceramic)
Primary mirror diameter	10 meters (33 feet)
Light-collecting area	76 square meters (818 square feet)
Mirror curvature	f/1.75 hyperbolic mirror
Focal length	17.5 meters (57.4 feet)
Total weight of glass	14.4 metric tons (15.9 tons)
Telescope mount	Altitude-Azimuth
Overall telescope height	24.6 meters (80.7 feet)
Total moving weight	270 metric tons (298 tons) (includes mirrors)
Dome height	30.8 meters (101 feet)
Dome width	37 meters (121.4 feet)
Total moving weight	635 metric tons (700 tons)
Scientific instruments	Long wavelength infrared camera (8—24 μ) Near infrared camera (1—5 μ) Low resolution imaging spectrograph (3800Å—1 μ) High resolution spectrograph (3100Å—1 μ)



A scientific partnership between the California Institute of Technology and the University of California



The World's Largest Telescope

Reaching the outposts of the universe requires both the intellect of an Einstein and the mettle of an Indiana Jones. Those qualities unite in the design of the Keck Telescope, which will soon lead us on the most adventurous exploration of the universe yet. Slated for completion in 1991, the Keck Telescope will combine 36 hexagonal segments into a mirror array with four times the light-gathering power of the 200-inch Hale Telescope of Palomar Observatory.

From its earthly outpost atop an inactive volcano, the Keck Telescope will take us on a treasure hunt for the origin of the universe, let us probe distant reaches of space with unprecedented power and precision, and open our eyes to new celestial vistas. In reaching for the universe's outposts, the Keck Telescope also will help us reach a deeper understanding of our relationship to the cosmos. (Photo by JPL Photographers Group)

celestial images is limited only by the natural properties of the earth's atmosphere. All activities related to telescope operation, scientific data analysis, and technical support are located in a building adjoining the dome so they do not affect the dome's thermal environment.

Observatory and Dome

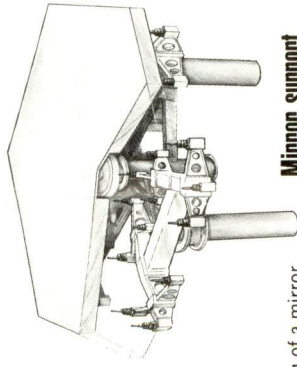
To take full advantage of sharp images obtainable from Mauna Kea, the observatory building and dome were constructed in a way that causes as little change in local environment as possible.

Astronomers have noted in recent years even small sources of heat within a dome can seriously degrade the images a telescope receives. Most people have examples of this effect in the distortions caused by hot air rising from a roadway or a barbecue grill, for example.

For the W.M. Keck Observatory, every effort was made to remove from the site all sources of heat that the quality of the

ing mountaintop. The dome's interior walls are insulated and covered with a paint chosen for its special thermal properties to minimize heating of the dome interior during the day. In addition, huge fans can replace the entire volume of air inside the dome a dozen times an hour, keeping the inside and outside temperatures as nearly equal as possible.

The observatory building adjoining the dome is surrounded with a berm of volcanic cinders, effectively



A cutaway drawing of a mirror segment shows the underlying support system.

Mirror support

Mounting the hexagonal mirror segments in the telescope involves two sets of devices, called "whiffletrees" and "flex disks." These supports keep the 880-pound mirror segments rigidly mounted against sideways motions while allowing them to be moved for alignment of the mirror array.

Working in tandem, the whiffletrees and flex disks effectively "float" the segments as if there were no gravity, absorbing strains that would otherwise deform the thin glass segments. One system is stiff where the other is pliant; together they share the load for any orientation of the telescope.

city lights, usually free of clouds, and above most of the atmosphere's water vapor, which absorbs infrared light from space.

The Keck Telescope is sited on a cinder cone at the mountain's 13,600-foot level.

Mauna Kea

An inactive volcano on the Big Island of Hawaii, Mauna Kea rises 7,966 feet above the Pacific Ocean. It is widely

acknowledged as the world's best site from which to conduct astronomical observations.

The pristine skies above the mountain bring point images to the telescopes. Its summit is a science reserve managed by the University of Hawaii, is far from



A construction crane lifts part of the Keck Telescope into the dome for installation. (Photo by Peter French)

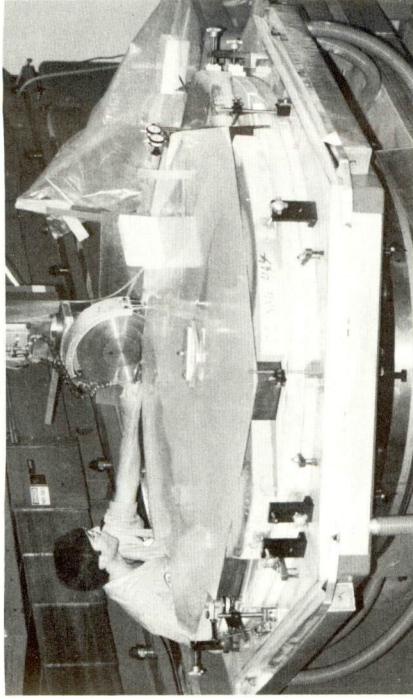
The Mirrors

Opticians have never before had to polish 36 hexagonal mirror segments so that each one focuses light to the same point, as if the segments were part of a single, continuous surface.

To succeed at this task, Keck Observatory project scientists had to develop new techniques for manufacturing and testing telescope mirrors.

When combined into the mirror array, the 36-segment ensemble forms a symmetrical curve; but each individual mirror segment has a surface curvature that is not symmetrical. Opticians, therefore, cannot polish the Keck segments in their usual manner, which produces a symmetrical surface.

To polish the mirror segments, project scientists developed a technique called "stressed mirror polishing." In



An optical technician monitors a diamond-edged saw cutting a mirror blank into hexagonal shape. (Photo by Itek Optical Systems)

this technique, opticians bend the glass mirror by applying forces around its perimeter and then polish it in the usual manner. When they remove the distorting forces, the glass relaxes and assumes the desired non-symmetrical shape.

When the glass is properly polished, it is cut into hexagonal shape. Sawing the glass causes it to change shape slightly. This change is

anticipated and partly compensated for during the polishing operation. Additional adjustments to the mirror shape are made through a series of leaf springs, which gently deform the mirror into the desired final shape.

The final adjustments to the surface of the glass are accurate to about a millionth of an inch, roughly a thousand times thinner than a human hair.

Mirror Control

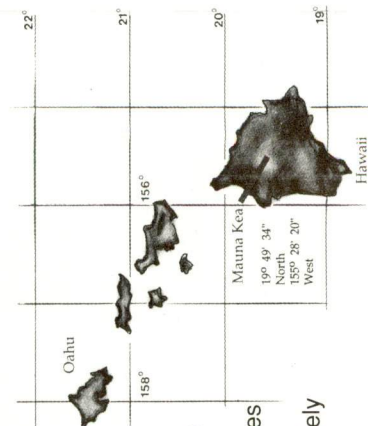
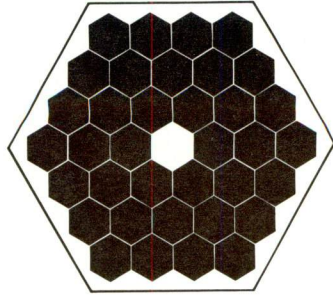
Actuators—precision, motor-driven screws that drive a hydraulic lever—create the microscopic motions that keep each segment aligned with its neighbors. Capable of repositioning segments by less than a millionth of an inch, 108 actuators (three per segment) operate under computer control to maintain the mirror array's light-focusing shape.

Measurements of the mirror array's shape come from 168 sensors distributed along the seams of the

mirror array. As a segment moves relative to its neighbors, it shifts a sensor's "paddle" within its "body" on an adjacent segment, generating an electronic signal that a computer uses to calculate needed adjustments to the array.

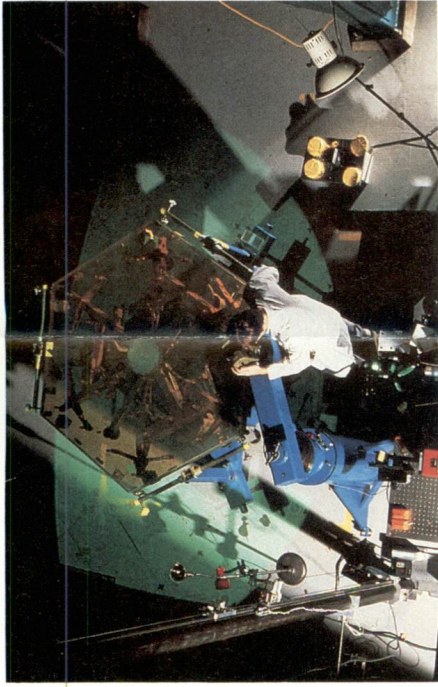
The mirror control system runs continually and corrects the alignment of the mirror array twice each second. Through its electronic components, the control system effectively makes the mirror array act as if it were a single, continuous piece of glass.

W.M. KECK OBSERVATORY



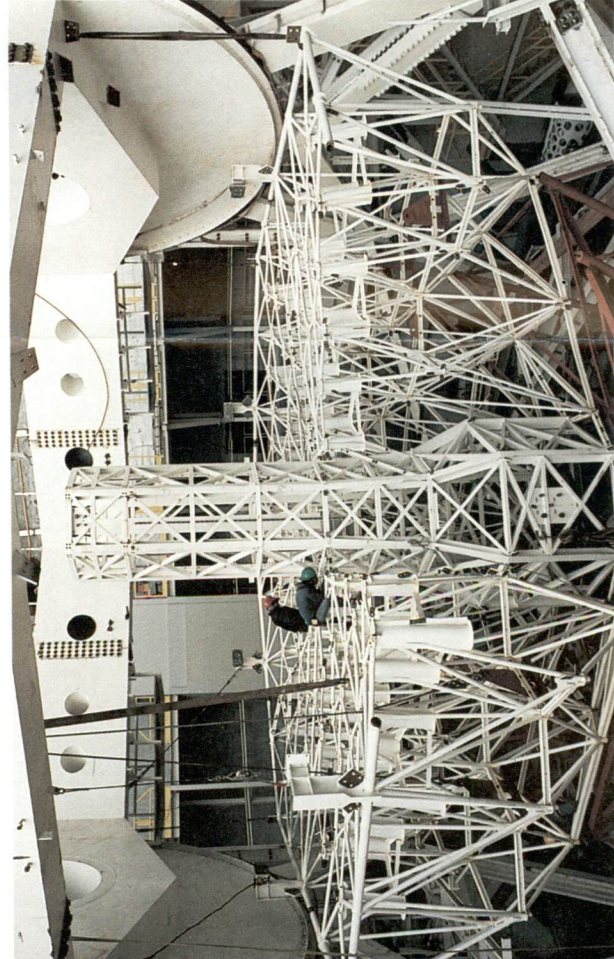
Segmented Mirror

he toughest challenge facing the Keck Telescope's builders was to create 36 precision mirror segments and mate them in near-perfect unison. Meeting this challenge required glass-polishing techniques to shape the hexagonal segments; a support system at once rigid and flexible to mount the segments in the telescope; and a robust control system that aligns the mirror array to an accuracy of a millionth of an inch, a thousand times more precise than a human hair. The many elements

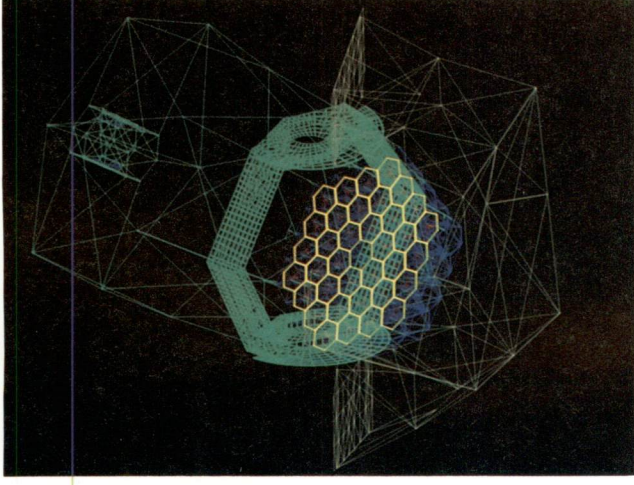


Looking through the transparent glass mirror reveals the underlying mirror supports. The hexagonal mirror segment, here undergoing final optical testing, will receive its reflective aluminum coating at the observatory. (Photo by Kim Steele)

They have to perform night after night without need for maintenance or replacement.



Keck Telescope's mirror cell will support the individual mirror segments, holding them in a precise pattern to allow error control system to make microscopic alignments of the mirror array. (Photo by JPL Photographers Group)



The 36 segments of the mirror array stand out brightly in this computer model of the Keck Telescope.

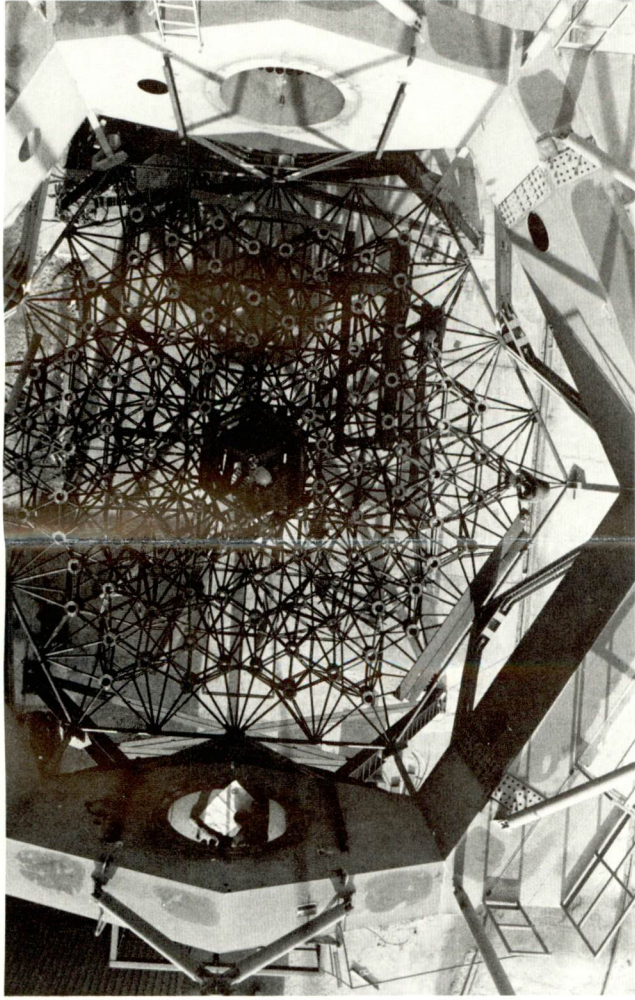
The Telescope

The Keck Telescope's steel structure looks unlike any other telescope. The 8-story, 270-ton structure was developed and optimized through computer analysis to provide the most strength and stiffness for the least amount of steel.

The telescope's purpose is to support the mirrors and scientific instruments and aim them at different celestial objects. The telescope must remain rigid under gravity, changing

wind loads, and changing temperatures to keep the 36-segment mirror array aimed with high precision.

The complexity of the telescope is most evident in the mirror cell, a space-frame structure onto which the mirror segments are mounted. The 33-foot-wide mirror cell, comprising more than 1,100 individual pieces, must hold its shape to within 1/25th of an inch as the telescope aims at different parts of the sky.



Left: Steelworkers pose on the partially assembled dome of the W.M. Keck Observatory. (Photo by JPL Photographers Group)

Middle: Inspectors measure the Keck Telescope's steel framework, assembled for testing at the fabricators in Tarazona, Spain. (Photo by Kim Steele)

Right: From the support facility at the 9,000-foot level, the road winds to the summit of Mauna Kea, the highest point in the Pacific at 13,796 feet.

Cover: The shutter of the W.M. Keck Observatory dome stands open, ready for the next section of the telescope to be hoisted inside for installation. (Photo by Peter French)

TELESCOPE BUILDERS

The California Association for Research Astronomy is building and will operate the W.M. Keck Observatory and Telescope. A nonprofit corporation, ARA was established in 1985 by the University of California and the California Institute of Technology, the two partners in this historic venture.

Caltech is funding the project's construction, giving for major support a 70 million grant from the W.M. Keck Foundation, one of the nation's largest charitable foundations. The University of California will provide

the observatory's operating costs and is funding development of the scientific instruments that will record and analyze the light collected by the telescope.

Caltech and UC astronomers will share equal use of the telescope. Astronomers from the University of Hawaii will also have use of the telescope in exchange for making available the site on Mauna Kea, Hawaii.

A UNIQUE TELESCOPE

The Keck Telescope will be the world's largest and most powerful telescope for optical and infrared astronomy.

In addition to size, the Keck Telescope also will be unique in design: It will hold

36 hexagonal segments, each about six feet (1.8 meters) across, in a honeycomb array that functions as if it were a single piece of glass.

Equivalent in area to a single mirror 33 feet (10 meters) across, the unorthodox segmented mirror avoids the difficulties of shaping and mounting a large piece of glass. With increasing size, a glass mirror eventually deforms and loses the precise curvature needed to focus starlight.

The Keck Telescope's many thin segments reduce the overall mirror weight and also the expense of the telescope. In this way, astronomers can build a large and affordable telescope.

OBSERVING POWER

Using telescopes, astronomers can gather enough light from a celestial object to separate the light into its component colors, which reveal the chemistry and motion of a star or a quasar, for example. Almost everything we know about the universe comes from studying this array of colors, called a "spectrum."

But many objects, such as very distant galaxies, are so faint that only a mirror as large as the Keck Telescope's can gather enough light to create the detailed spectra that will reveal the nature of the objects.

Infrared studies also gain from a large mirror. The Keck

Telescope will create infrared images much sharper than anything now available. This improved resolution, along with the Keck's light-gathering power, will dramatically alter our perception of the infrared universe and facilitate such studies as searches for planets around nearby stars.

LOOKING BACK IN TIME

Telescopes function like time machines, providing images of distant objects as they looked long ago. Light from a galaxy five billion light-years away, for example, takes five billion years to travel to us, arriving as a snapshot from the ancient past.

So by reaching deeper

into the universe, the Keck Telescope also will reach further back in time. It will enable us to trace the evolution of galaxies over billions of years, from the moment they condensed from the chaos of the big bang and formed their first generation of stars up until today. Distant clusters of galaxies and perhaps even the primordial clouds from which they evolved will come into view, bringing us closer than ever before to the beginning of the universe.

GALACTIC HISTORY

Faint stars on the fringes of the Milky Way contain clues to our home Galaxy's formation and chemical evolution.

Some 15 billion years ago, a cloud of hydrogen and helium collapsed to form our Galaxy. Successive generations of stars transformed part of the original gas into the many elements that make up our world, even our own bodies.

The Keck Telescope will look at the Milky Way's faint outermost stars, ancient holdovers from the first generation, to learn more about our Galaxy's chemical history and how the elements we are made of came to be.

NEW SOLAR SYSTEMS

Infrared light, sensed with modern detectors, opens an entirely new universe to view. In particular, a crucial range of infrared light passes through interstellar dust clouds shrouding the regions where new stars and planets arise.

The Keck Telescope, by gathering this infrared light, will let us look inside these dusty clouds to see stars forming and perhaps planets orbiting newborn stars. Studying these systems will enable us to reconstruct how our solar system formed and to determine how common planetary systems are in the Milky Way.