4.1 On The Proposed Redesign of Space Station Freedom

The Space Studies Board sent the following letter and attached position statement to Adm. Richard H. Truly, Administrator of NASA, on March 14, 1991.

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.

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.

Signed by
Louis J. Lanzerotti
Chair, Space Studies Board

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 division 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.[6] 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.[9,10,11]

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.[12] 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 report[13] 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 report,[14] 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.[15,16,17]

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.[18]

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.

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[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]See footnote 1 above.

[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]*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.

[10]*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.

[11]See footnote 8 above.

[12]See footnote 7 above.

[13]*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.

[14]See footnote 13 above.

[15]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.

[16]*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.

[17]*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.

[18]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.

4.2 On the NASA Earth Observing System

The Space Studies Board sent the following letter and attached position to Adm. Richard H. Truly, Administrator of NASA, on July 10, 1991.

We are pleased to transmit to you two new Space Studies Board reports: