On the Utilization of the Space Station: Letter Report

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On July 26, 1994, Space Studies Board Chair Claude Canizares, Committee on Space Biology and Medicine Former Chair Fred Turek, and Committee on Microgravity Research Former Chair William Sirignano sent the following letter to NASA Administrator Daniel Goldin.

Over the past decade or so, the Space Studies Board has issued a series of statements concerning scientific utilization of a space station .1 Two consistent themes appear throughout the Board's positions on the subject. First, there are national considerations for building a space station other than scientific research: to enhance international leadership and prestige, to stimulate the nation's educational achievement and the U.S. technology base, and to realize the long-term goal of long-duration human space exploration. Second, given that the space station program will have scientific objectives, the station that is built should be designed and equipped to support the two principal scientific disciplines it is best suited to serve, life sciences and microgravity sciences. 2

In 1993, the Board and its Committees on Space Biology and Medicine (CSBM) and Microgravity Research (CMGR) conducted an assessment of planning for research management in the space station program and of precursor research during the station assembly period on Shuttle Spacelabs and the Russian Mir. The results of this assessment were transmitted to you in a letter dated February 25, 1994.

On April 28 and 29, 1994, the CSBM and CMGR again met jointly to (1) review NASA's response to our letter of February 25, and (2) assess the capabilities of the newly redesigned International Space Station Alpha (ISSA) and its Phase I Shuttle-Mir activities for supporting scientific research. The committees received briefings and written materials from Mr. W. Trafton (Deputy Associate Administrator for Space Station) on an overview of the ISSA and its program management plan; Captain W. Shepherd (Deputy Program Manager for Space Station at the Johnson Space Center) on the details of the ISSA design; Dr. H. Holloway (Associate Administrator for Life and Microgravity Sciences and Applications) on changes since the committees' February letter relating to Spacelab and space station research management; Dr. J. Vernikos and Mr. R. Rhome (Directors, Life and

Biomedical Sciences and Applications, and Microgravity Sciences and Applications divisions, respectively) on plans for life and microgravity sciences research on the ISSA; and Dr. A. Nicogossian (Deputy Associate Administrator for Life and Microgravity Sciences and Applications) on the Shuttle-Mir program.

This letter was prepared by the CMGR and CSBM at the conclusion of their April 1994 meeting and subsequently approved by the Space Studies Board.

SUMMARY

In summary, the Board and the CSBM and CMGR have concluded the following:

- Research Management: NASA has responded positively to the committees' recommendations. The appointment of a headquarters-level Research Manager and his or her close relationship with the ISSA Integrated Product Teams promise an effective method for communicating and implementing life sciences and microgravity research requirements.
- Precursor Research: Continued vigorous research in the life and microgravity sciences is required to ensure that ISSA's maximum potential as a life sciences and microgravity research laboratory will be achieved. The CSBM and CMGR conclude, as detailed below, that the current plans do not allow for a sufficient level of space research activity, over the years preceding the availability of the ISSA, to maintain the vitality of research programs in the life and microgravity sciences. The committees recommend that, in order to promote scientific progress over the decade of ISSA construction, NASA should consider additional shuttle flights dedicated to scientific payloads.
- ISSA Scientific Research Capability: Substantial progress has been made in defining an international space station that can, the committees believe, provide an effective laboratory for research in microgravity and life sciences in space if a number of remaining concerns are addressed.

1. Research Management

The CSBM and CMGR were generally pleased with NASA's response to the committees' letter of February 25, 1994. The appointment of a headquarters-level Research Manager reporting to the Office of Life and Microgravity Sciences and Applications (OLMSA) and his or her close relationship with the ISSA Integrated Product Teams promise an effective method for communicating and implementing life sciences and microgravity research requirements.

2. Precursor Research

The committees are concerned about the apparent loss of major elements of the Spacelab program in order to support the Shuttle-Mir and ISSA programs. While a Spacelab module will be employed on 5 of the 10 Shuttle-Mir support flights, it will

be severely limited in research capability and will be used mainly for storage and logistical support. These flights are not an adequate substitute for previously planned or proposed science-dedicated Spacelab missions in either the life or microgravity sciences (e.g., SLS-3, SLS-5, 6, and 7, and USMP-5, 6, and 7). While substantial efforts are being made to find alternatives, such as utilizing Mir and flying an occasional Bion (a small Russian free-flying spacecraft), the demise of Spacelab (except for the 1998 SLS-4 Neurolab) will curtail planned research programs prior to research utilization of the ISSA. The present plans of OLMSA to maintain research during this period, while commendable, should be strengthened; a more ambitious plan for science over the interim decade leading to full ISSA utilization should be developed and matched with appropriate budgetary resources. Therefore, to continue the advance of microgravity and life sciences, the committees recommend that additional Shuttle flights be dedicated to scientific payloads in order to promote scientific progress over the decade prior to full ISSA capability.

The CSBM and CMGR have some additional specific concerns about the use of Shuttle-Mir flights as the main opportunities for life sciences and microgravity research prior to ISSA availability:

- NASA should consider including up-to-date equipment on Mir to support plant and animal physiology research. For example, addition of the Plant Growth Facility now under development by OLMSA would permit use of the long-duration microgravity environment of Mir to do important and needed plant experiments. At present, there are no plans to add such equipment to Mir.
- Without an agreement with the Russians for the participation of cosmonauts in human biomedical experiments, there will be an insufficient sample size to enable scientists to draw any firm conclusions about the effects of long-term exposure to microgravity on human physiology.
- The microgravity environment on Mir apparently will not permit high-quality microgravity experiments in many areas of research.

In addition, the CSBM and CMGR urge NASA to make every effort to preserve ground-based research programs in the life and microgravity sciences for identifying and refining those scientific questions that are significant enough to utilize the expensive facilities of space to best advantage. Ground-based efforts are essential also to developing the community of researchers that will exploit the potential of the ISSA.

3. ISSA Scientific Research Capability

The committees support the ultimate goal of an international scientific laboratory in space. A letter from Dr. Charles M. Vest to Dr. John H. Gibbons 3 noted the improvement in the management and the technical aspects of the ISSA program. The presentations to the CSBM and CMGR by Mr. Trafton and Captain Shepherd

likewise addressed the accomplishment of the ISSA as an engineering undertaking. It should be noted that the committees make no judgments on the engineering feasibility of assembly or operations of the ISSA. These may be addressed in studies by the National Research Council's Committee on Space Station of the Aeronautics and Space Engineering Board. The CMGR and CSBM believe, however, that in designing the space station to be suitable for life sciences and microgravity research, NASA has recognized and potentially overcome many significant environment, resource, and scientific problems. If the concerns expressed below are adequately met, the ISSA could provide a productive laboratory for life sciences and microgravity research.

- Dynamic Microgravity Environment: The goal of providing a quasi-steady-state acceleration environment of 1μ g is appropriate and adequate for the conduct of life sciences research and, indeed, this is one of the major reasons for the station. It is not yet clear, however, how scientific experiments will be isolated from disturbances of a dynamic nature (e.g., from machinery, crew activities, thruster firings, and so on). While quasi-static levels of slightly below 1μ g are currently achievable on Spacelab flights operated in a minimum drag configuration, *g*-jitter acceleration spectra show a wide range of intensities over various frequencies resulting from dynamic disturbances. The committees hope that the ISSA will be able to achieve g levels comparable to those of Spacelab and a better overall acceleration environment. In addition, some experiments in microgravity research in the future will require much lower quasi-static g values. A free-flyer platform may prove to be necessary in these cases.
- Centrifuge Facility: It must be stressed that a centrifuge for plants and small mammals is central to the conduct of life sciences research. Furthermore, the centrifuge is not just a rotor but a facility including various subject habitats and related equipment. It is important to install the facility in the station as soon as possible. The committees learned that the facility is unfortunately not part of OLMSA's "baseline plan" and that its planned inclusion has slipped further, from 2000 to 2004. At present, it is not clear where the resources to support construction of the centrifuge facility will be found or where the centrifuge facility can be accommodated on the ISSA.
- Cryogenic Capability: NASA should consider including a cryogenic capability on board the station. As currently planned, the lack of such a capability will limit certain kinds of research (e.g., in low-temperature physics) and use of instrumentation based on low temperature (e.g., infrared detectors and superconducting quantum interference device (SQUID)-based instruments).
- Carbon Dioxide: It is important to achieve NASA's stated goal of a 0.37% concentration of carbon dioxide. While such a concentration is generally acceptable, provisions also need to be made for ensuring concentrations of carbon dioxide lower than 0.37% in the immediate environment of sensitive organisms such as plants.
- Data: The projected capability for uplinking of commands and

downlinking of data to investigators during space operations appears limited. The limitations on communications capabilities may eliminate many telescience projects. Furthermore, long delays have been encountered to date in the Shuttle program in postflight access to specimens and delayed return of scientific data for analysis. This situation must be corrected in the ISSA program. Thus, the adequacy of plans for ISSA data storage, accessibility, and dissemination needs to be investigated further. These areas remain problematic and would gravely reduce the ISSA's utility to science if not resolved.

- Science Budget Impacts: While the Integrated Product Team approach to defining the space station program is striving to meet science requirements, it appears that OLMSA may be charged for certain necessary environmental accommodations, such as the dynamic vibration isolation system or a lower carbon dioxide environment. Such charges will have an adverse impact on the budgets available for research activities and could materially reduce the quantity and quality of science that can be done on the ISSA.

The CSBM and CMGR wish to thank the NASA personnel who provided information to the committees for this review. The committees believe that the ISSA is important to the future of U.S. life and microgravity sciences and look forward to working closely with NASA to ensure the best possible program.

NOTES

1 Letter to NASA Administrator James Beggs, September 13, 1982; Space Science Board Assessment of the Scientific Value of a Space Station, August 16, 1983; Letter to NASA Administrator James Beggs, September 9, 1983; Testimony of Committee on Space Biology and Medicine Chair L. Dennis Smith to the U.S. Senate Subcommittee on HUD Appropriations, Committee on Appropriations, "Space Biology and Medicine and the Space Station," May 1, 1987; Letter to NASA Associate Administrator for the Office of Space Station, Andrew Stofan, July 21, 1987; Letter to NASA Assistant Associate Administrator for Science and Applications, Joseph K. Alexander, December 12, 1990; Letter to NASA Administrator Richard Truly, March 14, 1991; Testimony of Space Studies Board Chair Louis J. Lanzerotti to the U.S. Senate Subcommittee on Science, Technology, and Space, Commerce Committee, April 16, 1991; Letter to NASA Associate Administrator for Space Systems Development Arnold Aldrich, March 30, 1992; Letter to NASA Administrator Daniel Goldin, February 25, 1994.

2 The National Research Council's Aeronautics and Space Engineering Board has issued a series of advisory letters and reports on engineering-related aspects of the space station program, viz: National Research Council, Space Station Engineering and Technology Development, National Academy Press, Washington, D.C., 1985; National Research Council, Space Station Engineering Design Issues, National Academy Press, Washington, D.C., 1989; and Committee on Space Station, Letter to NASA Administrator Daniel Goldin, May 6, 1993. See also, National Research Council, Report of the Committee on Space Station of the

National Research Council, National Academy Press, Washington, D.C., 1987.

3 Letter from Dr. Charles M. Vest to Dr. John H. Gibbons, April 4, 1994. Dr. Vest chaired the President's Advisory Committee on the Redesign of the Space Station that reviewed the redesign in mid-1993. Several members of his committee reviewed the ISSA plans in March 1994 in terms of their addressing the June 1993 advisory committee's recommendations (Final Report to the President, Advisory Committee on the Redesign of the Space Station, 1993). The letter to Dr. Gibbons conveyed his personal observations of that review.