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[ASSESSMENT OF THE SPACE STATION PROGRAM] (NAS-NRC) 6 p

N95-16352

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NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

AERONAUTICS AND SPACE
ENGINEERING BOARD

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June 27, 1994

P- 6

Wilbur C. Trafton
Director, Space Station Program
Office of Space Flight
NASA Headquarters, Code M-4
Washington, DC 20546

Dear Mr. Trafton:

As Chairman of the Aeronautics and Space Engineering Board's Committee on Space Station, I am pleased to respond to your letter of May 6, 1994, requesting our assessments of the Space Station program. This response is based on our meeting at Johnson Space Center (JSC) on April 21-22, 1994, several other meetings with NASA since the beginning of 1993[1], and previous NRC Reports on technical aspects of the Space Station. In this letter we provide: 1) comments on NASA's response to our 1993 letter report, 2) comments on NASA's response to technical and management recommendations from previous NRC technical reports on the Space Station, and, 3) our assessment of the current International Space Station Alpha (ISSA) program.

Response to our 1993 Letter Report to Administrator Goldin

As you know, the Committee views engineering research and technology development as an integral part of the Space Station program. Our ideas on this topic were documented in a May 6, 1993 letter report to the NASA Administrator. NASA's response to the letter's recommendations has been gratifying; engineering research and technology is an important element of the new program. The series of technology experiments being planned for the Shuttle/Mir phase, starting in 1995, are concrete examples of engineering research and technology development. If executed well, they will provide technical input to the later phases of the program (in the early part of the next century), reduce the uncertainties connected with International Space Station Alpha, and possibly enable the use of more advanced technologies than would otherwise be acceptable. These are the central objectives of engineering research.

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[1] (Since the beginning of the redesign, the Committee on Space Station or subgroups of the Committee met and received data on the status of the program on March 23-25, July 20-21, October 7, October 25, and December 17, 1993; and February 17-18 and March 31 - April 1, 1994.)

While progress has been made toward the inclusion of engineering research and technology in the Space Station program, work remains to be done to develop a fully rational engineering research and technology program that will foster a more efficient and economical space infrastructure. A model already exists for such an effort: the NASA Office of Advanced Concepts and Technology's (OACT) In-Space Technology Experiment Program (INSTEP) has systematically prepared and executed engineering experiments on the Space Shuttle. This program's stated mission is to "validate advanced technologies and manufacturing techniques, investigate space environmental effects, and provide access to space for industry, universities and government."[2] Its two-step process for experiment selection has worked well to keep the scope and cost of its projects reasonable. This type of program could be expanded and extended to the ISSA program. The Committee on Space Station and the Aeronautics and Space Engineering Board are prepared to help NASA bring appropriate attention in the community to the opportunity for space technology research on the Space Station, and to help to bring increased vigor to NASA's plans for this work. As we discussed in Houston, the Committee will work towards conducting a workshop, in the next fiscal year, to better define and prioritize the kinds of engineering research that should be done on ISSA. In the meantime, as mentioned in last year's letter to Mr. Goldin, the Committee reaffirms that, as the most massive and complex structure ever orbited, the baseline Space Station should be fully instrumented (with strain gages, accelerometers, etc.) so that during construction its structural and inertial properties can be verified and studied.

Response to Technical and Management Recommendations from Earlier NRC Reports

The Committee commends NASA for including within the latest redesign several changes that were in line with earlier NRC advice. In 1985, 1987 and 1989, NRC Committees stated that the management structure for the program should feature a single office and director to be accountable for the program and empowered with the authority to make necessary changes[3]; this is now the case. In 1987, the NRC recommended that NASA would benefit from closer coordination in its Space Transportation and Space Station programs; this seems to be occurring in the current program. In 1987 and 1989, NRC Committees stated that Space Station was too dependent on the Space Shuttle and that additional launch systems would be useful for deployment and construction and for logistics resupply; assembly of ISSA is currently

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[2] (Dr. Jack Levine and Dr. Judith Ambrus, Presentation to the NRC Committee on Space Station: "Plans for Utilizing Space Station for Technology Development in Space," 4/1/94)

[3] (National Research Council, Space Station Engineering and Technology Development, National Academy Press, Washington DC, 1985; National Research Council, Report of the Committee on Space Station of the National Research Council, National Academy Press, Washington DC, 1987; National Research Council, Space Station Engineering Design Issues, National Academy Press, Washington DC, 1989)

projected to require two more shuttle flights than assembly of Freedom[4], but the addition of Russian launch systems responds partially to this concern, especially after the initial assembly phase is completed. Also in 1987 and 1989, an assured crew return vehicle (ACRV) was recommended as an integral part of the Space Station program, and the new program contains this capability as part of its baseline plan, although it must be noted that the Soyuz vehicle represents some compromise with the original requirements established by NASA for an ACRV.

Assessment of Current International Space Station Alpha Program

Based on our two-day meeting at JSC in April, and our several meetings with NASA since the beginning of the redesign in 1993, the Committee offers the following preliminary observations and assessments of the current International Space Station Alpha program:

1. The Committee was favorably impressed by the technical personnel, and the quality and content of the briefings, at the April 21-22 meeting at JSC. The new organization in place is making good progress, especially considering the circumstances associated with the current program (including closing a major office and opening and staffing another one, developing a new design, participating in ongoing negotiations with the Russian Space Agency, changing the relationships with major contractors, and changing the entire upper management of the program).

2. The Committee commends NASA for the establishment of a single organizational focal point within the ISSA program for the management of scientific and engineering research to be performed onboard the Space Station. The Committee endorses further development of the current plans for the overall governance and operational programs of the Space Station, and recommends special attention be paid to the problems of research governance in a laboratory jointly operated by several nations.

3. The Committee is encouraged by the statement that approximately 75 percent of the designs for Space Station Freedom (SSF) will be used in ISSA. Much of the SSF design was subjected to a rigorous Critical Design Review in 1993. The changes made to some systems in the new program are, upon first examination, good ones in that they generally add capability or reduce complexity (e.g. more capacity in the electrical power system, and less complexity in the command and data handling system). ISSA will also have more volume, power, and crewtime than SSF.

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[4] (The final NASA information on Space Station Freedom to the Committee, presented by Dr. William Raney on October 12, 1993, showed 18 assembly flights. The information from the ISSA program at the April 21-22, 1994 meeting showed 20 assembly flights.)

4. Russian hardware will dominate in the early stages of the Space Station build-up, and some parts will retain central and critical roles when the Station is completely assembled (e.g. the Russian "FGB" Propulsion and Control module, the Soyuz Assured Crew Return Vehicle, and the Progress resupply vehicle). The ISSA design depends on Russian components for its basic operation.

5. There is a significant lack of detail available at present about the Russian components and plans for ISSA. There is no evidence that this information cannot be obtained, or that the integration of U.S. and Russian systems and hardware cannot be achieved. However, there is much work to be done in this area. This is not to suggest uncertainty in Russia's resolve or technical abilities, just uncertainty in the specifics of what Russia will be responsible for once negotiations are completed: e.g., providing life support technology to the U.S. side of ISSA, performing significant mission control duties, resupplying expendables with the to-be-developed "Progress-X" spacecraft, piloting Soyuz Assured Crew Return Vehicles, and providing video uplink and other communications functions.

While the Committee is heartened by much of what it has seen at JSC, it has identified some issues to which it believes NASA must give special attention. They are as follows:

1. The potential departure from accepted practices for NASA in accepting the use of (Russian) partner systems as flight-safety-critical elements of ISSA without detailed review by NASA of their design, construction, reliability, and operational characteristics. Russian components and systems were incorporated into the ISSA design before they underwent in-depth analysis by NASA. NASA should expedite its analyses of Russian elements that are now part of the baseline plan.

2. The small number of NASA personnel currently on the ground in Russia, and the need for adequate direct interchange between U.S. and Russian technical and programmatic personnel. Combining U.S. and Russian systems and methods will be a time-consuming and challenging enterprise and direct working relationships appear to be developing too slowly.

3. The need for a stated policy on the consistent application of standards across the entire station (e.g. the planned Russian side may have a lesser degree of shielding for space debris than the U.S. side). The decision could be made to waive current system-wide standards in light of Russian orbital experience, but decisions to do so should be made explicitly and should be open to scrutiny.

4. The need for complete success in the Space Shuttle improvements program to provide adequate launch capacity to the higher-inclination orbit that has been selected for ISSA. This includes operation of the Space Shuttle Main Engines at 106% speed and the use of Aluminum-Lithium alloy in the External Tank. The impact of these changes on Shuttle reliability should be carefully assessed.

5. The changes associated with increased outfitting of the laboratory modules (U.S. Laboratory, Japanese Experiment Module and European Attached Pressurized Module) on-orbit. Additional Space Shuttle flights are necessary to carry up the pressurized payloads, and there will be a significant increase in the amount of complex intra-vehicular activity that will be necessary associated with performing integration in orbit.

6. The need to recognize that ISSA will be a single spacecraft, despite the facts that it will require more than 30 flights to assemble and many countries will be participating in the development of flight hardware. As the leader of the program, NASA must account for demands that will exist for the whole ISSA, not just the U.S. side. For example present estimates of Extravehicular Activity (EVA) hours for ISSA are about the same as for Space Station Freedom, but do not count EVA required on the Russian side of ISSA.

7. The extraordinary efforts that will be necessary to orchestrate a large number of launches in short time periods (13 U.S./Russian in the first 11 months and up to 19 in a year). Any delays could eliminate cost savings expected from accelerating the program.

8. The disproportionately low funding level allocated to OACT payloads in the ISSA payloads budget. Current NASA plans[5] apparently allocate about 15 percent of the ISSA budget for payloads to OACT, while assigning OACT 40 percent of payload resources (such as volume, power, crewtime, etc.). Unless there will be additional funding for OACT payloads and in the absence of any evidence that this work will be much less expensive to perform, it appears unlikely that sufficient experimental payloads will be ready to make use of available resources.

In closing, I wish to note that despite the important questions we have raised, our overall impression from the April 21-22 review was quite favorable. We hope that these comments are of help to you and look forward to continuing discussion of the open issues and questions in the months and years ahead.

Sincerely,

Jack L. Kerrebrock

Jack Kerrebrock
Chairman, Committee on Space Station

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[5] (NASA Fiscal Year 1995 Budget, International Space Station: Science/Commercial Payloads and Related, June 27, 1994)

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