RECORD OF DECISION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

International Space Station
Tier 2 Environmental Impact Statement

A. THE INTERNATIONAL SPACE STATION

The International Space Station (ISS) is an international cooperative effort undertaken by the United States, Russia, Canada, the European Space Agency, Japan, and Italy. The ISS will provide a world-class orbiting laboratory for conducting high-value scientific research in a microgravity environment and provides a framework for future international cooperative space ventures. The history of the ISS dates back to May of 1982 when the National Aeronautics and Space Administration (NASA) formed a Space Station Task Force to develop ideas for a permanently human-occupied space station to be deployed in low-Earth orbit. In January 1984, President Reagan committed the Nation to developing a permanently occupied space station, with NASA establishing a Space Station Program to implement that commitment. The Program developed a number of alternative design configurations, with selection in 1988 of the Space Station "Freedom" (SSF) design.

On March 9, 1993, President Clinton directed NASA to reduce development, operation, and utilization costs of the space station, while still achieving many of the goals established for long-duration scientific research. The results of the redesign effort were presented in June of 1993 which culminated with the adoption of the current ISS design. NASA's Space Station Program was also restructured to ensure that the space station would deliver significant science and technological benefits at an affordable cost.

The resulting configuration of the ISS retains about 75 percent of the original SSF hardware design, incorporating hardware contributed by all the international participants. The total pressurized volume and total mass of the ISS (1,309 m^3 [46,200 ft^3]; 420,000 kg [924,000 lb.] respectively) are about twice that of SSF. The orbital inclination of the ISS has also been changed to 51.6 degrees from the 28.5-degree inclination of SSF. This will enable assembly and resupply launches by the Russians, along with the use of Russian mission control facilities. First element launch to initiate assembly of ISS is presently scheduled for November 1997, with permanent human presence capability in May 1998. Completion of assembly is presently scheduled for June 2002. The individual components of the ISS will be launched to low-Earth orbit by NASA, the Russian Space Agency (RSA), and the European Space Agency (ESA), using their respective launch vehicles with assembly on orbit. The design life for

mission hardware is a minimum of 10 years from completion of assembly. The ISS design also includes Orbital Replaceable Units that allow the crew to replace hardware on orbit, thereby extending the practical life of ISS beyond the 10-year design life. Throughout its operational life, ISS will be resupplied by a combination of U.S. Shuttle flights and flights by the international partners.

B. INTRODUCTION TO THE ENVIRONMENTAL IMPACT STATEMENT (EIS)

In March 1991, NASA published the Final Tier 1 EIS for Space Station Freedom, providing the information necessary to support decision-making to continue the design and development, and ultimately assembly and operation of Freedom. The Record of Decision (ROD) for the SSF Final Tier 1 EIS was rendered in July 1991. In the Tier 1 ROD, NASA highlighted its commitment to prepare a Tier 2 EIS which would address: ". . . the environmental impacts of significant modifications to Space Station Freedom; the probability of accidental reentry; the injury/damage probability associated with such reentry; and any significant new information relevant to environmental concerns." Other subjects deferred to the Tier 2 EIS included venting nontoxic gases during station operation and changing to a hydrazine propulsion system.

The ISS Tier 2 EIS has been developed to address the commitments made by NASA in the ROD associated with the SSF Final Tier 1 EIS. The ISS Final Tier 2 EIS addresses the changes incorporated into the space station design including the venting of nontoxic gases and the change to the propulsion system that are reflected in the current ISS design. The ISS Final Tier 2 EIS also addresses the current decommissioning plan for the ISS--a controlled deorbit with the burnup and breakup of ISS during atmospheric reentry with surviving debris targeted for a remote ocean area.

Formal scoping for the Tier 2 EIS began on May 23, 1995, with publication of NASA's Notice of Intent (NOI) in the Federal Register (FR). In parallel, NASA mailed the NOI directly to over 130 Federal and state agencies, individuals, and organizations. The scoping period closed 45 days later in July 1995. All responses received were reviewed; however, they raised no new environmental issues.

The ISS Draft Tier 2 EIS was made available to the public via NASA's Notice of Availability (NOA) published in the FR on December 6, 1995, at 60 FR 62480, and Environmental Protection Agency's (EPA) NOA published in the FR on December 8, 1995, at 60 FR 63044. The public review and comment period closed on January 22, 1996. As requested, however, the review and comment period was extended to February 29, 1996, for Federal employees furloughed during December 1995 and January 1996. A total of 12 letters were received from reviewers, with 3 of those letters providing comments on the following topics: groundwater impacts at the launch sites; air quality and public safety at the launch sites; and construction and operation impacts of the Neutral

Buoyancy Laboratory at the Lyndon B. Johnson Space Center in Houston, Texas. These comments were taken into account and addressed in the ISS Final Tier 2 EIS.

The ISS Final Tier 2 EIS was made available to the public via NASA's NOA published in the FR on June 10, 1996, at 61 FR 29429, and EPA's NOA published in the FR on June 7, 1996, at 61 FR 29095. The public 30-day notice period ended July 10, 1996.

Alternatives Considered

The alternatives addressed in the Tier 2 EIS were:

1. NASA's proposed action to continue to provide U.S. participation in the assembly and operation of the ISS. This includes contribution of specific components of the ISS facility and structure; 27 Shuttle launches to lift ISS components to low-Earth orbit where assembly will occur; provision of additional Shuttle launches to resupply the ISS over its minimum 10-year lifetime; continued support to management of the ISS mission; as well as additional hardware, software, and maintenance items including support for U.S. contributions to the scientific and engineering studies and experiments on board ISS.

2. NASA's termination of the current Space Station Program, canceling U.S. participation in the assembly and operation of ISS--specifically, the No-Action alternative.

Environmental Consequences of the Alternatives

1. Consequences of the Proposed Action: The development and manufacture of U.S.-contributed components, payloads, and experimental devices will take place at existing ground-based NASA facilities (Johnson Space Center, George C. Marshall Space Flight Center, and Lewis Research Center), and numerous commercial facilities throughout the United States. Some expansion of existing facilities is in progress, or has been accomplished resulting in construction activities. The potential environmental impacts of these activities have been addressed in the SSF Final Tier 1 EIS and in site-specific environmental documents and have been updated in the ISS Final Tier 2 EIS.

The 27 Shuttle launches associated with ISS assembly and the follow-on launches to resupply the ISS over its operational lifetime constitute the major source of environmental impacts associated with the Proposed Action. The impacts of Shuttle launches have been addressed in the 1978 Shuttle EIS, and subsequent updates occurring in later NEPA documentation, as well as the 1994 Kennedy Space Center (KSC) Environmental Resources Document, all of which

have been summarized and updated in the Tier 2 ISS EIS. These impacts center largely upon the emission of large quantities of solid rocket booster exhaust products to the local environment at KSC and to the stratosphere upon passage of the Shuttle to low-Earth orbit.

With respect to the local KSC area, these air emissions have a temporary and localized impact upon air quality and upon wildlife and vegetation at and near the launch pad with essentially no substantial offsite consequences. Stratospheric ozone impacts from solid rocket booster exhaust products are reflected in a localized and temporary ozone depletion along the Shuttle trajectory through the stratosphere with no permanent lasting effects.

Operation of the ISS would have little negative impact upon the human environment. All solid waste, and most liquids and gases, generated on board the ISS would be returned to Earth in sealed containers for disposal in accordance with environmental regulations. Venting of nonhazardous liquids and gases such as helium, argon, neon, carbon monoxide, and oxygen from the ISS would be allowed during operation. A small amount of outgassing and leakage, principally of the internal station atmosphere, through seals and joints of the ISS will be normal and unavoidable. This is expected to be minimal with no substantial deleterious impact.

The currently proposed method for decommissioning ISS when its useful life is over is a controlled deorbit of the ISS with burnup in Earth's atmosphere and entry of surviving debris into a remote ocean area. The footprint or area within which the surviving debris would be expected to fall has been estimated with a large degree of conservatism. The nominal or expected footprint has been estimated at about 43,009 km^2 (12,430 n.m. ^{2}). The probability of a piece of surviving debris striking a very large ship (70m x 250m; 230 ft. x 810 ft.), located within the nominal footprint has been conservatively estimated at about 1 chance in 1,182. Prior to decommissioning, warnings (e.g., notices to aviators and mariners) would be issued for the footprint area well in advance. The impact of this surviving debris upon the targeted remote ocean impact area is expected to be small. The debris would settle to the ocean floor, where some of it would become encrusted with marine life while other debris would eventually decompose and become incorporated into the sediments. Most, if not all, hazardous, toxic, and radiological materials on board the ISS would be removed prior to decommissioning. Thus only residual quantities, if any, would have the potential to survive reentry and enter the ocean. No substantial impacts on marine life would be expected in such an event.

The Tier 2 EIS also addresses the potential consequences of an accidental deorbit of the ISS. An accidental deorbit could occur if an accident of sufficient magnitude: (1) rendered the altitude and attitude control functions inoperable; and/or (2) removed the capability to dock or attach any vehicles which could replace the propulsive functionality of the ISS; and (3) no

combination of activities by the U.S., Russia, or the other international partners could restore that functional capability. Without its propulsive functionality, the ISS would not be able to reboost to a higher altitude, creating the potential for aerodynamic drag to ultimately result in an uncontrolled reentry. Most ground or ISS failures preventing reboost or a controlled deorbit can be corrected before they result in accidental reentry. Even without a planned resupply, the ISS will carry enough reserve propellant on board to maintain about 1 year of normal operations and reboost capability. Further, by sacrificing normal operations, the solar arrays could be "feathered" to reduce aerodynamic drag, thereby essentially doubling the orbital lifetime.

The most critical time for an accidental or random failure leading to an uncontrolled reentry would be during the deorbit decommissioning sequence. There would be no personnel on board to intervene; the orbital lifetime would, by design, be very limited; and opportunities for recovery by the ground controllers would be similarly limited. An inadvertent reentry of ISS would, like the planned decommissioning deorbit, result in the breakup, burning, and vaporizing of ISS into various fragment sizes. The difference lies in the indeterminate location of the impact/footprint area under the orbital flight path.

Three methods were assessed by NASA to estimate the risk of injury to people and structures in the event of an accidental uncontrolled deorbit of the ISS. The Tier 2 EIS used the most conservative of the three methods in evaluating these risks. Assuming an inadvertent reentry, the number of injuries within the population residing in the area described by the ISS orbital inclination (51.6 degrees north and south latitude band) would range from 0.0966 to 0.030, with the risk to any given individual ranging from 1 in 787 billion to 1 in 250 billion. Likewise, the number of structures potentially hit within the 51.6 north/south latitude band was estimated to range from 0.57 to 1.8. It is important to note that these risk calculations did not account for the initiating probability of a disabling accident. Inclusion of the initiating probability in the calculations would substantially reduce the risk estimates.

2. Consequences of the No-Action Alternative: The No-Action alternative would appear to present the least environmental impact and risk. The principle source of normal/expected environmental impacts, the solid rocket exhaust emissions associated with the assembly and resupply launches of the Shuttle, would very likely occur even in the absence of the ISS. The Shuttle flights that would have been allocated to these activities would very likely be reassigned to other NASA missions. The airborne emissions from the reassigned launches would impact the air quality, vegetation, and fish near the launch pad, as well as result in the same temporary impacts on stratospheric ozone. Thus, from this perspective there would probably be no net change in total environmental impacts from the No-Action alternative. The No-Action alternative would, however, not entail any of the impacts associated with the

current targeted deorbit decommissioning plan and avoid the potential for an inadvertent uncontrolled reentry of the ISS.

The No-Action alternative would likely result in a loss of employment and income for at least some of the 15,400-person Space Station Program workforce located at numerous facilities over a 35-state area. In addition, the No-Action alternative would not yield the anticipated science data from ISS, thus effectively preventing the United States and our international partners from achieving their science objectives and losing the potential for new technological advances that could accrue from investigations on board the ISS. This alternative would also terminate, with attendant repercussions, the international agreements that are in place to develop the ISS. In addition, it would deter U.S. plans for forging future international partnerships for the peaceful uses of space.

While the United States could continue to fly limited microgravity experiments on the Shuttle, and the international partners could design and build an alternative space station using current Russian hardware as the core, the quality of the microgravity environment would probably be measurably less than that achievable with the ISS. This would also result in less scientific data than would have been achieved with U.S. participation.

Further, in the absence of U.S. participation, it is unlikely that the international participants would continue their involvement in the ISS, depriving the world of untold benefits of an internationally peaceful enterprise.

C. CHOICE OF ALTERNATIVES

It is my intention to choose the Proposed Action, Alternative 1 (above, page 3), based on the following environmental and programmatic grounds:

Alternative 1, continuing to provide U.S. participation in the assembly and operation of the ISS entails no substantial environmental impacts and has small risks associated with the currently proposed decommissioning plan. At the same time, the Proposed Action will ensure the success of the international team's efforts to establish a long-term, human-occupied, world class orbiting microgravity facility where scientific and engineering research are likely to yield knowledge and technological advances that will benefit life on Earth. Adoption of the Proposed Action will also allow the United States to honor its international agreements and commitments and to maintain its leadership role in the peaceful use and exploration of space.

The No-Action alternative (Alternative 2) appears to present the least environmental impact of the two alternatives, as well as the minimum amount of risk. In fact, it is highly likely that there would be little difference

in environmental impacts relative to the Proposed Action. This is due to the fact that the Shuttle launches that would be assigned to the ISS, would likely be reassigned to other NASA missions and the impacts incurred in any case. Further, the No-Action alternative would deprive society of the scientific and technological advances that will be facilitated and/or produced by the ISS. It would also disrupt the international partnerships the United States has formed to enable the ISS to be realized and would strain our ability to enter into international agreements for the peaceful uses of space in the future.

The choice to continue providing the U.S. commitment to the ISS is fully consistent with the mandate of the National Aeronautics and Space Act of 1958, as amended, to meet the needs of scientific, technological, and commercial research and to foster international cooperation.

D. ADDITIONAL INFORMATION

As with most programs dealing with evolving technology and international cooperation, changes in ISS configuration, participation, implementation, and operation may arise as the ISS program continues to evolve and as other influential events arise. Also, since reliability estimates for Russian components were derived from analysis of the similarity of those components with known U.S. components, the reliability analysis supporting the Tier 2 EIS will be updated when Russian component failure rate data become available. If changes in the ISS program, or the results of updated analyses, indicate a substantial departure from the information in the Tier 2 EIS, appropriate environmental documentation and mitigation measures will be considered.

E. MITIGATION

This EIS primarily addressed the impacts associated with restructuring the Space Station Program and design changes associated with the evolution from Space Station Freedom to the present International Space Station. The only expected or immediate environmental impacts of the Proposed Action are those that will be incurred with the assembly and resupply Shuttle launches. Those impacts will be the same as those for every Shuttle launch, and mitigation will be the same. The impacts associated with other aspects of the Proposed Action such as the change to a hydrazine propulsion system, outgassing of nontoxic gases during operation, and impacts on stratospheric ozone have been estimated to be small and not substantial. No specific mitigation measures are necessary as indicated by this EIS analyses. In addition, the risks of the current deorbit decommissioning plan have been estimated to be small, and the impacts of surviving debris on the ocean are not expected to be substantial. Appropriate means to avoid or minimize environmental harm from ISS deorbit have been or will be adopted to mitigate the risks associated with both the planned and unplanned accidental deorbit

of ISS. A more detailed discussion of environmental impact mitigation and monitoring is presented in the Tier 2 EIS.

DECISION

Based upon all the foregoing, I am confident that reasonable means to avoid or minimize environmental harm from the U.S. role in the International Space Station have been adopted or, if not already adopted, will be adopted as appropriate, as the assembly and operation of the space station evolve. Accordingly, it is my decision to continue U.S. participation in the assembly and operation of the International Space Station.

Wilbur C. Trafton
Associate Administrator for Space Flight

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