Assuring Effective International Space Station Utilization

An AIAA White Paper

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THE PROBLEM

Previously planned investment in science and engineering research in low earth orbit has been virtually eliminated in projected NASA budgets for the next five years because of the cost overruns on the International Space Station (ISS). This will allow few flight opportunities for current researchers. Significant levels of peer reviewed research on ISS will not be achieved in the near term because NASA has put a priority on completing ISS assembly while deferring the inclusion of world-class research capabilities on ISS to later years, assuming sufficient resources for research are eventually provided. Delay or cancellation of ISS utilization facility development that would enable sophisticated experiments in the space environment negates the capability of the United States to get a return on its enormous investment in the development of the ISS for the foreseeable future.

SOME MITIGATING ACTIONS

Provide additional resources for in-orbit research. Namely, sponsor additional Space Shuttle research or combined research/assembly missions until the postponed ISS research-related utilization facilities are ready for use. These Shuttle flights will provide means to perform experiments that have been in development for years.

Simultaneously, prepare for ISS utilization in the long term by providing seed support for preliminary development of experiment hardware and engineering technologies that will be needed on the ISS when its utilization capabilities can support more intensive research. However, the additional funding needed for these mitigating actions should not be provided at the expense of other NASA enterprises.

BACKGROUND

After almost two decades of conceptualization, redirection, and redesign, the initial assembly phase of the ISS assembly is near completion. The already deployed facilities, which include the U.S.-supplied Destiny laboratory module, are accommodating a permanent, rotating crew of three people. Current plans are to deploy the European Columbus laboratory module and the Japanese Experiment module during the next few years. These three laboratory facilities provide much of the infrastructure needed to utilize the ISS for long-term micro-gravity research, engineering research, and other space-based investigations in low earth orbit. ISS should then begin to deliver a long overdue return on the substantial investment by the United States and international partners in the program. However, over the past several years, a projected ISS program cost growth of about $10 billion has had adverse impacts on NASA low earth orbit research, aeronautics, space science, and earth science programs. An additional program cost growth projection this year of $4.8 billion has resulted in proposed reductions in the U.S.-supplied ISS orbital infrastructure, including cancellation or indefinite delay of most of the research utilization facility plans.

Until recently, the ISS development plan included a U.S.-supplied habitation module that would have enabled a permanent crew of seven to support maintenance of the station as well as research utilization programs. Quarterly Space Shuttle flights to the ISS would have provided some of the necessary operational supplies as well as means for rotation of three to four of the ISS crew members. Other unmanned vehicles provided by Russia, Europe, and Japan would have provided the rest of the ISS re-supply lift capability. In addition to the habitation module, support of an ISS crew of seven would require means for emergency return to earth of the entire crew on short notice. A Crew Return Vehicle that would have had a capacity to carry seven passengers was planned for development with United States leadership and European participation. Without the Crew Return Vehicle, current ISS storage of a single Russian Soyuz vehicle for emergency return limits the ISS crew size to three regardless of the status of a habitation module.

The immediate impact of the ISS research budget reductions is a cessation or a long-term delay of entire classes of ISS-based scientific and engineering research. The investment to date in ground-based research, in development of experiment hardware and new technology facilities, and in the associated intellectual capital is being lost, and may not be regained. The science and engineering community that has focused on understanding and benefiting from research in space will be greatly diminished. If adequate resources are not reinstated in these areas in the very near future, few of the applicable experts will remain to capitalize on the United States’ investment in the ISS as an orbiting research laboratory.

While both the House and Senate have recognized the issue of ISS utilization funding for their consideration of NASA’s FY 2002 budget request, they acknowledge that their bills cannot address the entire problem.

THE STATE OF ISS UTILIZATION

The ISS was supposed to provide a unique environment and facilities for long-term research in earth orbit with more power and volume to support research goals than has ever been available before. The vision for space research included:
• Means to evaluate the effects of long-term exposure of humans and other living organisms to reduced gravity environments. With the addition of a large centrifuge to the ISS that could provide forces similar to partial earth-standard gravity, biological researchers could begin to explore the expected effects of long-term habitation of the Moon or Mars in addition to the effects of living in micro-gravity. The future of the centrifuge is in doubt and approximately 40% of the supporting hardware and laboratory support equipment is no longer funded in the Fiscal Year (FY) 2002 budget.

• Means to explore the behavior of fluids, materials, and combustion in micro-gravity. Removal of the influence of gravity and the associated effects such as convection offer the opportunity to discover fundamental physical laws that would otherwise be concealed in ground-based laboratories. However, materials science, molecular biotechnology, and glovebox experiments were reduced by approximately 60% including the loss of 50% of the principal investigators and 20% of the ground-based investigators. Combustion science, which contributes to the understanding of environmental effects and fire safety applications, lost 100% of the previously approved investigations including those critical to droplet combustion, combustion of solids, gaseous fuels combustion, unique combustion ignition phenomena, and space-based combustion detection. Fluid Physics, which investigates the most elemental behavior and characteristics of fluids, was also reduced from 36 investigations to nine. The means to nurture and expand the academic investigator core has been eliminated.

• Means to evaluate new instruments, space systems, and materials in the space environment. This capability could accelerate the application of new technologies and research tools for space applications. Knowledge about space systems, closed-system life support operations, and techniques to maintain health in space could be acquired to support a future decision for new human exploration and settlement beyond earth orbit. Significant fundamental scientific advances and discoveries of commercial importance could result from effective ISS application. All of this research is jeopardized without a new plan for ISS utilization.

The promise of being able to conduct fundamental and applied research in a permanently occupied orbiting research facility has been a major justification for building the ISS. There is a growing concern by the research community that ISS will not live up to its promise of world-class research. The state of ISS utilization is obvious when one compares the planned number of peer reviewed flight investigations per year. In 1997, over 90 such investigations were accomplished on the Shuttle. However, the FY 2001 budget submittal allowed for just 25 investigations and only 10 were accomplished. The continued reduction in space research funding and opportunity will preclude significant science output from the ISS for the foreseeable future.

OPTIONS FOR THE NEAR TERM AND BEYOND

While NASA has been attempting to find solutions to the cost overruns and crew limitations, the pressure on the human space flight budget has left little flexibility to pursue near-term options that could help support research while larger ISS program restructuring occurs. Any approaches to mitigating the problem will require additional funding. Still there are a number of options that should be considered to bring some relief to the research communities:

1. Restore some funding for ISS research facilities and payloads in the near term, keeping the research program on track while the agency addresses options for increasing crew size.
2. Develop and apply new robotic systems or other enabling technologies to support ISS maintenance and utilization, thereby increasing the productivity of the current ISS crew of three.
3. Fly research on dedicated Space Shuttle missions at regular intervals, which may be possible with one or two additional Shuttle missions during ISS assembly, to provide continuity and support to the biological and physical research program. These missions could be extended-duration orbiter flights of about 18 days.
4. Add research payloads to scheduled crew exchange logistics missions of the Shuttle, replacing one or two Multi-Purpose Logistic Module flights a year with a SPACEHAB logistics double module that can accommodate both logistics and research payloads.
5. As a major advance in crew availability, develop a Long Duration Orbiter capability for visits of several months to the ISS. Seven additional astronauts could then visit the ISS on each flight. The Long Duration Orbiter visit would not only greatly augment the science crew of the ISS, but could bring supporting equipment and consumables for the long duration missions, and could provide habitation facilities as well as an emergency return capability for the entire docked-operations period.

How can significant early science be restored on ISS? NASA and the science communities should identify currently approved experiments for early flights with durations of one to three months. NASA should sponsor continued development of the applicable hardware and plan for the early operation of these experiments. Science must be a priority in a more balanced ISS program plan that assures a large research-achievement-based return on investment as is expected by the American taxpayer.

Beyond the financial challenges that accompany any of these options, there is an additional issue: NASA must not barter away the very limited crew time now reserved for the U.S. science and technology communities. The United States has invested too much time and money in the building of the ISS to see its use traded away to solve short-term financial problems.
RECOMMENDATIONS

While the cost of completing ISS development and of operating the ISS must be limited to an acceptable level, an effort must also be made to get an adequate return on that investment by assuring its effective utilization for scientific research. The following recommendations are made toward that end:

- Promptly investigate the cost/benefit trades of the ISS options for utilization improvement identified above, as well as any other ideas of equivalent merit. The assessment of these strategies should benefit both ISS and science and technology users.
- Provide additional funding to sponsor timely development of one or more of the utilization options that have the best-expected cost/benefit ratio. This additional funding should not come at the expense of other NASA enterprises.
- View ISS utilization as an ongoing priority, on a par with infrastructure development, throughout the duration of ISS operations in addition to near-term improvements in utilization. New technologies or cost-effective capabilities should be applied to improve utilization in the future. ISS utilization upgrades must be a continuing part of the overall program planning and budget.
- Ensure a more balanced investment between the Station infrastructure and payloads by interleaving research capabilities and opportunities in the ongoing planning and implementation of the ISS program.

Billions of dollars have already been invested to build the ISS; it would be a great tragedy for the U.S. to fail to commit adequate funding to effectively utilize this research facility to enable the long-anticipated scientific return. The research objective of the ISS, to be an orbiting laboratory that brings the benefits of the unique space environment home to the American people, should not be abandoned. The United States must use this extraordinary asset to accomplish world-class research. An International Space Station, that brings nations together and space research results back to earth, can transform the future condition and well being of this planet’s citizens. Assuring its effective utilization for research is critical to achieving this goal.