NASA Report to Congress

Regarding a Plan for the

International Space Station National Laboratory

May 2007

NASA REPORT TO CONGRESS

REGARDING A PLAN FOR THE

INTERNATIONAL SPACE STATION NATIONAL LABORATORY

1.0 BACKGROUND

NASA prepared this report outlining a plan for the International Space Station National Laboratory in response to direction in Section 507 of the NASA Authorization Act of 2005 (Public Law 109-155). The specific requirements of this plan are outlined below.

SEC. 507. NATIONAL LABORATORY DESIGNATION.

(a) DESIGNATION.—To further the policy described in section 501(a), the United States segment of the ISS is hereby designated a national laboratory.

(b) MANAGEMENT.—

(1) PARTNERSHIPS.—The Administrator shall seek to increase the utilization of the ISS by other Federal entities and the private sector through partnerships, cost-sharing agreements, and other arrangements that would supplement NASA funding of the ISS.

(2) CONTRACTING.—The Administrator may enter into a contract with a nongovernmental entity to operate the ISS national laboratory, subject to all applicable Federal laws and regulations.

(c) PLAN.—Not later than 1 year after the date of enactment of this Act, the Administrator shall transmit to the Committee on Science of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a plan describing how the national laboratory will be operated. At a minimum, the plan shall describe—

(1) any changes in the research plan transmitted under section 506(3) and any other changes in the operation of the ISS resulting from the designation;

(2) any ground-based NASA operations or buildings that will be considered part of the national laboratory;

(3) the management structure for the laboratory, including the rationale for contracting or not contracting with a nongovernmental entity to operate the ISS national laboratory;

(4) the workforce that will be considered employees of the national laboratory;

(5) how NASA will seek the participation of other parties described in subsection (b)(1); and

(6) a schedule for implementing any changes in ISS operations, utilization, or management described in the plan.

(d) UNITED STATES SEGMENT DEFINED.—In this section the term ''United States segment of the ISS'' means those elements of the ISS manufactured—

(1) by the United States; or

(2) for the United States by other nations in exchange for funds or launch services.

2.0 INTRODUCTION

The International Space Station (ISS) constitutes a partnership among the nations of Canada, Europe, Japan, Russia and the United States (US) to cooperate on the design, development, operation and utilization of a permanently occupied civil space station. Assembly began with the first element launched in November 1998, and the ISS has been permanently crewed since November 2000. The on-orbit assembly, as of the STS-116 mission concluded December 22, 2006, is approximately 60% complete. All of the principal remaining US elements of the ISS, as well as the European and Japanese laboratories, have completed development, test and evaluation, and are awaiting launch at the Space Station Processing Facility, Kennedy Space Center.

In a major space policy address on January 14, 2004, President Bush directed NASA to focus its future human space exploration activities on a return to the Moon as prelude to future human missions to Mars and beyond. The NASA Authorization Act of 2005 (hereafter called the Act) also called for this renewed emphasis on space exploration. Included in this new national "Vision for Space Exploration" are plans to complete assembly of the ISS and retire the Space Shuttle fleet by the end of fiscal year (FY) 2010. In the second half of calendar year (CY) 2006, NASA demonstrated its commitment to achieve the FY 2010 objectives by successfully completing three Space Shuttle missions to the ISS. A $500 million NASA commitment also was made to partially finance demonstrations by 2010 of new US commercial orbital transportation services (COTS). These commercial services are planned to help support US maintenance and utilization of the ISS in the post-assembly era after the Space Shuttle is retired from service. Although the US commercial transportation services are targeted to be available in parallel with existing and

emerging space transportation assets of Russia, Europe and Japan, a cost-effective COTS capability is the preferred NASA option.

Along with concentrating NASA space systems development and operation efforts on space exploration, the US research mission for the ISS also was re-evaluated and subsequently refocused primarily on requirements-driven, exploration-oriented research. This research includes use of the ISS to develop, demonstrate, and deliver technologies, biomedical counter-measures, and technical and operational knowledge that will enable humans to withstand the rigors of space and permit more ambitious long-duration exploration missions. In addition, the Act mandated that 15 percent of the NASA funds budgeted for ISS research be dedicated to non-exploration oriented ISS research. While this combination of research committed NASA as the "anchor tenant", it also freed up ISS resources (e.g., power, cooling, communications…) and accommodations (e.g., laboratory space and external attachment sites) over and above NASA mission needs.

The Act also designates the US segment of the ISS as a "national laboratory" to be made available for use by US public and private entities.[1] **[Reference Tab 1]** Through this approach, basic and applied research and applications that are not applicable to the NASA mission can be pursued by those organizations whose own activities will directly benefit. NASA has embraced this legislative directive and launched a broad ISS applications development initiative as a result. This report summarizes NASA progress in this regard during CY 2006 and discusses the prospects for productive utilization of the ISS in the post-assembly timeframe.

Initial encounters with US government agencies have been positive relative to their potential use of the ISS. To date, a firm interest in the use of ISS has been demonstrated in the areas of education, human health related research and defense sciences research. In Section 2: Progress in CY 2006, the specific actions taken by NASA and the responses from these communities are discussed in detail. ***In brief, an inter-agency task force has provided a full report on the potential for using ISS to advance science, technology, engineering and math (STEM) educational objectives; a Memorandum of Understanding between NASA and the National Institutes of Health on use of the ISS is now under discussion; and, NASA is continuing to reach out to the private sector by an announcement of Sources Sought for commercial provision of water generation services on the ISS***. As these activities progress, NASA remains confident that further applications of ISS capabilities will emerge in parallel with the potential reduction in perceived risks resulting from: (1) completion of ISS assembly and (2) availability of next generation commercial space transportation services. This reduction in perceived risk will be key to the identification of sources of funding for non-NASA use of the ISS.

NASA is carefully considering the operations plan during the ISS post-assembly period. Before determining final details of management structures and processes, it will be important to reasonably define the scope of future ISS applications. The nature of research and exploration, through scientific and engineering applications, is such that discovery can influence outcomes at any point in an endeavor. The low-Earth orbit environment in which the ISS resides is a unique and relatively new human domain of activity; hence the opportunity for discovery remains rich and the effect on evolution of the national laboratory must be compatible in terms of management structures and processes.

The ultimate form of the ISS National Laboratory management structure, to some degree, will depend on the functional breadth of the organization. Several models of successful national and international management systems, as well as more tailored approaches, are under consideration by NASA and the NASA Advisory Council. Flexibility remains important at this early stage. In Section 3: Preliminary Operations Plan, several strategic considerations are discussed, such as the need for NASA to continue as the executive agent for integrating interests of other US government agencies that might not be inclined to work with a third party entity when seeking access to a US government asset. NASA also will continue to explore the benefits of an associated non-profit, or for-profit, management entity for non-government access to the ISS, in the event it becomes a valuable

[1] "US segment of the ISS" includes both US elements and US rights of access to international elements as defined in the ISS Memoranda of Understanding with the international partners.

feature in the evolving private sector space economy.

3.0 PROGRESS IN CY 2006

Completion of the ISS assembly phase is now appearing clearly on the horizon in FY 2010. During FY 2005, NASA recognized the need to focus attention on exploration-driven mission requirements for ISS, and the Exploration Systems Mission Directorate (ESMD) subsequently delivered a utilization plan to the Congress.[2] Following closely, the Space Operations Mission Directorate (SOMD) launched an applications development initiative directed toward public and private sector organizations having potential uses for the ISS as a national laboratory. In the context of this initiative, ***NASA is seeking partnerships with other government agencies… as well as the commercial sector to conduct research onboard the ISS".***[3]

In order to organize and expeditiously address the challenge of transition from the assembly phase to a national laboratory utilization phase, it was first necessary to step back and consider future ISS ***schedule milestones*** that will affect the operation and longevity of the facility and its various components. Within this context, the ***objective*** became clearly defined and ***constraints*** were established from national policy and technical perspectives. Development of an executable ***strategy*** followed that included a series of near-term ***tactical initiatives*** for achieving the objective. As a result of the work accomplished in CY 2006, NASA has made a number of ***preliminary findings*** that can guide the future development and evolution of a framework for ISS National Laboratory operations. The following sections discuss each of these aspects.

3.1 Schedule Milestones

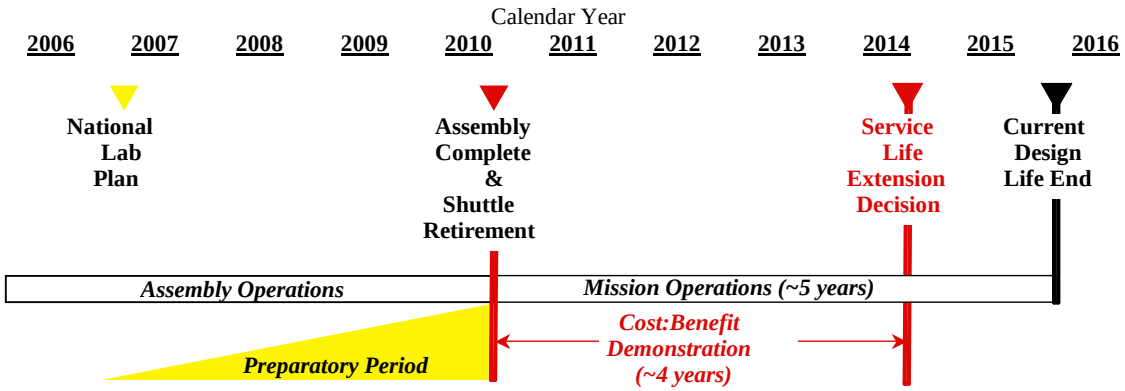
The design life of US ISS elements is defined in system specifications as 15 years from the time of deployment of the element on orbit. Since elements are deployed sequentially during the assembly period, the launch of the "US Laboratory" module, in February 2001, is most frequently cited as the nominal reference point for beginning the ISS "lifetime".[4] Formal life cycle costing studies to date have thus reflected FY 2016 as the corresponding milestone for completion of program operations. Nonetheless, past operating experience with both human-rated and robotic spacecraft clearly indicates that systems are capable of performing safely and effectively for well beyond their original design lifetime. Service life can be extended dependent on actual operating experience, and the selected approach to maintenance and refurbishment. The ISS program is proceeding with the analyses necessary to extend service life if warranted and affordable in the context of the larger exploration vision.

If outyear costs can be reduced to levels that accommodate both exploration and ISS operations post-2016, operation of the US Laboratory beyond 2016 would then require active extension of the certified design lifetime. The critical path for continued operation of the ISS as a coherent entity also would have to be evaluated in the broader context of the non-US ISS element design lifetimes. Since these steps could require analyses, tests or related actions at additional cost, decisions on whether or not to pursue service life extension options will begin to be required in the late FY 2014 timeframe. This will allow sufficient lead-time to conduct the work needed to validate any lifetime extension. Such a decision would be rationally based on a determination of the benefit and cost prospects for extended ISS operations at that time. Options available for re-supply logistics and maintenance would be important factors, as would be the desires and capabilities of the international partners.

[2] NASA Research and Utilization Plan for the International Space Station, June 2006.

[3] Written Statement of Michael D. Griffin, NASA Administrator, before the Subcommittee on Science and Space, Committee on Commerce, Science and Transportation United States Senate, April 25, 2006.

[4] In practice, the design lifetime is assessed for each ISS element as it becomes due. For instance, since the FGB and Node 1 were deployed earlier than the US Laboratory, their certification expires in 2013 and these elements also will need to be re-certified for an extended service life.



Considering that Station assembly is scheduled to be complete by the end of FY 2010, a four-year period exists during which the ISS will be able to demonstrate its value as a national laboratory, or as a platform for further NASA mission applications. Four years (FY 2011 through FY 2014) represents a relatively short operations period considering the lead times necessary to define, finance, organize and produce high-value, space-based missions. Therefore, it becomes important that any entity which intends to use the ISS take judicious steps during the FY 2007 – 2010 preparatory period in order to be operationally ready for ISS utilization at the conclusion of assembly.

Each of the major future milestones discussed above are illustrated in the figure above.

3.2 Objective and Constraints

Over the past decade, several program offices at NASA headquarters have examined and evaluated the possible uses of the ISS in the post-assembly timeframe. Explicit in these studies were corresponding "utilization management" structures and alternative approaches to recruiting, selecting, financing, producing and performing utilization missions on the ISS. Numerous external, expert sources were also consulted and their findings thoroughly documented. As a result, an extensive body of work is readily available to inform NASA's current initiative **[Reference Tab 1]**.

Explicit in all prior efforts were statements of objective. In reviewing this history, a persistent theme emerges that is consistent with the current policy to operate a portion of the ISS as a national laboratory. This common objective can be summarized as:

> ***Develop a diversified portfolio of productive research and application projects that exploit the unique attributes of the ISS and contribute to US scientific and technological leadership and economic growth.***

In the course of pursuing this objective, a limited set of NASA constraints must also be taken into consideration. Following the return-to-flight of the Space Shuttle, the completion of the ISS is the next step in the Vision for Space Exploration. The assigned NASA mission for the ISS is to enable exploration-driven research that supports the Vision. Thus, ***NASA uses of the Station to enable the exploration mission must command top priority***. Since the ISS was originally designed to accommodate multiple, concurrent mission applications, its capacity is robust and also capable of supporting non-NASA utilization mission objectives.

Due to the fiscal challenges of mounting a human and robotic space exploration program, while also sustaining a vigorous aeronautics research program, NASA must rigorously apply all available spending authority to its own Agency mission. For this reason, ***funds necessary to carry out the missions of other public or private entities must be funded by those entities,*** so to not impact the primary missions of NASA.

As operators of the ISS and stewards of this new national laboratory asset, NASA remains committed to covering the annual cost of ISS operations and maintenance for as long as the benefits to the nation are justifiable and the Agency's ISS operations' budget is reduced to permit both exploration and ISS operations. NASA is also resolute in its plan to employ the

ISS, and other spacecraft as they become available, to advance research on human physiology, in order to enable the long duration human space flight missions of the future.

Ongoing NASA Leadership Responsibilities

NASA recognizes that the single greatest risk related to the ISS that must continue to be addressed is that of safe and reliable operation. NASA is committed to continued analysis of the "aging" process of the ISS. An important ISS contribution to the future of space exploration will be improved understanding and prediction of failure modes in space flight systems, and the design of systems for extended life in space environments. This knowledge contributes toward improved system qualification techniques and standards and can enhance the effectiveness of future exploration infrastructures. ***Safety and reliability of space flight is a fundamental responsibility that NASA must continue to maintain in its role as a global leader of space exploration.*** The NASA management organization, with its linkages to national space agencies and industrial firms on a global scale, represents an enduring technical institution contributing toward the future development of both public and private space endeavors, as well as related activities here on Earth.

3.3 Strategy and Tactical Initiatives

The principal element necessary to successful operation of the ISS National Laboratory is a body of external organizations that are knowledgeable and prepared to undertake and fund missions in space, i.e., qualified end-users. Therefore, while continuing to define and evaluate potential management structures for the national laboratory, the ***NASA strategy is to focus early efforts on identifying qualified end-users from the public and private sectors.*** In order to ensure visibility and sustain advocacy at the highest levels of NASA leadership, the ISS management and applications development initiative is being directed at the Headquarters level by the Associate Administrator for Space Operations, and is under the direct cognizance of the NASA Administrator. The NASA Advisory Council is also actively engaged through periodic review and assistance in opening dialog with viable end-user communities, as well as in providing independent evaluations of potential management structures and processes.

Due to the complexity and potential hazards of space flight endeavors, written agreements must be employed to define key aspects of all relationships. In the public sector, agency-to-agency memoranda of understanding (MOUs) are used, while Space Act agreements (SAAs) accomplish a similar purpose in private sector arrangements. ***All such agreements will be formulated in strict accordance with statutory law and national policies.*** Close review will be coordinated with the NASA Headquarters Office of General Counsel on legal aspects, and the ISS Program Office in Houston, Texas will review and validate all technical requirements involving the use of government furnished equipment and facilities, ISS physical accommodations, and ISS utilization resources during the pre-flight, on-orbit and post-flight phases of the mission.[5]

The tactical initiatives that support this strategy fall into three general categories, each of which are discussed below:

- Public/Private Sector Initiatives in Education;
- Public Sector Initiatives in Research; and,
- Private Sector Initiatives in Applications.

Public/ Private Sector Initiatives in Education

NASA shares with the Administration and Congress a belief that education is the gateway to opportunity and the foundation of a knowledge-based, innovation-driven economy,

> ***"Accordingly, we are preparing the pathway for the next generation with great anticipation. These 'explorers and innovators of the new millennium' must fully represent our Nation's vibrant and rich diversity. Furthermore, we will support our Nation's universities, colleges and community colleges by providing exciting research and internship opportunities that 'light the fire' and 'fuel the passion' for a new culture of learning and achievement in STEM".[6]***

Stimulating youth to pursue STEM education with a view toward careers in scientific and technological vocations, as well as preparing the broader population for future technical opportunities and challenges and for its

[5] The initial list of ISS "utilization resources" are defined in the international MOUs to include power and crew time.

[6] Written Statement of Shana Dale, NASA Deputy Administrator, before the Committee on Science, House of Representatives, March 30, 2006.

participation in society, represents a growing national challenge.

As recently pointed out by the NASA Advisory Council, such stimulation of the "best and the brightest" of the nation is particularly critical to the agency's and the nation's future. The exploration of space has consistently been an area of fascination and excitement for young minds, and the ISS represents the most recent US government program to bring the stimulus of human space flight into classrooms at all levels of the educational system. ***During the first 10 expeditions to the ISS, almost a million students participated in some form of educational project involving interaction with the station or astronaut crew***. **[Reference Tab 2]** Successful educational projects have ranged from classroom versions of experiments to "*Saturday morning science*" hosted live by the ISS Science Officer. In the case of televised educational demonstrations, ***over 30 million students have had the opportunity to receive downlinks from the ISS that are broadcast via networks across the country***.

In recognition of the ISS potential for expanding the STEM educational impact, the NASA Office of Education established an interagency task force consisting of representatives from the educational offices of six US government agencies.[7] The task force's deliberations were further informed by consultations with members of a wide variety of private sector educational associations and industry trade groups. Meeting periodically during CY 2006, the task force evaluated future prospects for use of the ISS as an educational asset in their ongoing programs. In collaboration, an "ISS National Laboratory Education Concept Development Report" was produced, in which ***the task force concluded from its first phase of discussions that there is significant interest among Federal agencies in the opportunity to further develop the ISS as an asset for education.*** **[Reference Tab 3]** The opportunity for private sector participation in supporting various features of the ground-based portions of ISS-based educational projects was apparent. The opportunity for extending the "space university" concept to encompass the ISS is also notable in this context[8].

Over and above the need to develop educational content, the capability to transport student equipment and collateral educational materials was examined at length. It was clear that ***the availability and affordability of space transportation services is the principal obstacle to expanding a high-value ISS education program.*** As a result, representatives on the interagency task force can resume their efforts at such time new, affordable space transportation services emerge.

Public Sector Initiatives in Research

US government agencies are strong contributors to research in areas germane to their respective missions. The ISS, in turn, offers a unique and only recently accessible natural environment in which to conduct scientifically relevant experiments across the biological, chemical and physical research spectrum, as well as in the Space and Earth Sciences (e.g., geology, oceanography, meteorology). Prior space experiments conducted under NASA sponsorship, and frequently involving other government agency investigators, have produced positive results that suggest the opportunity for meaningful advances in a variety of fields. **[Reference Tab 4]** However, these fields are not all closely associated with NASA's recently focused mission of space exploration.

In recognition of the potential value of the ISS to support missions of other US government agencies, the NASA Administrator issued a letter of invitation to the US Secretaries of Energy and Commerce, and to the Directors of the National Institutes of Health (NIH) and the National Science Foundation (NSF). A response was received on the behalf of the NIH Director. **[Reference Tab 5]** Based on the positive results of prior space biotechnology research, coupled with NASA's ongoing program in human biomedical research, the Chairman and members of the NASA Advisory Council (NAC) organized a multi-agency meeting in December 2006 on "Space Related Health Research" **[Reference Tab 6]**. The goals of the NIH-hosted event were to share information across key Federal agencies about space-related health

[7] Department of Education, National Science Foundation, Department of Energy, Department of Defense, National Institutes of Health, and National Aeronautics and Space Administration.

[8] Schmitt, H.H., AIAA Conference Proceedings, Huntsville, AL, 1974.

research interests and activities, and to identify potential opportunities for collaboration to facilitate future research. Representatives from five Federal agencies attended to hear about research opportunities on the ISS in the new role as a national laboratory. During a round robin session, over a dozen briefings were offered on current areas of applicable research, and future interest areas of the NIH, NSF, Food and Drug Administration (FDA), National Institute of Standards and Technology, and the US Department of Agriculture (USDA). As a result of the December 2006 meeting, ***NASA and NIH are now on a course to develop an MOU that will provide a framework for NIH to encourage use of the ISS as a national laboratory*** for research in related space and terrestrial physiology such as bone, muscle and immunology**.**

In addition to scientific research pursuits under civilian programs, NASA maintains a close ongoing relationship with allied interests in the defense sciences research community. Each year a Space Experiments Review Board (SERB) meets to evaluate and recommend candidates for future US Department of Defense (DOD) space missions under the Space Test Program (STP). During the November 2006 meeting of the SERB, the ISS National Laboratory opportunity was reviewed by military leaders from all services. NASA re-affirmed its commitment to continue to accommodate DOD scientific research in accordance with existing defense policy guidance. **[Reference Tab 7]** To date, the STP has fielded multiple missions employing the ISS, and further missions remain on the drawing board scheduled for future flight opportunities[9].

For both civil and defense agencies involved in research and development (R&D), there is a thorough understanding of the technical challenges associated with design, development and operation of space-based missions. In the case of the ISS, ***affordable space transportation services remains the single greatest barrier to fielding a productive public sector program in research***. Transportation can represent the greatest cost component in space R&D; thus, the availability to acquire cost-effective transportation services will directly affect the success of ISS as a national laboratory in the years to come.

Private Sector Initiatives in Applications

There are numerous forums engaged in advocating commercial space development in an effort to stimulate a new space economy. All involved recognize the pivotal role that affordable space transportation plays in closing the business case for any private sector venture. To this end, NASA has committed $500 million toward the demonstration of commercial orbital transportation services (COTS), and created a government market for such services by the demand inherent in maintenance and utilization of the ISS National Laboratory.

In the past, private firms have demonstrated interest and participated in space research across topics as diverse as molecular biology, tissue culturing, bone demineralization, antibiotics production, plant genetics, combustion synthesis, and ultrahigh vacuum and microgravity processing of materials. Increasing the frequency and predictability of access to space, in order to sustain consistent progress toward a research objective, has proven to be a necessary requirement for success. NASA looks forward to COTS demonstrations by the end of this decade that will satisfy this requirement.

In addition, NASA continues to explore the potential for agreements with private sector firms that involve use of ISS accommodations and resources as test beds for engineering research. Although numerous discussions have taken place on topics as broad ranging as test beds for electric propulsion, laser-optic communications and wireless power transmission, ***it is premature to identify commercial end-users that are fully prepared to undertake the risks associated with future space missions***. The perception of risk is closely related to two factors: (1) remaining challenges in the ISS assembly process and (2) uncertainty in the future price and availability of space transportation services. As these uncertainties fall away toward the end of the decade, confidence may rise and private sector interest in use of the ISS National Laboratory may then develop.

During the period leading up to ISS assembly completion and COTS demonstration, NASA will continue to participate directly in discussions with private firms and host sessions under

[9] Basic scientific research sponsored by the US Department of Defense is undertaken consistent with the Intergovernmental Agreement on use of the ISS for peaceful purposes.

the sponsorship of industry trade associations. This was most recently demonstrated by NASA's attendance at a ***May 2006 "Commercial Space Forum",*** organized by the California-based Alliance for Commercial Enterprise in Space, and in NASA's organization of a ***January 2007 Special Session on "ISS a New National Laboratory"*** at the 45th Annual Aerospace Sciences Meeting, which was sponsored by the American Institute of Aeronautics and Astronautics. **[Reference Tab 8]** Under development for CY 2007 are efforts that work with the National Chambers of Commerce and establish linkages between space entrepreneurs and industry sponsored investor forums.

Finally, the model of procuring commercial services, instead of financing government-developed systems, is emerging strongly now that the COTS approach is setting the precedent. Based on this promise of success, NASA hopes to pursue an analogous ***opportunity for commercial water production services on the ISS*** utilizing the Sabatier process for recovery of carbon dioxide and hydrogen effluents from the environmental control and life support system. Rather than develop this important future capability under a government-funded program, NASA issued a January 2007 Sources Sought announcement for an industrial supplier of the service. **[Reference Tab 9]** This initiative is designed to expand the market for commercially supplied services to the ISS National Laboratory.

3.4 Preliminary Findings

This past year was a very active year both from the perspective of resuming ISS assembly, with three successful Space Shuttle missions in a six-month period, and in terms of implementing an applications development initiative consistent with designation of the ISS as a new national laboratory. In order to sustain progress on this latter objective in CY 2007 and beyond, it will be important to recognize and directly address the rate-limiting parameters that are applicable for each of the tactical initiatives:

- The **Public/Private Sector Initiatives in Education** can build on significant interest among Federal agencies in the opportunity to further develop the ISS as an asset for education. Fortunately, the cost of educational projects is an order-of-magnitude less than that of most R&D efforts.

- The **Public Sector Initiatives in Research** will be paced by ongoing evaluations made by US government agencies. Agencies sponsoring research initiatives that offer prospects for increasing knowledge may need to acquire the space transportation services and support for those efforts.

- For the **Private Sector Initiatives in Applications,** progress is dependent on a reduction in the perception of risk due to remaining assembly challenges, and the cost and availability of space transportation services. As these milestones are achieved and perceptions change, business cases can close at acceptable risk levels for products and services commercially supplied, instead of government developed.

The rate-limiting parameters for success are not related to the ability to form public, or private, partnerships -- NASA has the necessary instruments of agreement (e.g., MOUs, SAAs, contracts, grants, cooperative agreements) and has consistently demonstrated the ability to apply these tools effectively in cases where mutual benefits and responsibilities can be identified. Once the range of qualified and committed end-users becomes clearer, the management structure can be tailored to meet specific needs, and leverage to the maximum degree practical existing management practices of respective end-users. NASA, in close coordination with the NASA Advisory Council, will continue to examine future options for management structures in parallel with end-user identification. The availability of an experienced workforce and ground-based assets is, likewise, not a pacing item. These resources can be applied on a case-by-case basis in accordance with specific needs and terms of partnership agreements.

The rate-limiting parameter for success is affordable and reliable space transportation services to and from the ISS. The ***availability of cost-effective transportation services will directly affect the ability of the ISS to operate as a national laboratory in the years to come***. In the absence of such a capability, uses will be limited to the achievement of space exploration mission objectives that are to be accomplished within the NASA programs. In order to fully evolve in the capacity of a national laboratory, public funds may be required and private

investments will be needed to pursue non-government objectives.

As the plan for operating the ISS as a national laboratory evolves, the composition of the end-user communities will affect the outcome. The future management structure will rationally reflect practices of the public and private sector sponsors of ISS missions. ***If the range of sponsors is broad and diverse, a new management authority may be required***.

With these considerations in mind, the following section of this report provides a broad outline for a preliminary "operations plan" as requested by the Congress. The emphasis is focused on flexibility to respond to the environment as practical considerations, such as other government agency spending authority and cost of commercial space transportation systems, come to bear on the situation at hand. Lastly, it is worthwhile to recall that the nature of research and exploration, through scientific and engineering applications, is such that discovery can influence outcomes at any point in an endeavor. The low-Earth orbit environment in which the ISS resides is a unique and relatively new human domain of activity; hence the opportunity for discovery remains rich and the effect on evolution of a national laboratory must be compatible in terms of management structure and processes.

4. 0 PRELIMINARY OPERATIONS PLAN

Section 4.0, Preliminary Operations Plan, addresses the ISS Research Plan submitted to Congress in June 2006; ground-based assets and flight equipment; the government workforce; and participation of other agencies. This section also addresses the proposed management structure for the national laboratory and the schedule for implementation. The proposed management structure and schedule discussions acknowledge that it is too early to describe detailed plans for management models with implementation timelines. This section describes a phased implementation process with NASA continuing to operate the national laboratory while working with other government agencies and the private sector. In the second phase, depending on the end-user, the national laboratory could evolve into an institute or other entity to manage participation by other non-government organizations. This phased implementation provides the greatest flexibility to match the management model with the national laboratory user communities.

Research Plans and Partnerships

NASA remains committed to the ISS as its primary analog for long-duration space missions beyond low-Earth orbit. As articulated in the NASA Research and Utilization Plan for the ISS, as submitted to the Congress in June 2006, NASA has re-focused its ISS research to meet agency exploration needs.[10] As humans venture further into space, the next generation of long-duration human exploration missions will need:
(a) Crew that can withstand the rigors of space;
(b) Spacecraft systems with high reliability and longevity; and
(c) Long-term operational experience at the crew-systems interface.

The research and utilization plans of potential future public or private sector entities are not known and cannot be fully predicted at this stage. Due to the CY 2006 initiative, NASA is now in the process of pursuing MOUs with other Agencies, such as the NIH, regarding frameworks for potential future uses of the ISS. Once these MOUs are formalized, potential US government interests in using the ISS will be better understood. Since each MOU serves as a model for the next, valuable lessons are anticipated as the ISS National Laboratory evolves from concept to practice. Administrative aspects will be elucidated and "best practices" can be brought to bear on future management structure and processes.

Workforce and Ground-Based Assets

US Government workforce and ground-based assets can be made available in accordance with the negotiated terms of new MOUs and SAAs, and within the boundaries of existing international agreements. The specific terms depend on the objective and perceived benefits to the parties of each unique agreement.

In addition to ground-based assets, NASA continues to maintain flight equipment that was originally developed to conduct research on the ISS. In some cases, this equipment currently

[10] http://exploration.nasa.gov/documents/reports.html

resides on the ISS, while in other instances it may be awaiting flight, or flight plans may have been suspended due to changes in the NASA research program. **[Reference Tab 10]** Such equipment can also be made available under terms of specific agreements.

Management Structures

NASA researched possible government and non-government organizations weighing the positive and negative attributes of each model to enhance ISS utilization. An independent review of potential management structures is also underway by the NASA Advisory Council. Based on NASA's research, much of which is captured in a recent report by the Congressional Research Service[11], NASA has determined the best approach for the ISS National Laboratory, in the event of growing interest from a non-government community, would be through a phased transition.

In Phase I, which is already underway, NASA will continue to operate the ISS National Laboratory with a focus toward identifying qualified and committed end-users and putting in place agreements for the post-assembly time period. NASA will establish a small project office within the Space Operations Mission Directorate to work with other US government agencies and the private sector. Much of this work has begun already. NASA has been in contact with other Federal agencies and private firms, and is continuing to coordinate informational sessions to discuss opportunities for access to the ISS National Laboratory.

In Phase II, provided non-government demand for access to the ISS National Laboratory evolves to a scale that warrants, NASA could establish an institute, or other cost-effective entity, to manage opportunities for non-government organizations that are pursuing applications unrelated to the NASA mission. At the strategic and tactical levels, NASA would work closely with such an institute or entity to facilitate the integration of its applications portfolio with NASA's ongoing research mission, and within the overall availability of US accommodations and resources on the ISS.

[11] Congressional Research Service Report for Congress RL30533, *The Quasi Government: Hybrid Organizations with Both Government and Private Sector Legal Characteristics*, by Ronald Moe & Kevin Kosar (2005).

NASA currently considers an institute to be the preferable organizational structure for management of non-government interests in the ISS National Laboratory because it provides the greatest flexibility to evolve in parallel with potential future scientific, technological and commercial interests. It is an organizational body created for a defined purpose, which can operate either as a for-profit or nonprofit entity. It could be created by contract, cooperative agreement, grant or other transaction (SAA). However, other organizational structures are available and will be examined in further detail prior to implementing Phase II.

NASA will continue to be the executive agent for other government uses of the ISS. In this manner, NASA will also ensure that the ISS is operated as a national laboratory within the boundaries of all precedent international agreements.

5.0 CONCLUSION

The ISS continues to be an important destination and laboratory for exploration-focused NASA research. Research into the effects of microgravity on the human body, and reliable counter-measures for these effects, is ongoing and will continue for the foreseeable future. In addition, ISS affords a unique facility to perform technology demonstrations for future incorporation into NASA space flight systems.

The prospects for use of the ISS by other Federal entities are promising. The work conducted in CY 2006 indicates interest is already strong in the areas of human health research, defense sciences research and projects designed to advance national STEM educational objectives. In each of these cases, other US government agency spending authority may be necessary.

At this early stage, the perception of risk on the part of non-NASA entities remains high due to two factors: (1) the ISS assembly challenge that remains between 2007 – 2010 and (2) the need for demonstration of next generation, lower cost commercial space transportation services by the close of CY 2010. As this decade comes to an end, the perception of risk should decline so that additional interest in the use of the ISS could emerge. Once the COTS capability is demonstrated, public and private organizations

will be able to procure transportation services directly from US vendors.

Steps taken in the 2007 – 2010 preparatory period will determine the outcome of the 2011 – 2014 utilization period. This will position the US government for a sound decision on ISS lifetime in consideration of the benefit-to-cost trade that NASA must finalize in the 2014 time frame.

APPENDICES

Tab 1: Public Law 109-155, Section 507: National Laboratory Designation
and,
Bibliography of Prior NASA Studies on ISS Utilization Management

Tab 2: Inspiring the Next Generation: Student Experiments and Educational Activities on the ISS 2000 – 2006, NASA/TP-2006-213721, 2005.

Tab 3: Multi-Agency, ISS National Laboratory Education Concept Development Report, December 2006.

Tab 4: Representative Exhibits on ISS Scientific Research Prospects

Tab 5: Letter from NASA Administrator [M. Griffin] to DOE Secretary [S. Bodman], DOC Secretary [C. Gutierrez], NIH Director [E. Zerhouni] and NSF Director [A. Bement] Inviting Participation in ISS National Laboratory Applications Development.
and,
Letter from Director, National Institute of Arthritis and Musculoskeletal and Skin Diseases, NIH [S. Katz] to NASA Administrator [M. Griffin] regarding working with NASA on the ISS National Laboratory initiative, December 6, 2006.

Tab 6: Agenda, Summary and Attendees List for Multi-agency Meeting hosted by National Institutes of Health, December 8, 2006.

Tab 7: Memorandum from DOD Deputy Secretary of Defense [P. Wolfowitz] to Secretaries of the Military Departments regarding "Space Test Program Management and Funding Policy", July 8, 2002.

Tab 8: Agenda and Summary for AIAA Special Session on ISS - A New National Laboratory at 45th Annual Aerospace Sciences Meeting, January 11, 2007.

Tab 9: NASA Sources Sought and Presolicitation Notices for Sabatier-Based Water Production Services on ISS, January 9 and April 17, 2007.

Tab 10: Inventory of NASA Equipment Available to Support National Laboratory Operations under terms of MOUs and SAAs