Statement of

Louis Stodieck, PhD
Director of BioServe Space Technologies
Research Professor, Aerospace Engineering Sciences
College of Engineering and Applied Science
University of Colorado

before the

Committee on Science and Technology
Subcommittee on Space and Aeronautics

April 24th, 2008

Chairman Udall, Ranking Member Feeney and members of the subcommittee, thank you for inviting me to testify on a subject that I feel is very important to our nation. As you will see, I believe there is tremendous potential for the International Space Station (ISS), as a National Laboratory, to be utilized for high-value research and development in low-Earth orbit. I also hope to convince you that more must be done now to position the ISS National Laboratory to succeed.

My name is Louis Stodieck and I am a Research Professor in the department of Aerospace Engineering Sciences at the University of Colorado at Boulder. In addition to my academic role at CU-Boulder, I am privileged to serve as the Director of BioServe Space Technologies, a space life sciences research center. BioServe was founded in November 1987 through a NASA grant to the University. Through its 20-year history, BioServe's mission has essentially remained unchanged: we work in partnership with industry, academia and government to conduct space life sciences research that primarily focuses on commercial applications that could benefit the public. BioServe has served the biotechnology, pharmaceutical, agribusiness and biomedical industry sectors with most Center projects focusing on the effects of microgravity, often referred to as weightlessness.

Starting with our first flight in 1991 on STS-37, the Center has flown 40 payloads on 29 missions. Our experiments have launched on the Space Shuttle, Progress and Soyuz vehicles and were operated in orbit on the Space Shuttle, the Russian Mir space station and, more recently, the International Space Station. A wide range of experiments have been carried out across the full spectrum of space life sciences applications that have evaluated molecular processes, cell and tissue biology and the development and adaptation of various plants and organisms. BioServe's commercial partners have included large Fortune 500 companies such as Amgen, Bristol-Myers Squibb, Procter and Gamble and Weyerhaeuser along with numerous start-up and established smaller life sciences companies.

It is through the above activities that I feel I am qualified to present to you today the reasons why the nation should capitalize on the ISS and utilize its capabilities to the greatest possible extent.

Potential for R&D on the International Space Station

The International Space Station (ISS) represents an incredible human achievement for which our nation and our International Partners can be very proud. The launch of the first ISS element took place just under 10 years ago in 1998. Today, the ISS is a remarkable orbiting laboratory with unequaled capabilities. It represents the culmination of the dedication and commitment of thousands of people who have worked tirelessly on the design, fabrication and on orbit assembly of this massive undertaking. The ISS also represents an unparalleled opportunity in human history: The ability to use the "lens" of microgravity to understand and exploit gravity as a physical force. The ISS offers a superb vantage point from which to observe the Earth as well as providing access to the space environment, attributes that can both be exploited for research. The ISS is rapidly growing in capability and even now can support a wide array of research and development activities that simply cannot be done on Earth.

During the last 10 years, the focus for the ISS Program has necessarily been on assembly. NASA's ISS Payload's Office at the Johnson Space Center has done an excellent job of supporting research utilization, but in reality such utilization has had to take a back seat to ISS assembly and maintenance. The focus on assembly has meant that comparatively little transportation volume, mass, power and, probably most important of all - crew time - have been available to utilize the ISS to any significant extent. As a result, many of the ISS racks and equipment are currently sitting idle awaiting the day when ISS utilization can be ramped up. So, when can ISS utilization be ramped up, and what will it take to do so?

Based on the current schedule, the ISS project is now only 2 ½ years away from completion. At that point, the ISS can be officially and substantially opened for business. A significant part of that business, in my mind, ought to be scientific and commercial research and development. It will indeed be unfortunate if the ISS remains substantially under-utilized once it is completed in 2010. I hope instead that with proper planning and strategic investment now, the ISS will be able to live up to its fullest potential as a unique laboratory the like of which has never before been available and possibly never again will be in our lifetime. It is probably not possible to predict when the ISS will reach the end of its lifetime and be decommissioned, and it seems quite premature to discuss this when the lab is not yet completed and anything close to full utilization remains unrealized. However, the operational lifetime of the ISS is currently certified only through 2016. Even if this date is extended, it should be clear to all of us that the ISS will be available to serve the interests of the U.S., our International Partners and, more broadly, humanity for a finite period of time. Once the space shuttle is retired, our ability to service and replace major components of the ISS will be severely constrained. This ultimately could limit or reduce the amount of science that is conducted in this laboratory. Compare this situation with that of the Hubble Space Telescope. Just imagine how the lifetime of the Hubble Space Telescope would have been shortened and consider the amount of science lost without space shuttle servicing missions. The period of actual use of the ISS after assembly complete may be only 5 to 10 years and may be determined more by an inability to maintain safe operations than by U.S. policy. Thus, it will be very important to derive the most benefits possible from this incredible, one-of-a-kind laboratory as early as possible and for as long as possible.

Currently, NASA remains the predominant user of the ISS. Research is being performed to better understand the negative effects of long-duration space flight on the human body and to develop countermeasures and technologies to mitigate these effects. Non-exploration utilization research on the ISS has been conducted but only on a limited basis due to resource constraints and NASA's focus on the Exploration Vision. If the ISS is going to live up to its full potential, then clearly the productivity of the station must significantly increase, especially for non-exploration research.

Before discussing the future of ISS utilization, I believe it is important to revisit the potential that ISS represents and why planning and further investment should be considered to jump start the great body of work to be done there.

Value of ISS as a National Lab

It is easiest for me to speak from the experience and flight research projects that my Center has directly sponsored or supported. Of course there are numerous articles and studies that have identified and vetted the best R&D applications for the ISS across a host of scientific disciplines. The examples below are based in the life sciences, which is the focus of our Center and my area of expertise.

Despite significant funding challenges over the last few years following the termination of NASA's Space Product Development program, the program within NASA under which BioServe was funded, BioServe has strived to remain productive in space flight research endeavors. We have done so for the simple reason that we believe strongly in the potential of the ISS to benefit the general public, commerce, scientific knowledge, technology development and education. Since December of 2006, space flight hardware designed and developed by BioServe has supported 17 different commercial, international, NASA and K-12 research projects. These research experiments have flown on 5 different shuttle missions, launched and landed on the Russian Soyuz spacecraft, and spanned 3 ISS increments. In addition, BioServe has had operating research hardware on board the ISS since December of 2002.

Over the years BioServe has worked with several different commercial companies in support of collaborative research with commercial applications. Some of these companies are mentioned above but the most recent support of commercial research involved experiments conducted in collaboration with Amgen and Spacehab.

Amgen, one of the world's largest biotechnology companies, has collaborated with BioServe in the area of disuse bone and muscle loss since 1995. During this time BioServe conducted ground- and space-based studies both to verify the models utilized in these studies as well as to determine the effectiveness of two Amgen developed investigational compounds designed to reduce or prevent significant bone and muscle loss associated with certain types of disease and disuse conditions. This work culminated in two successful space flight experiments, one conducted on board STS-108 and the other on board STS-118. For each experiment, in addition to the primary research that was conducted, Amgen agreed BioServe could arrange a tissue-sharing program in which unused tissues from the space experiments were given to over 20 separate investigators each researching the effects of space flight and microgravity exposure on different physiological systems. In essence with careful planning productivity was greatly enhanced despite limited resources. Although these two space flight experiments were shuttle missions, it is believed that significant additional information could be learned through longer duration studies on board ISS.

The research projects with Amgen show the potential for alignment between industry and NASA goals and needs in the broader context of the ISS National Lab. For example, the research investigation of a bone therapeutic on STS-108 was part of a much larger traditional development program being conducted by Amgen. Today, that development program has led to a therapeutic called Denosumab which is in Phase III clinical trials. In addition to helping patients with osteoporosis, bone metastases, and other serious bone loss conditions, this drug could become a highly effective countermeasure for future flight crews exposed to long-duration skeletal unloading. In the context of the ISS National Lab, this project shows the potential for industry-sponsored research to benefit the company, NASA's exploration vision and the general public.

As part of a Space Act Agreement that is being completed between NASA and BioServe to support ISS National Lab commercial pathfinder research, BioServe recently collaborated with Spacehab Inc. to launch a series of commercially applicable experiments in the area of vaccine development for certain infectious diseases. The first of these payloads launched in March on board STS-123 and the second is scheduled to launch in May on board STS-124. The results, while still preliminary, are very encouraging. Spacehab, which is represented here today, can speak more to this promising work.

Additionally, BioServe supported four NASA peer-reviewed life science researchers on board STS-123. The Microbial Drug Resistance and Virulence or MDRV payload was sponsored by NASA's Exploration Systems Mission Directorate under the non-exploration research program. As the payload name implies, the research conducted by these investigators focused on the effects of space flight on virulence in pathogenic microbes, specifically bacteria, and antifungal resistance in a yeast model organism. This research has tremendous space- and Earth-based applications. Again, one of the investigators from this mission is here today and can speak to the value of this important work.

BioServe has a long history of providing training and educational opportunities to graduate, undergraduate and K-12 students. The Center has trained and educated over 115 graduate students since its inception. BioServe students are highly sought by NASA and industry once they graduate due to the unique education in bioastronautics and hands-on training received within the Aerospace Engineering Sciences department and at the Center. This important benefit of the ISS National Lab simply cannot be overstated. With the sharp cuts by NASA in the physical and life sciences, universities and colleges have lost critical support for students to keep them engaged in these important fields. More importantly, academic institutions have lost the single largest set of opportunities for students to be involved with the human space program. Without this connection, I fear that fewer and fewer students will pursue lines of study and choose careers associated with NASA's ambitious Vision for Exploration. The ISS National Lab has the potential to restore some of these lost opportunities.

In late 2006 BioServe started a formal K-12 education program called CSI. CSI brings actual space flight experiments into the K-12 classroom. Through its education partners, curriculum supplements are developed for each CSI experiment. These materials are delivered to participating classroom teachers via the internet. Once the experiment is activated on orbit, images and data of the experiment are downlinked to BioServe and then uplinked to the educational website. Students are able to conduct their own "ground controls" in the classroom and compare their results on a near-real time basis to the space experiment. These experiments have examined seed germination, growth of metallic salts in silicate solutions, multi-generational organism growth in space and plant development. The CSI-01 and 02 projects have reached over 10,000 students. This program is an excellent example of utilizing a national asset, the ISS, to inspire K-12 students in science, technology, engineering and math. It utilizes a unique element, the ISS, to promote inquiry of gravity's effects and influence on our every day lives. In turn, this type of activity creates a very real connection between students and parents and the tremendous accomplishments of NASA and the ISS.

This brief description of work we have recently been conducting provides what I believe is only a very small glimpse into what could be possible on the ISS National Lab if research utilization were significantly stepped up. There is great potential to use ISS to advance applications in biotechnology, life sciences, fluid physics, fundamental physics, combustion, energy, Earth sciences, materials and biomedicine. Of course, there are critics of the ISS who disagree with this statement as would be expected when competing interests come into play. I would argue, however, that the work done to date on the shuttle and on the ISS has shown the potential of the ISS National Laboratory to produce a rich return for taxpayers and that far greater benefits and discoveries await us. In any event, strict scientific return on investment should not be the sole measure of the worth of taking the ISS National Lab to the next level. Like it or not, the investment to build and assemble ISS in orbit has been made. We should now recognize the historically unique capability of this tremendous facility and exploit that capability to the maximum extent possible while we can.

Status of ISS National Lab Utilization

It is difficult to assess the current status of ISS utilization without first considering how we arrived where we are today. It is well known that NASA policy concerning utilization of the ISS changed dramatically in January 2004 with the release of the new Vision for U.S. Space Exploration. The new vision for NASA clearly enumerated that the NASA Administrator should:

- "Complete assembly of the International Space Station, including the U.S. components that support the U.S. space exploration goals and those provided by foreign partners, planned for the end of this decade;"

- "Focus U.S. research and use of the International Space Station on supporting space exploration goals, with emphasis on understanding how the space environment affects astronaut health and capabilities and developing countermeasures;"

Two significant decisions by NASA leadership pertinent to the future of the ISS followed from the new Vision for Exploration policy:

1. NASA's life and physical science programs were drastically cut with many lines of research being eliminated altogether. Even life sciences research that was seen as supportive of the Vision for Exploration but was more fundamental in nature or involved preclinical animal models, was effectively canceled. For many scientists within NASA and at universities across the country, these decisions translated to the termination of grants and forced the redirection of research programs, even whole careers. Hundreds of college undergraduate and graduate students were discouraged from engaging in physical and space life sciences research. The development of much of the life and physical sciences equipment that was being built to support robust research programs on the ISS was canceled.

2. As part of the realignment of NASA programs to the Vision for Exploration, in 2006, NASA terminated the Space Product Development program, which at the time supported 11 Research Partnership Centers around the country, including ours. Many of these centers were engaged in commercial research and development activities that planned to utilize the ISS.

These changes, along with others, certainly had the desired effect to reprogram significant funding and define budgets to carry out the Vision for Exploration and help focus NASA squarely on the development of replacement vehicles to the space shuttle and the development of plans and hardware systems to return to the Moon.

Of course these decisions also placed in serious doubt the future of the ISS as a world-class, productive research laboratory in space, as had been originally envisioned. The momentum that had been built up by the collective efforts of thousands of people was depleted by these decisions in what seemed a very short period of time. There are in fact few organizations remaining today with the knowledge and expertise to conduct ISS utilization. Even now, these organizations are at risk of disappearing altogether and would take years to recreate.

The NASA Authorization Act of 2005 designated the U.S. segment of the International Space Station as a National Laboratory. This designation was made as a result of strong leadership within Congress who recognized that limiting ISS utilization to only exploration research would do a disservice to the taxpaying public and the myriad of ISS stakeholders who should expect a reasonable return from the ISS in the form of scientific advances, new technologies, economic development, inspiration of education in technical fields and overall societal enrichment. This designation clearly opened the door to reestablishing the ISS as an important and productive R&D facility.

The designation of the ISS as a National Lab represents an important step in the right direction. However, this step by itself is insufficient to ensure that ISS will be productive in supporting high-value R&D activities. In my view, there are three actions that need to be taken for the ISS National Lab to become successful.

1. Establish an independent management organization to provide leadership and oversight of the ISS National Lab R&D activities.

2. Provide modest funding to encourage and support non-NASA agencies, U.S. industry, universities, colleges and other organizations to utilize the ISS.

3. Ensure regular, reliable and frequent transportation access to and from the ISS.

Please allow me to expand on each of these steps.

ISS National Lab Management Organization

The ISS National Lab designation from the 2005 Authorization Act establishes the potential for the ISS to be used for non-exploration research but does not establish a path by which this is to happen. In essence, this designation establishes the national lab facility without specifically identifying the people who would manage it. Imagine if Brookhaven National Lab, with its incredible facilities, were operated and maintained but no organization existed to serve the extramural research scientists and communities who might want to use the facilities. The productivity of Brookhaven's facilities would drop off precipitously.

The NASA Report to Congress regarding a Plan for the ISS National Laboratory in 2007 partially addressed the question of management. In the report, NASA acknowledged the issue and indicated that various management structures had been considered to create a possible future ISS National Lab management organization. The report went on to recommend a two-phase approach to implementation. Phase I, which is currently being followed, utilizes the expertise of a small project office at NASA headquarters under the direction of the Associate Administrator for Space Operations. In this phase, NASA is focused on identifying end-users of the ISS National Lab and securing agreements intended to provide access to NASA expertise and eventual access to ISS for R&D activities. Phase II would occur depending on whether demand for access to the ISS National Lab evolved to a scale that would warrant such an organization. In this event, *"NASA could establish an institute, or other cost-effective entity, to manage opportunities for non-government organizations that are pursing applications unrelated to the NASA mission."*

I am very encouraged by the steps that NASA has so far taken in creating a small project office at headquarters and by the accomplishments of this office. Clearly, our Center is a beneficiary of the work of this office through the Space Act Agreement about to be completed. However, demand for the use of the ISS is already high and continuing to grow. This can be evidenced, in part, by the increasing number of agreements being formed with NASA by various organizations including, commercial, academic and government, all of which are interested in utilizing the ISS. Many of the witnesses here today are testifying about these interests. I would argue that now is the time to move into the second phase of the ISS National Lab management strategy identified in NASA's report. An effective management organization put into place now should have a strong initial focus on expanding the user base by providing outreach to scientists, engineers and leaders of R&D organizations. This would continue to build demand for ISS utilization, which would lay the foundation for a high level of productivity of the ISS National Lab soon after completion of the ISS facility in 2010.

How can an organization capable of leading ISS National Lab utilization be created in a short time frame? One approach could be pursued by the ISS National Lab office at NASA headquarters. Specifically, this office could seek interested parties, identify one or more qualified organizations and then proceed to execute a Space Act Agreement that would establish a public-private partnership to oversee ISS National Lab utilization on behalf of multiple users. I have recently become aware of one such organization that allows me to believe that this approach would be possible. The Biotechnology Space Research Alliance (BSRA) is a self-organized partnership between university, industry, foundation and economic development organizations. The purpose of BSRA is to facilitate access to the ISS National Lab and create benefits for the biotechnology industry sector in Southern California. This represents a possible model of how an ISS National Lab management organization might be structured. It should also be pointed out that BSRA could grow to support other industry sectors and expand to meet the needs of other regions across the nation.

The ISS National Lab management organization should be chartered to develop and manage a rich portfolio of non-exploration research activities on the ISS. To be clear, this organization would not be intended to replace the office at NASA headquarters but rather to greatly augment its efforts. This organization also would not replace any of the responsibilities of NASA's Payloads Office, which serves to integrate requirements for flight research across all users of the ISS including exploration and non-exploration research, but rather work hand-in-hand with this group.

An effective ISS research management organization would have a number of key responsibilities in supporting the ISS National Lab:

1. Perform outreach to scientists across multiple disciplines such as physics, materials science, life science, biomedicine, chemistry, Earth science, etc. The organization would educate scientists and others on the known effects of gravity, the space environment and other space attributes and how conducting studies on the ISS might benefit their research. The ISS would essentially be marketed to prospective university, government and commercial users. The goal would be to identify researchers whose work could benefit the most from utilizing the ISS and develop a substantial portfolio of prospective R&D projects.

2. Develop a selection process to prioritize and support the best research from a regularly updated list of candidates. The goal would be to serve as a fair broker in selecting research, particularly when flight resources are constrained, based on criteria that would be established by the organization when it is formed.

3. Work to seamlessly integrate and fly research as a turn-key operation. The goal would be to take responsibility for the onerous process of flying research so that the scientists can focus solely on their science.

4. Work closely with the ISS Payloads Office to streamline the process of integrating and certifying research for flight. The goal would be to shorten the payload processing timeline as much as possible so as to maximize the productivity of the ISS National Lab.

5. Maintain a database with key specifications for all space flight research hardware that might be used on the ISS. In some cases, the organization might maintain an inventory of

flight hardware and make this hardware available, as needed. The goal would be to match the best available hardware with a particular research project to avoid duplicate hardware development.

6. Assist NASA to archive results from work performed on the ISS and effectively communicate these results to the public.

ISS National Lab Utilization Costs

Performing research in orbit is more expensive than comparable ground-based research. Conducting a research investigation on the ISS could include 1) the cost of the science itself (research team, materials, analyses, etc.), 2) the cost for development of new hardware necessary to meet the science objectives, 3) the costs for payload integration, operations, preparation and flight certification, 4) the costs of transportation to and from the space station and, 5) use of the ISS and associated resources (power, crew time, volume, etc.).

Within the concept of ISS as a National Lab, it is appropriate that the research sponsor or beneficiary would cover the cost of the research itself. This expectation would apply whether the work was being sponsored by a commercial, academic or government organization. In short, whoever brings research ideas forward and expects to benefit from those ideas should cover the full costs for executing the research.

On the other end of the spectrum, it is currently NASA's policy to cover the costs associated with space shuttle transportation and the use of the ISS utilization resources. Compared with the costs being borne by NASA to launch the shuttle, and assemble and operate the ISS, costs for transporting research and use of ISS resources for utilization are certainly marginal. Assuming that the costs for use of ISS resources continue to be covered by NASA for the foreseeable future, the obvious question is what happens to the transportation costs after the ISS is complete and the space shuttle is retired in 2010? Without doubt, this question poses a significant risk to ISS R&D productivity post-assembly complete. Transportation costs for ISS National Lab research communities after 2010 need to be understood as soon as possible so they can be taken into account in laying a plan for productive ISS utilization. I'll address more on the subject of transportation shortly.

Cost categories 2 and 3 present a different type of challenge. The costs of developing new hardware and meeting all of the NASA requirements associated with safety, integration, operations and flight certification can be significant. These costs are not ones that are normally associated with terrestrial research and, as such, even with the transportation cost excepted, the cost for conducting a research investigation on the ISS may be anywhere from two- to tenfold higher than a comparable ground investigation. These costs could impose a high barrier to research utilization of the ISS. Passing these costs to the end user will discourage high-risk, high-payoff research on the ISS. One obvious solution might be to provide modest funding to the ISS National Lab management organization so the organization can assume the responsibility for performing and meeting all NASA payload integration, operations and flight requirements. If research is selected for flight through an appropriate prioritization and vetting process, then the ISS National Lab organization could assume the responsibility and costs for its execution in orbit. This approach would have the important advantage that neither the research sponsor nor the science team will need to learn the daunting process for integrating and certifying an investigation for flight. At the same time, more high-risk, high-payoff experiments will be possible.

ISS National Lab Utilization Transportation

After the space shuttle is retired in 2010, the options for transporting research between Earth and the ISS become limited. At this point, the U.S. Space Shuttle, the Russian Soyuz and Progress vehicles and now the European Space Agency's Autonomous Transfer Vehicle are the only means for transporting research equipment, supplies and samples. By 2009-2010, the H-II Transfer Vehicle (HTV) being developed by JAXA should have a similar capability to transport cargo to the ISS. Of these, **only** the Space Shuttle has significant capacity for transport back to Earth and yet it will be retired exactly at the time that research on the ISS should be significantly stepped up. Without a solution to this dilemma, ISS National Lab utilization will be crippled. The only research that will be practically possible, other than exploration research involving the station crews as test subjects, will be research where data are generated on orbit and samples and payload equipment are considered disposable and incinerated in the atmosphere after use. While this approach might work for some investigations, the technology necessary to do this on a large scale on the ISS has not been developed nor are there any plans to do so.

NASA should be credited for pursuing commercial options for ISS resupply. The Commercial Orbital Transportation Services or COTS providers may help to solve the transportation problem for the ISS National Lab. The release by NASA only recently of the request for proposals for Cargo Resupply Services (CRS) represents a critical step forward and suggests a certain level of confidence that one or more COTS providers will step up and be able to meet the cargo resupply and sample return needs of NASA and the ISS. To be clear, the solicitation appears to only cover NASA's needs for logistics and science materials and equipment. The solicitation does not cover ISS National Lab research users. Instead, NASA's expectation is that prospective ISS National Lab users will independently negotiate transportation to meet their needs.

There are two concerns with NASA's approach to the CRS procurement from the perspective of ISS National Lab users.

First, in planning for success with the ISS National Lab, there will be many different users needing to make transportation arrangements. Clearly, having multiple organizations, such as individual companies, agencies, government labs, even individual scientists, all approaching the successful COTS provider for a ride will create some degree of chaos. More importantly, it is not clear how coordination between ISS National Lab users and NASA (logistics resupply and exploration science) will be done. It is my opinion that the ISS National Lab will be most productive if research material can be transported both up and down on a schedule of 4-5 times per year or more. This schedule will provide the greatest flexibility to meet the requirements of multiple end users. ISS National Lab users should be included on every NASA procured shipment. This will require careful coordination between the ISS National Lab management organization and NASA. For now while the Cargo Resupply Services are being procured, NASA needs to plan to include perhaps 20-25% of the volume on each supply mission for the ISS National Lab work.

Second, the cost of this component of the research, as mentioned above, could be the most severe challenge of all. Without knowing the charges for transportation that the selected Cargo

Resupply Services providers will decide is needed to allow them to recoup their investment, it is difficult to know how to predict this critical cost component. However, as a point of reference, a reasonable approximation that has been previously used is $20,000 to launch and return a kilogram of mass. Of course the actual charge could be different, either higher or lower. Based on this value, one modest sized experiment, comparable to what is currently flown in the shuttle middeck, would cost over $600,000 to transport to and from the ISS. Add the cost of integration, operations and safety certification (category 3 discussed above) and an experiment may cost ~$1,000,000. Add the cost of any modest new hardware development, if suitable existing hardware cannot be found, and the cost for a single experiment may reach as high as $2,000,000, a cost prohibitive to most research sponsors.

Conducting research on the ISS National Lab is going to require 5-10 times the investment for comparable research on the ground. The transportation element is a significant portion of this cost. As previously stated, if this cost must be fully borne by the ISS National Lab users, then there will be a very high barrier that many end users may choose not to cross. This will have the unfortunate effect of precluding a number of excellent ideas and projects from going forward under the ISS National Lab. Keep in mind that some of the best and most successful ideas originate with entrepreneurial individuals or start-up companies, which may have little investment capital on hand.

The issue of transportation and cost go hand in hand. One solution might be for the ISS National Lab management organization, if it were to be established, to be given sufficient funding outside of NASA to negotiate transportation contracts with the COTS providers on behalf of all ISS National Lab users. This would need to be done working with NASA to ensure sufficient capacity could be made available on each delivery mission to the ISS for ISS National Lab users.

The greatest risk to the ISS National Lab failing to deliver on its research potential, in my opinion, is that the COTS providers may not succeed in developing an ISS re-supply capability soon enough or perhaps at all. Even though NASA is investing $500M into this program, considerably more investment capital is required from each of the COTS companies for these new rocket and spacecraft systems to be developed and tested and to meet NASA's safety requirements to dock with the ISS. Having a successful commercial transportation provider is strategically and technically important to the U.S. Without a U.S. provider, we will be purchasing extensive services from the Russians (Progress and Soyuz vehicles) and there will still be insufficient return mass capability to meet anyone's needs. All ISS research, including that of NASA and the ISS National Lab, will be crippled. While there is no simple solution to this issue, it is one that NASA should carefully consider, perhaps with the development of a contingency plan to assist any selected Commercial Resupply Services providers, if they encounter major technical difficulties.

Summary of Key Points and Recommendations

- The ISS National Lab has tremendous potential to advance the interests of the nation in commerce, science, medicine, technology and education.

- Not enough is being done to ensure that the ISS National Lab will succeed in what should be the most productive time for the highly capable ISS facility after assembly is complete. Given the finite period of time that it can be safely assumed to be operational, perhaps only 5-10 years, it will be very important to accommodate as many of the best research and development ideas as possible.

- Transportation of research utilization equipment and materials to and from the ISS with a frequency of at least 4-5 times per year is critical. With the shuttle retiring in 2010, the only other viable option will be for one or more COTS providers to be successful at developing new launch vehicles and docking-capable spacecraft. NASA is pursuing this solution with the recently released solicitation for Cargo Resupply Services.

- Recommendations

    a. NASA should proceed to identify and select an ISS National Lab management organization as soon as possible. (Described in NASA's Plan for the ISS National Laboratory.) Time is of the essence when considering what must be done to set the stage for full ISS National Lab utilization after 2010. Use of a Space Act Agreement to form a public-private partnership could allow this to be done relatively quickly.

    b. Once it is formed, the ISS National Lab management organization should be given adequate resources to identify, manage and support a rich portfolio of utilization projects. The organization should not cover science costs, as those will be the responsibility of the research sponsor, but should be structured to cover some or all of the additional costs (hardware, integration, operations, transportation, etc.) not normally associated with terrestrial research. This approach could change over time as demand for the ISS increases where more and more of the full costs are covered by the end users.

    c. NASA should plan to fully accommodate ISS National Lab transportation needs in their effort to secure Cargo Resupply Services. At the least, this should include setting aside 20-25% of the up and down volume and mass on any given ISS resupply vehicle, even if that means that the number of total commercial launches per year must be increased.

Biography

Louis S. Stodieck, Ph.D. is the Director of BioServe Space Technologies and Associate Research Professor in Aerospace Engineering Sciences at the University of Colorado, Boulder. Dr. Stodieck earned his doctorate in Aerospace Engineering from the University of Colorado, Boulder in 1985. His research focus was biomedical engineering. He trained for two years as a postdoctoral Medical Research Council Fellow in the Department of Physiology at the University of British Columbia. He returned to the University of Colorado in 1987 to take a position as Associate Director for Technical Affairs for BioServe Space Technologies, a newly-formed NASA-sponsored Commercial Space Center. The Center's mission was to engage the private sector in conducting space life sciences research and development. Dr. Stodieck became Director of BioServe in 1999 where he currently leads an organization of approximately 25 faculty, staff and students. During his tenure at BioServe, Dr. Stodieck has overseen extensive ground-based research and over 40 space-based research payloads flown on the space shuttle, Mir space station and International Space Station. As a result of Dr. Stodieck's strong leadership BioServe is widely recognized for its successful partnerships with large and small biotechnology, pharmaceutical, biomedical and agricultural companies and for its highly successful, cost effective and innovative commercial space flight research program. Based in the College of Engineering and Applied Sciences, BioServe is also well regarded for providing high quality and unique hands-on educational opportunities for the next generation of scientists and engineers involved in space exploration. Dr. Stodieck's current research focuses on the development of countermeasures to the deleterious effects of space flight on human health especially in regard to space flight-induced bone and muscle loss. He has authored or co-authored 24 peer reviewed journal publications and over 40 conference papers in the fields of biomedical engineering and space life sciences research and hardware development.