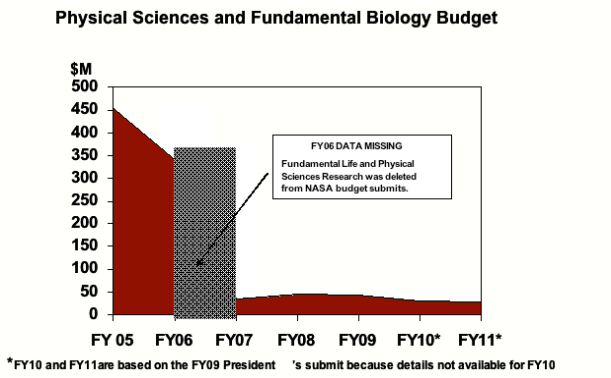
Recapturing American Leadership in Space Life and Physical Sciences:
An AIAA Information Paper

ABSTRACT

NASA's decision to reduce funding by 85% to fundamental biological and physical sciences research has contributed significantly to the loss of U.S. leadership in this arena. The affected research laboratories have lost the ability to train the next generation of scientists and engineers for space research. Foreign competitors are reaping the scientific and technological benefits from US investment in the International Space Station. In addition to the lack of a ground and flight basic research program, the U.S. International Space Station National Laboratory lacks hardware, up mass and down mass access, designated ground support, and an organizational entity to direct the science to enable full utilization. We recommend that NASA be directed to re-establish basic life and physical sciences programs that re-engage academia and industry and pursue research agendas that align with past National Research Council reports on physical and biological gravitational sciences.

ISSUE



In 2004-2006, NASA decimated the fundamental biological and physical sciences research program by the unprecedented retraction and termination of funding for basic research. The basic biological and physical sciences program was cut by 85%, over 1,700 scientists and nearly 3,000 students were abandoned. Despite attempts by Congress to provide some subsistence funding for these programs, NASA continues to provide no support beyond that mandated by the Congress. The research programs have not recovered, eliminating the ability to train the next generation of scientists and engineers for space research. This unprecedented action severed links to academia, eliminated leveraging funding, and destroyed NASA's corporate memory of how to build a balanced program of flight and ground research.

The current NASA agenda over-emphasizes engineering and applied science for human exploration and lacks fundamental discovery science that previously contributed knowledge enabling human exploration. The existing imbalance defies the National Aeronautics and Space Act of 1958 that created NASA to expand human knowledge of Earth and space, develop and operate aeronautical and space vehicles for carrying materials and organisms through space, establish long-range studies of benefits, opportunities and problems involved with aeronautical and space activities, and preserve the role of United States as leader in aeronautical and space science and technology through research and technology development. The flawed stewardship has crippled the US's ability to maintain leadership. Europe, China, Japan and other nations wisely continued support of robust ground and flight research in fundamental life and physical

sciences and, as a result, are postured to reap the scientific and technological benefits of the International Space Station (ISS). It is imperative to reinvigorate the US's science community and recapture leadership in space research.

BACKGROUND

The American Institute of Aeronautics and Astronautics (AIAA) and the American Society for Gravitational and Space Biology (ASGSB) are working jointly to restore a program of fundamental life and physical sciences in NASA. Without restoration, the U.S. will not realize the gains in economic and health issues from the 100 billion dollar investment in the International Space Station. We are a diverse group of scientists, engineers and students from universities, government, and industry who exchange ideas that bridge basic and applied research in space and gravitational sciences. This research is conducted on the ground in US laboratories, analog environments and specialized facilities such as centrifuges and in flight in parabolic aircraft, sounding rockets, sub-orbital vehicles and low Earth orbit in the Space Shuttle, Russian biosatellites, U.S. free flyers and the International Space Station. This community generates and disseminates fundamental knowledge about how physical elements and living organisms respond to gravity and the spaceflight environment. This knowledge provides understanding into physical and physiological processes that cannot be derived using traditional experimental approaches on Earth. Microgravity is a tool for innovative technological and biomedical discoveries to enable human exploration of space and improve the quality of life for the general public. Our goals include education and outreach to the public, students and teachers, Congress, NASA and other governmental agencies and industry. We encourage students to pursue careers in the life and physical sciences, technology, engineering and mathematics. Our research environments provide the venues for training the next generation of engineers and scientists. Today, these activities have essentially stopped due to a lack of a fundamental life and physical sciences program in NASA's portfolio.

The community of life and physical scientists advocated and provided the science justification for the ISS platform to enable research on long term exposure to microgravity and the spaceflight environment. Funding authorized by Congress to outfit ISS for research and to support ground and flight programs was siphoned off into spacecraft engineering under the guise of redirecting it to higher priority research directed toward implementing the "Vision for Space Exploration". This action crippled participation of the biological and physical space sciences research community and generated lingering mistrust of NASA to follow through on its commitments. In the 2005 timeframe, nearly $1B annually was devoted to Biological and Physical Science Research. NASA is asking other federal science agencies to support this research, but no transition plan, budget and agency have been identified to continue stewardship. Years of U.S.-invested research and intellectual capital are being abandoned without proper vetting. Now is not the time to abandon the investment in fundamental gravitation and space biology research and miss the opportunity to utilize the ISS for its intended purpose. Other nations are capitalizing on US investment in the ISS, including over 3,000 European Space Agency (ESA) scientists as well as Canadian, Japanese, Russian and Malaysian scientists who have both access and funding to conduct ISS experiments. Due to the lack of funds and flight equipment, U.S. scientists are being forced to beg time and specimens from their international colleagues or turn their scientific interests away from space.

The U.S. component of the International Space Station was designated as a National Lab in 2005 (PL 109-155). In truth, the existing and planned ISS National Laboratory facilities for research have been severely decimated by cut backs. There is 1) inadequate hardware and instrumentation to support biological and physical sciences experimentation, including biocontainment work stations and variable speed centrifugation for inflight gravity controls, 2) a lack of frequent and affordable transportation to and from ISS, 3) absence of designated ground and facilities support for fundamental life and physical sciences flight experiments, and 4) insufficient commercial and basic research entities participating jointly on missions. Descoping occurred even though Congress voted to go forward with the International Space Station (ISS) as a national priority, and NASA argued that the basic life and physical sciences are a timely priority.

The ISS National Laboratory needs a guiding management unit that includes a consortium of stakeholders who are tightly-coupled with external advisory and peer review committees, previously disbanded by NASA. An administrative unit within NASA does not exist to fund and integrate the flight hardware and science for fundamental gravitational life and physical sciences research. There is an absence of an external science advisory structure with oversight and influence on NASA programmatic priority decisions. Collectively, these deficiencies must be addressed to enable full utilization of ISSNL and reap translational benefits.

Basic biological and physical sciences research is needed in space because multiple health risks, such as radiation, neurosensory, musculoskeletal and immune system degeneration, remain too high for long duration human spaceflight. A balanced biology program should include a robust component of plant research key to the development of a self-sustaining life-support system. Hardware systems cannot be properly engineered without knowledge of the physical properties of fluid dynamics, thermal flow and combustion mutated in microgravity. These research priorities for life and physical sciences align with recommended strategies in National Research Council reports (e.g. A Strategy for Research in Space Biology and Medicine in the New Century 1998; An Assessment of Balance in NASA's Science Programs 2006; Review of NASA Plans for the International Space Station 2006).

An appropriately structured space program enables discovery research and science, technology, engineering and mathematics education missions that promote preeminence of the U.S. in space research. Our goal is to use the unique spaceflight environment as a tool to bring a new technological approach to understanding living systems and discover basic biological responses and mechanisms. In the closed environments of a spacecraft, Lunar base, or Martian outpost, plants will be vital components of a regenerable life-support system providing food, clean air and water. Spaceflight offers a unique environment for discovery of mechanisms of degeneration and adaptation to the stresses with potential applications to human health and quality of life in several areas (infectious disease, immunology, cancer, aging, bone and muscle wasting and tissue engineering). Identification of key molecular pathogenic responses to the unique environment of spaceflight will lead to new targets for treatment and innovative prevention strategies for human disease.

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RECOMMENDATIONS

- NASA should be directed to re-establish an organizational entity and budget designated for a space life and physical sciences program that reconnects with American colleges, universities and industry and to re-engage the scientific community in an official advisory capacity. This organizational entity will also provide accountability.

- Congress should restore FY10 funding for space biological and physical sciences research budget at a level sufficient to begin rebuilding a substantive research program in this essential scientific arena. The initial investment should concentrate on establishing a strong ground research program. The program should be apportioned approximately 50% ground research, 10% ground facilities and 40% flight research. It is necessary to invoke oversight and specific legislative language to ensure that resources directed to basic science are specifically defined and not subject to reallocation without independent oversight.

- The NASA entity should consider a peer-reviewed science agenda that aligns with the recommendations in past reports of the National Research Council (NRC) and the forthcoming 2010 "Decadal Survey" of life and physical sciences research in microgravity and partial gravity.

- To enable utilization of the ISS National Laboratory for physical and life sciences research programs requires the establishing: 1) a management unit that includes stakeholders, external advisory and peer review committees, including the NRC, 2) a NASA administrative unit to fund and integrate missions, logistics and the science, 3) regular transportation to/from ISS by NASA and/or commercial ventures, 4) U.S. hardware to support experimentation, and 5) ground and facilities to support flight experiments.