Challenges Facing U.S. Leadership of Space Life and Physical Sciences

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ABSTRACT: Disruption of a key national research segment consisting of fundamental and applied biological and physical science research has resulted in the U.S. being poorly positioned to take full advantage of the scientific opportunities offered by the now fully equipped and staffed International Space Station laboratory, and to effectively pursue the scientific research needed to support the development of advanced human exploration capabilities. More directly related to the U.S. economy, the reduction in research funding has greatly reduced Science, Technology, Engineering, and Mathematics (STEM) opportunities across the U.S. In 2004, there were over 1,800 students engaged in this research, while today there are only 144 across the U.S. The present research segment, managed only by NASA, has contracted to below critical mass and now lacks global preeminence and the commitment of resources to attract researchers to accomplish real advances in space and ground research.

The current NASA program lacks fundamental discovery science that previously contributed knowledge that facilitated human exploration. Fundamental science is important as the seed for beginning the growth of applied applications. In 2004–2006, NASA reduced its fundamental biological and physical sciences research program with an unprecedented retraction and termination of funding for basic research. The basic biological and physical sciences program was cut by 85%, resulting in 1,700 scientists and nearly 3,000 students losing funding for their work. 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 International Space Station (ISS) National Laboratory facilities for research have been decimated by cutbacks. NASA is currently addressing: 1) inadequate hardware and instrumentation to support biological and physical sciences experimentation on the ISS; 2) a lack of frequent and affordable transportation to and from ISS; 3) underutilization of the ISS. However, the research investment for the ISS only remains at $229 million out of a $3.0 billion ISS Operations Budget (FY13 request). The science funding is not within the NASA science budget request, but part of the ISS request. The research programs have not recovered, preventing training of the next generation of scientists and engineers for space research. The FY13 budget request severely limits links to the academic community, reduces the possibility of leveraged funding, continues the loss of NASA's corporate memory, and prevents a balanced program of flight and ground 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 science research in space. NASA is the only federal agency that establishes the programmatic agenda for this research. With the limited science investment, the U.S. cannot realize the economic gains and health insights that could be enabled by the research. This research is conducted on the ground in laboratories, analog environments, and specialized

facilities such as centrifuges, and in flight using parabolic trajectory aircraft, sounding rockets, sub-orbital vehicles, Russian biosatellites, U.S. free flyers, and the International Space Station. Students are encouraged to pursue careers in the life and physical sciences, technology, engineering, and mathematics. This research provides a venue for STEM careers.

The ISS was built as a scientific laboratory enabling biological and physical science research in space. ISS research was redirected in 2005 for higher priority research directed toward implementing the "Vision for Space Exploration." This re-prioritization crippled participation of the fundamental biological and physical space sciences research community. Years of U.S. invested research and intellectual capital was cast off without careful vetting. In 2011, the National Research Council examined the priorities, and published the report "Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era." NASA is in the process of assessing the report and developing an investment strategy. The very limited FY13 budget allocation for ISS research will restrict research opportunities. The $229 million proposed in the FY13 budget request for ISS research is not entirely dedicated to research funding either: at least a third of the money will be used for infrastructure to implement the research within NASA. Meanwhile, other nations are capitalizing on our 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.

ISS-based research is conducted "in" space and "for" space making it different from any other research that is done in the United States. Doing science “in” space provides a deeper understanding of the role of gravity in biological and physical systems on the ground. Understanding the role of gravity can provide insights into how to optimize biological and physical-world functions on Earth, such as identifying mechanisms to slow the loss of bone or cardiovascular function associated with aging. Doing science "for" space is needed to address multiple health risks, such as radiation exposure and degeneration of the neurosensory, musculoskeletal, and immune systems, which remain too high for long-duration human spaceflight. Many of the design challenges of new exploration technology systems are addressed by physical science research on fluid physics, combustion, and materials. Hardware systems cannot be appropriately engineered without knowledge of how physical properties of fluid dynamics, thermal flow, and combustion are altered in microgravity.

Fundamental biological and physical science research in space depends on federal funding. While it is basic in nature, it can eventually drive new engineering and biological approaches. The U.S. cannot rely on industry to invest in basic R&D because the return on investment is not rapid and predictable. An appropriately structured space biology and physical sciences research program enables discovery, supports STEM education, and promotes economic growth. Basic and applied discovery research should be an integral part of the overall NASA mission.