America's Human Presence in Low Earth Orbit

Statement by

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Chairman Smith, Ranking Member Johnson, and Members of the Committee:

I appreciate the opportunity to submit testimony and participate in the discussion surrounding the microgravity space science research portfolio and the transition of ISS to a new LEO landscape after 2024. This is a very important subject and the discussion is timely as we have just seen the delivery of the National Academies report, *A Midterm Assessment of Implementation of the Decadal Survey on Life and Physical Sciences Research at NASA*, which reviews the health and progress of the life and physical microgravity sciences portfolio.

I have phenomenal colleagues at Arizona State University where I work, and I have been privileged to work with literally hundreds of microgravity scientists and engineers in National Research Council studies, but I speak to you today from my personal perspective. I am a space systems engineer with experience on teams that built and operated the Space Shuttle, the ISS and a number of non-crewed satellite missions. My life's work has focused exclusively on enabling great science, big ideas and the implementation of large, complex systems. My comments today are informed not only by my engineering experiences, but also by roles I have played in advising NASA exploration programs. I was Co-Chair of the National Research Council[1] Committee that produced the decadal survey report "*Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era*," published by the National

[1] Now more commonly referred to as The National Academies of Sciences, Engineering and Medicine.

Academies in 2011[2] (referred to hereafter as the Decadal or Decadal Survey). This Decadal Survey lays out a comprehensive portfolio of life and physical sciences research that is enabled by spaceflight and that enables further spaceflight exploration. I am also currently the Co-Chair (with Dr. Rob Ferl of the University of Florida) of the National Academies' Committee on Biological and Physical Sciences in Space (CBPSS). Finally, I am Co-Chair of the National Academies' Aeronautics and Space Engineering Board (ASEB).

The US has not conducted human operations on an extraterrestrial planetary body for close to 50 years. The opportunity to do this again, and to have a meaningful life and physical sciences research program that enhances our ability to go back to the Lunar surface and even further, is thrilling. This committee has heard a great deal over the years about how the NASA-funded portfolio of life and physical sciences in microgravity has enabled our exploration missions, brought value to our terrestrial lives and delivered entirely new discoveries that have yielded new thinking for space and terrestrial endeavors. Under discussion today, and highlighted in these transition hearings, is a shift to private-sector platform providers as part of an increasingly privatized LEO ecosystem that could clearly be part of a successful microgravity sciences program if properly incentivized.

My comments are guided by the following questions.

1) What would be the implications for basic research, its application to deep space exploration, the pipeline of microgravity research and development, and the next generation of space biology and physical scientists if this transition failed to adequately accommodate these S&T areas?
2) To what extent has the existing ISS facility supported research requirements, and what is needed going forward? Are there any areas where the ISS has fallen short in meeting the needs of the research community?
3) What do you see as the opportunities and challenges for the future of space life and physical sciences under the ISS Transition Report scenarios, and what needs to be considered in order to support a successful transition of the research to an alternative platform or operating module?
4) Prior to 2024, are there ways in which NASA can begin to reduce the costs of supporting its research and technology development requirements in LEO, without sacrificing the quantity and quality of that research?

My comments emphasize space life and physical sciences as they enable exploration, but I would be remiss if I did not point out that microgravity research has delivered clear benefits for Earth and is an equally important part of NASA's work to advance the frontiers of science.

The "Recapturing a Future for Space Exploration" Decadal Survey provides a comprehensive set of research priorities for the space life and physical sciences. While an entire chapter (Chapter 11) is dedicated to the capabilities of the ISS, it should be noted that the Decadal recognized that ground-based experiments are necessary in some areas. In addition, it is clear that some

[2] https://www.nap.edu/catalog/13048/recapturing-a-future-for-space-exploration-life-and-physical-sciences

microgravity and spaceflight related studies are well suited for platforms other than the ISS, and could just as easily be conducted on other long duration platforms if they were available. Congress should encourage costing and pricing paradigms for NASA-supported S&T that fully enable a range of platforms, analogs and ground based facilities.

The ISS is finally now a fully functioning laboratory. It has a well-trained crew that understand the conduct of science. NASA has invested millions in building world-class research hardware assets (CIR, FIR, Glovebox, rodent habitats, etc.). Keeping these assets in play will be critical for moving research forward in a timely and affordable manner. NASA has increasingly sophisticated onboard analytic capabilities, such as recently demonstrated DNA sequencing. The ISS is equipped with many unique science facilities, launched at great expense but providing considerable payback. Consideration of how to optimally utilize these facilities to serve multiple investigations over many years should be included in our transition thinking.

As commercial platforms emerge, they will be shaped heavily by the demand they anticipate. A commercially operated station catering to pharma research will create a very different capability than one designed to pull fiber optic cables. NASA research has thrived on having a flexible platform and astronaut cohort that can sequence genomes in the morning and conduct combustion experiments in the afternoon. Such breadth of science and technology objectives is critical to responding to exploration needs and scientific opportunities. NASA will need to communicate a clear demand signal for a flexible platform. Otherwise, they may find themselves unable to pursue critical lines of emerging research.

There appears thus far to be little to no commercial pull for the research portfolio our decadal represents – which has largely always been the case for discovery science and exploration mission-enabling investigations. The microgravity science portfolio of the Decadal and Mid-Decadal focus on the human exploration mission and on discovery science. If NASA intends to position itself as a purchaser of ISS or long-term LEO capabilities, rather than having the role of major funder, what is now important is that microgravity exploration research be part of a coherent transition plan, a plan that understands that business models for research are not the same as those driving commercial interest, and a plan that recognizes the different perspectives on incentives for research. This approach would forestall unanticipated and unrecoverable gaps in research capacity (and particularly in workforce development) brought about by incomplete understanding of research requirements for continuity.

In part due to business-model changes, and in part because long-term studies are in their infancy, ISS research has not yet completely addressed the highest priorities of decadal studies. As an example, consistent opportunities for high priority rodent studies have only now been re-initiated after years of funding and capability gaps. With the exception of the final space shuttle flight (STS135 in 2011) NASA didn't sponsor any other rodent research in space for 14-years (2003-2017). CASIS has been able to partially bridge the hiatus with industry-directed research during the past three years using a NASA-developed habitat for mice; however, I note that that industry is under no obligation to fulfill NASA's high priority research needs as specified in decadal studies. ISS is only now (in the past year) giving us regular, longer duration (30-60 day) mouse studies. Rats have yet to fly on the ISS. By way of comparison, STS90 alone flew more than 170 rodents (rats and mice), which is a similar in scope to the past five years of ISS work.

The Mid-Decadal categorically finds that long-term microgravity studies are lacking. Quoting from the Mid Decadal, “With the totality of human exploration experience beyond LEO restricted to the Apollo era, and the limited number of long-duration experiments conducted to date on the ISS, the need for microgravity and radiation science research is as strong now as ever.” In reality NASA must seek to better understand and better mitigate the long-term effects microgravity in both the biological and physical systems involved in extended missions in deep space, and do so on the time scale measured in years. This scale of long duration projects on the ISS have yet to occur, creating a need to for integrated long duration experimentation well beyond 2024.

As stakeholder conversations are developed regarding this Transition process, we feel it is critical to include our research community, especially as pricing structure decisions are eventually made.

A robust prioritization scheme that identifies the key research that NASA needs for its deep space program has actually been done in the mandated National Academies studies commissioned to date. What is still needed is NASA clarity in calling out the specific research that needs to completed on ISS for the development of the Gateway. A focused study, to directly answer the question of what research is needed to develop Gateway, could help address this

While transitioning to a commercial LEO ecosystem for NASA is an approach that the National Academies’ Committee on Biological and Physical Sciences in Space (CBPSS) has been examining for about 3 years as it affects microgravity research, and is largely supported among the relevant scientific experts, such a transition is fraught with challenges for our research portfolio and community. We see the next 5-6 years as absolutely critical to get right for microgravity science continuity.   For example, many in the community do not believe there are cost reduction opportunities as much as cost sharing opportunities. Now is the prime of the ISS’s life.   If we fail to make the best and fullest use of this station in its current configuration, we will not plant the seeds necessary for future growth under a more commercial model. The opportunity is to look at how the cost of research can be shared with new partners and in payment for sharing the cost, sharing the opportunity that research delivers. Right now, the biggest cost of research is launch and operations costs – this is where a full cost approach will best help determine how NASA can create new business models for research that help us all understand how to mitigate the largest space-based cost of research, which are launch, in-space operations and downmass.

Summary and conclusions:
As stakeholder conversations are developed regarding this Transition process, we feel it is critical to include our research community, especially as pricing structure decisions are eventually made.

What could be done to mitigate some of the issues I have discussed?

- Congress can work with NASA to develop new funding mechanisms for commercial/university partnerships. Part of this transition, to assure that it goes well, should broadly strengthen the relationship between university research and the growing LEO commercial sector through real, meaningful incentives – as we have heard ESA does where LEO contracts are contingent on including a university partner for some research.

- The greatest ambiguity in the transition plan is operational (including launch and timely and reliable down-mass) costs. It would be very useful to commission a full-cost-accounting study for the needed research, to create an honest picture of transferability of a research portfolio to commercial LEO. Such a full-cost accounting approach for the needed research would allow the entire commercial community to understand and then develop business models that allow NASA and the business community to credibly absorb the cost of research, and the research community to have some ability to have confidence in a future where their research can be conducted.