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SUBCOMMITTEE ON SPACE AND AERONAUTICS

NASA'S SPACE SCIENCE PROGRAMS: FISCAL YEAR 2009 BUDGET REQUEST AND ISSUES

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Mr. Chairman, members of the subcommittee, thank you for inviting me here to testify today. My name is Lennard Fisk, and I am the Thomas M. Donahue Distinguished University Professor of Space Science at the University of Michigan. I also served from 1987 to 1993 as the NASA Associate Administrator for Space Science and Applications. I am currently the Chair of the National Research Council's Space Studies Board, although the views I offer today are my own.

In your invitation letter asking me to testify before you today you asked a series of questions that I would to address now in sequence.

The State of the Space Science Program

You asked me to comment on whether the space science program is moving in the right direction. I would like to expand this question to read is space science moving in the right direction and are the resources adequate to achieve success.

The budget for the Science Mission Directorate (SMD), and its projected runout, has many, very positive features. There are new starts for seven different missions. Each of the major disciplines—planetary, astrophysics, heliophysics and Earth science—has at least one major new start. Earth science in particular is able to begin making progress in pursuit of the science objectives of its recent NRC decadal survey. There are also increases in the Research & Analysis program, which is vital to the health and the future of space science. The space science community is buoyed by the opportunity to pursue important new science missions and relieved that the unwise decisions of the past have been reversed.

All of these positive features of the SMD program have been accomplished within a fixed budget envelope, which is currently, and for the next few years, growing at only 1% per year. This is a problem. Some of the new starts in the budget come at the expense of other programs that are displaced or deferred. The growth in Earth science is heartening given the importance that society places on deploying NASA's technical prowess to understand global climate change. The growth in Earth science, however, came by taking funds from other science disciplines, all to remain within the fixed budget envelope. Moreover, there is no flexibility in the SMD budget, no robustness. A single major setback in the cost of some mission under development would

seriously stress the carefully woven plan of maintaining the vitality of all the different science disciplines.

It needs to be recognized also that NASA's response to the NRC Earth science decadal survey is inadequate if we are serious about understanding global climate change. That decadal survey report pointed out that the Earth science budget has decreased by about $500 million per year since 2000. Restoration of at least this amount of annual funding is required in order that the nation can have a satellite system that adequately provides the sound scientific underpinning for planning for the inevitable climate change that lies before us. However, in the runout of the SMD budget to FY2012 only a total of about $600 million, not $500 million per year, is provided. To be sure, the increased funds for Earth science are all that are available in an overall flat budget. The new funds come from the other science disciplines, and to take more would devastate those constrained, but otherwise healthy programs.

In many ways SMD is a graphic illustration of the dilemmas that face all of NASA—too few resources to accomplish the many tasks that the nation has placed on the agency. Whether it is human space exploration, the use of the Space Station, aeronautics, or science, the funding is not adequate. SMD is doing well with what it has, trying to maintain the vitality of the space and Earth science communities, and to move the program forward with new mission opportunities. However, there is so much more that needs to be done, whether it is a solid start on the Earth science decadal survey recommendations, a vigorous Mars program, a full Living-with-a-Star program, or a vigorous program to understand the astrophysical challenges of dark energy and dark matter. And the budget needs to be robust so that it is actually executable. The funding constraints on all of NASA and on SMD in particular need to be lifted, and the required resources need to be provided so that the nation can have the space program that the nation needs and deserves.

The State of Heliophysics

You asked me to comment in particular on whether the Heliophysics program is moving in the right direction. Heliophysics is the study of the Sun, the heliosphere (i.e. the region of space created by the solar wind, the outward expansion of the solar atmosphere), the plasma environment of the planets, and the coupling and interactions among these various environments. Research in Heliophysics is essential for understanding the coupling between the Sun and Earth, and for predicting the space environment through which our space assets and eventually our astronauts will fly.

There is good news in this program. As in other disciplines in space science, there is an increase in the Research & Analysis program budget and a new start for the Solar Probe mission. This good news is tempered, as in other disciplines, by the reality that the increase in budget for these elements of the program came at the expense of other planned initiatives, which cannot now be pursued. The budget envelope for Heliophysics is fixed, and in fact has been used, in part, to provide Earth Science with needed funds to make a start on its decadal survey missions. In the case of Solar Probe, then, the required funds have come from the Living-with-a-Star program,

which is now unable to pursue, in the near term, either the Sentinel program or missions to the ionosphere.

The new start for Solar Probe should be viewed, then, as a realignment of the scientific priorities. NASA has judged that it is more important to make direct measurements in the region of the solar atmosphere closest to the Sun, than are other priorities such as the study of the ionosphere. This logic is understandable. The inner region of the solar atmosphere is the source of the solar wind and solar energetic particles. It is a region where current instrumentation cannot observe the governing magnetic field and where direct in-situ observations are required to resolve the many mysteries that inhibit our ability to predict the space environment created by the Sun. The Solar Probe mission was endorsed by the 2003 NRC decadal survey for this field. It was considered to be an important, large mission for which funds beyond the planned budget envelope needed to be provided. This has not proven to be feasible, and the required funds have been taken from other planned missions. The science priority, however, of Solar Probe is not in question.

The planned Solar Probe mission is very clever, and solves a number of the concerns associated with previous concepts for Solar Probe. Solar Probe needs to make multiple passes through the solar atmosphere, which is a dynamic, ever changing environment. Only by multiple passes can we avoid confusion that arises from the fact that this is such a dynamic place. The required multiple passes are achievable because the planned Solar Probe mission does not penetrate as close to the Sun as some previous versions of Solar Probes were planned to do. However, the current Solar Probe concept is judged by the scientists who have studied the mission in detail to have a penetration distance that is adequately close to be able to resolve the fundamental processes resulting in the heating of the solar atmosphere and acceleration of energetic particles.

The other important feature of the planned Solar Probe mission is that it is to be undertaken in concert with the European Space Agency Solar Orbiter mission, for which NASA has agreed to provide part of the payload. Solar Orbiter is to be placed in an orbit around 30 solar radii from the Sun, and to achieve an orbit that is inclined to the solar equator. From this vantage point, a capable set of remote sensing instrumentation will make detailed observations of the solar surface and atmosphere, and a capable set of in-situ instruments will observe the solar outputs of plasma and energetic particles in detail.

It should be possible to have Solar Orbiter in place while Solar Probe is doing its penetrations deep into the solar atmosphere, and the combination will be an historic opportunity to once and for all develop a comprehensive, predictive understanding of the basic processes that control the solar atmosphere and its influence on the heliosphere, and on the Earth and other planets. There is, however, an obligation with this combined program that must be met. The instrumentation on both Solar Probe and Solar Orbiter must be comprehensive and complete. The investment in these missions will be large, and the scientific payloads need to be capable of realizing the scientific breakthroughs that this historic opportunity will allow.

The Status and Health of the Science and Engineering Workforce

You asked for my perspectives on the status and health of the science and engineering workforce as it relates to NASA's space and Earth science plans. I would respond to this question from several different perspectives.

Let me comment first on the NASA workforce. The age distribution of the civil service workforce at the NASA centers is disturbing. It is strongly peaked at age 45-49, with only a small fraction of the workforce under 30, and almost an equal number over 60. There needs, in my judgment, to be a rejuvenation of the NASA workforce. Experience is important, but more current training, particularly in the engineering disciplines, and the enthusiasm, energy, and willingness to explore new concepts that inherently come with youth, are important as well. It will not be easy to rejuvenate the NASA workforce. Fixed budgets, the current age distribution, and the requirement mainly imposed by Congress for 10 healthy NASA centers places severe restrictions on NASA's ability to hire new scientists and engineers.

There is an unfortunate corollary to NASA's inability to rejuvenate its workforce. We want our best young scientists and engineers to aspire to participate in the nation's space program, yet it is widely known that the prospects for jobs at NASA, and thus a major leadership role in the exploration of space, are meager at best.

Next I would comment on the science and engineering workforce outside of NASA. The number of students available to participate in the space program is probably adequate for the simple reason that space requires only a small fraction of the nation's science and engineering workforce. The issue here is the quality of the students, their particular training, and their attitude when they enter the workforce.

There are many capable science and engineering students in this country. The question is why should the best and the brightest aspire to participate in the space program when there are so many other exciting technical challenges that lie before them. The students see a space program that is not a national priority sufficient to receive the funding and support that is necessary for its success. Under these circumstances, only those students who have always aspired to pursue a career in space are likely to enter the field, as opposed to those who have the talents and the capabilities to pursue many different technical disciplines. Thus workforce and priorities for space are linked. If space becomes a national priority, the nation's highly capable technical workforce will respond.

There is also a question of training. It is essential that engineers in particular receive hands-on training with real space projects or space-related hardware. The vast majority of the senior technical workforce currently executing the space and Earth science program had hands-on opportunities earlier in their careers, and they all would say that it was essential for their current success. We should expect no difference for the next generation. It is incumbent upon NASA to provide the universities with the opportunities to offer their students hands-on experience if we are to continue our technical success.

The previous two items are strongly coupled. The experience in most universities is that when students have hands-on research experiences in space engineering as undergraduates they invariably decide to pursue careers in space. If NASA provides universities with the opportunities to offer hands-on experience, not only does the required training occur, but the best and the brightest are recruited into space.

Finally, there is the issue of attitude, particularly among young scientists entering the fields of space and Earth science. Space science is 50 years old this year; Explorer 1, the first space science mission, was launched in 1958. In a science discipline at this age, which is dominated now by scientists who have practiced their disciplines for decades, inevitably there are well established points of view that have been developed, which are resistant to new ideas. It is important that the new scientists entering the field challenge these established points of view, for that is how progress is made in science. And it is incumbent upon NASA, through its Research & Analysis program, to encourage new approaches and new thoughts, so that progress is made and the true answers to the many mysteries of the universe are revealed. Consequently, I strongly support the proposed increase in funding for the Research and Analysis program.

The State of NASA's Space Weather Program

You asked what is the status of NASA's program to collect data and conduct research on space weather. There are two aspects of this issue that I would like to address: first, the monitoring of space weather that affects Earth, and second, our ability to learn how to predict space weather.

It is important to have a spacecraft at the Sun-Earth L1 point in front of Earth that can provide real-time warning of space weather events that will impact Earth, and also provide information on solar wind conditions for basic research on the response of the Earth's magnetosphere, ionosphere, and atmosphere to space weather events. At present this information is provided by the Advanced Composition Explorer (ACE), which was launched in 1997. It is unwise to rely entirely on ACE and its instrumentation, some of which is showing signs of age. It is possible to put up a relatively inexpensive spacecraft to perform the basic monitoring function. I would add that such a spacecraft may be more appropriately a NOAA rather than a NASA responsibility, since NOAA is to provide operational space weather predictions.

The second issue is our ability to develop a true predictive capability for space weather. It is not sufficient simply to monitor the immediate arrival of a space weather event, or to base predictions on general correlations between events on the Sun and the arrival of space weather disturbances at Earth. Rather, we need to have an adequate understanding of the basic physical processes that govern the acceleration of the solar wind, the release of Coronal Mass Ejections, and the acceleration of energetic particles. With this understanding, we will eventually be able to make detailed observations of the Sun, put that information into comprehensive numerical models, and make real-time predictions of the space weather that will impact the space environment of the entire solar system, and of the Earth in particular.

The pursuit of a detailed understanding of the basic physical processes that govern the solar atmosphere and its extension into space, the response of the space environment of Earth, and the

development of comprehensive numerical models is the main purpose of the Heliophysics Division in SMD. It is important that these efforts be encouraged so that a true predictive capability is developed as soon as possible. Missions such as Radiation Belt Storm Probes, which are currently under development, are important for understanding the response of the Earth's magnetosphere to space weather events. Missions such as the upcoming Solar Dynamics Observatory and the proposed Solar Probe and Solar Orbiter, which I discussed earlier, are essential for developing an understanding of the basic mechanisms that heat the solar atmosphere and accelerate energetic particles.

It is also important to make maximum use of the space assets currently in place to study the Sun and the plasma environments that the Sun creates throughout the solar system. There is a flotilla of spacecraft in place known as the Heliophysics Great Observatory. These missions, from the recently launched STEREO missions that observe the Sun and its outputs in 3-dimensions to the venerable Voyager missions probing the distant heliosphere, all are essential to our understanding of the physics that governs the plasma processes in our solar system. It is important to use these missions in a coordinated way, to derive the maximum possible information from them, and in doing so to create the scientific foundation for the predictive models of space weather that we require.

Issues to Address in the Reauthorization of NASA

You asked for input on the important issues that should be addressed with respect to NASA's space science program as Congress considers its reauthorization of NASA. I would like to take the liberty of answering this question in the broader context of NASA as a whole since I do not believe that the NASA space science program can be considered separately from NASA's overall activities and goals.

We are now four years into implementing the Vision for Space Exploration that was announced by President Bush in January 2004, and it is worth a critical analysis of where we are. So far, with the exception of the initial FY2005 budget, the Administration has not requested the funds it said were required to execute the Vision. There were underestimates of the costs required to continue to fly the Shuttle and complete the International Space Station. Consequently, NASA has been forced to cannibalize much of the rest of its program to even begin to make progress on the Vision. And it is hard to say that the Vision of returning to the Moon has generated much excitement, or even understanding among the public, particularly among the young who are expected to benefit most from the future that the Vision promises.

We should ask ourselves whether there was a flaw in the Vision for Space Exploration, which we did not recognize at the time. The Vision is all about the future – extending our civilization into space, with the long-term benefits that we expect to accrue for our country. There is, however, little in the Vision that is of immediate concern. So when near-term needs intervene, such as providing funds for the war in Iraq or for Hurricane Katrina, it is NASA that comes up short in funding.

I would encourage you, then, as you consider the reauthorization of NASA, as I would encourage the next Administration, to provide NASA with a role that is not only about the future, but is important in the present. There are several ideas worth discussing:

NASA could use, and serve, a more important geopolitical role. The obvious one is to lead the world in the exploration of space, in a cooperative and facilitating way. NASA then becomes an instrument of our foreign policy through its ability to improve the image and impact of the United States around the world. If that is important to the next Administration then perhaps the resources necessary for NASA to play its proper role in leading the world will be provided.

NASA could use, and serve, a more important role in improving the competitive position of the United States, through the encouragement of technology development, entrepreneurialism, and technical education. This would be a new emphasis for NASA that would encompass more than just human space flight, which is an engineering challenge but which does not often emphasize new technologies. It is the science disciplines of NASA, with their needs for new sensors and electronics and robotic capability that are a better stimulus for technology.

And finally there are the programs in NASA that are of demonstrable immediate importance to the taxpayers – Earth science to provide the scientific basis for understanding global climate change, and aeronautics. In the current implementation of the Vision these programs have been allowed to decline and atrophy, and they deserve strong re-emphasis.