

Testimony of

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Chairman Babin, Ranking Member Bera, and members of the committee:

Thank you for the opportunity to appear before you today in my capacity as a member of the Committee on Astronomy and Astrophysics (CAA) of the National Academies of Sciences, Engineering and Medicine. CAA is one of five subcommittees of the Academies' Space Studies Board that span the science disciplines supported by NASA. In the case of the CAA, the committee is also a subcommittee of the Academies' Board on Physics and Astronomy, so that the one committee can cover all of astronomy and astrophysics, including programs supported by the National Science Foundation and the Department of Energy. Each of the five subcommittees is charged to assist the federal government in integrating and planning programs in space sciences by providing advice on the implementation of decadal survey recommendations. As you know, the National Academies' decadal surveys—mandated by law—provide NASA with consensus advice from the scientific community on proposed science priorities for the decade ahead.

I have the honor of serving on the CAA and, as you mentioned in your introductory remarks, I was one of the co-chairs of the 2001 decadal in astronomy and astrophysics. The highest recommendation in our report, *Astronomy and Astrophysics in the New Millennium*, was the James Webb Space Telescope (JWST), a truly remarkable feat of engineering that is expected to deliver groundbreaking scientific capability beyond that envisioned when we recommended it. I am also honored to be a member of the CAA when, under a new charter from the Academies, it is able to issue fast-turn-around reports that will provide guidance to federal agencies that support astronomy and astrophysics research.

Chairman Babin, I would like to thank you and the committee for giving me the opportunity to present to you today some perspectives on the status of NASA's program in astrophysics—drawing in particular on the Academies' 2016 report *New Worlds, New Horizons: A Midterm Assessment* which came to some very important conclusions on the status of the implementation of the 2010 decadal and looked forward to the next decadal. I'd like to start by reading a quote from that report:

New Worlds, New Horizons in Astronomy and Astrophysics (NWNH), the report of the 2010 decadal survey of astronomy and astrophysics, put forward a vision for a decade of transformative exploration at the frontiers of astrophysics. This vision included mapping the first stars and galaxies as they emerge from the collapse of dark matter and cold clumps of

hydrogen, finding new worlds in a startlingly diverse population of extrasolar planets, and exploiting the vastness and extreme conditions of the universe to reveal new information about the fundamental laws of nature. NWNH outlined a compelling program for understanding the cosmic order and for opening new fields of inquiry through the discovery areas of gravitational waves, time-domain astronomy, and habitable planets. Already in the first half of the decade, scientists and teams of scientists working with these cutting-edge instruments and with new capabilities in data collection and analysis have made spectacular discoveries that advance the NWNH vision.

Mr. Chairman, while the discoveries are remarkable, the fact that they have occurred is not: The Congress, the Executive and the research community have relied on the independent and non-advocacy convening power of the National Academies to develop a national consensus on which scientific space missions NASA should pursue across the programs in the Science Mission Directorate. This process, over a period of nearly 60 years, has led to the United States developing clear leadership across all the fields of space science, which is why the Congress has repeatedly instructed NASA and the Executive to use the decadal process as the foundation of the agency's strategic planning in space science. Every prioritization process produces winners and losers, but there is broad support in the scientific community for the consensus-building process that has given us winners such as Hubble, Cassini, and Curiosity.

Mr. Chairman, members of the committee, as you well know the decadal process involves a broad cross section of the community. In the case of the 2010 decadal survey in astronomy and astrophysics, the Academies appointed nearly 200 astronomers to the survey committee, supporting panels and working groups. They received input from hundreds of astronomers, who submitted over 700 white papers describing opportunities for the current decade. The committee identified 20 key science questions that provided a framework for evaluating a compelling program of high-priority research activities. The science goals for the decade were focused into three science objectives, labeled "Cosmic Dawn," "New Worlds," and "Physics of the Universe." The committee then undertook the hard and painful task, necessitated by the relatively severe financial constraints under which the agencies were expected to have to operate, of prioritizing the many exciting and realizable activities presented to it. The resulting program is described in the 2010 decadal report.

Mr. Chairman, today NASA is implementing the decadal survey. The *Wide-Field Infrared Survey Telescope* (WFIRST) was the 2010 decadal's highest-ranked large space observatory with science goals that drew on and combined a set of mission concepts proposed by the community into a unified science program that, as the decadal report said, is "designed to settle essential questions in both exoplanet and dark energy research, and will advance topics ranging from galaxy evolution to the study of objects within our own galaxy." The midterm report underscored the continuing scientific case for the pursuit of this mission and its planned implementation with a larger mirror than envisioned at the time of the decadal's prioritization, saying that the 2.4-meter telescope, larger infrared detectors, and addition of a coronagraph make the 2016 design of WFIRST an ambitious and powerful facility. However, because the risk of cost growth in WFIRST could distort the NASA program balance and limit options for the next decadal survey, the midterm report called for an independent technical, management, and cost assessment of WFIRST. The report recommended that, if the mission cost estimate were high enough to compromise the scientific priorities and the balanced astrophysics program recommended by the decadal, then NASA should descope the mission. At our last CAA meeting in October, we heard the results of that assessment and the resulting efforts requested by NASA from the mission team to reduce the planned cost of the mission. The committee will no doubt hear at its March meeting the outcome of those efforts, and we may be asked to comment in a CAA report.

Meanwhile Mr. Chairman, it is also worth noting that the midterm report endorsed NASA's plans for executing the second priority recommendation of the 2010 decadal, the enhancement of the

Explorer program, and that NASA should execute at least four Explorer Announcements of Opportunity during the 2012-2021 decade, each with a Mission of Opportunity call, and each followed by mission selection. The Explorer program is currently supporting the development of the *Transiting Exoplanet Survey Satellite* (TESS), scheduled for launch in March 2018. This satellite will use similar techniques to the highly-successful Kepler telescope, but it will observe bright, relatively nearby stars over the whole sky, thus identifying exoplanet targets that are ideal for follow up by the *James Webb Space Telescope* and other facilities.

NASA is also implementing the third and fourth high-priority recommendations in partnership with our European colleagues at ESA through participation in the Athena x-ray telescope and in the ambitious and exciting opportunity that will be provided by the LISA gravitational wave observatory. LISA will open a new window on the cosmos by measuring the ripples in space-time produced by the merger of black holes much more massive than can be detected by the NSF-supported LIGO facility, which has confirmed Einstein's theory of gravity and solved the mystery of the source of many of the elements in the periodic table beyond iron—such as gold and uranium.

There are many other exciting aspects to NASA's execution of decadal survey recommendations that I could address, but I have concentrated on the highest priorities of the recent decadal survey since they set the context for the next decadal that is expected to start in about a year's time. At the CAA we have heard in presentations, made over the last 2-3 years, how NASA is supporting teams of astronomers and engineers to develop mission concepts for the large strategic class of missions—sometimes called flagship missions—and for moderate-scale missions. The scientific cases being developed for each telescope are compelling and ambitious. This methodical approach to preparing the community for the decadal is, in my personal opinion, vitally important. The CAA is at the same time preparing to release the first call for white paper inputs from the community in advance of the survey so that when the chair is appointed, she or he will have fresh community input on the science when designing the plan to execute what is nominally called Astro2020.

It would, Mr. Chairman, be remiss of me to provide any comparisons among the missions that will be proposed to the decadal survey as I have complete confidence in the ability of the survey process to assess the science cases for each, the technical challenges each bring, and the likely affordability of the missions. This is what my community has been doing now for nearly 60 years, and each time the result has been a flexible and impactful program that pursues large strategic-class missions that can take over a decade to develop and launch and that produce major scientific results unmatched by any other nation, as well as pursuing smaller, rapid response missions like the TESS exoplanet mission I discussed earlier.

Mr. Chairman and members of the committee, the bottom line result of the decadal survey process in astronomy and astrophysics—and in the other scientific fields supported by NASA—is that the United States has reaped the benefits of this community-based process which the Academies conduct on behalf of the nation under its unique charter from the Congress. I am here today to reiterate why this process works as well as it does, and to answer any questions you may have.

Thank you.