Testimony of

Governor Mitch Daniels
President of Purdue University
and
Professor Jonathan Lunine, Ph.D.
David C. Duncan Professor in the Physical Sciences
Cornell University

Co-Chairs, Committee on Human Spaceflight
Division on Engineering and Physical Sciences
National Research Council
The National Academies

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[Governor Daniels begins]

Mr. Chairman, Ranking Member Johnson, members of the committee**:**

Thank you for the opportunity to speak to you today on issues concerning the nation's human spaceflight program. Today my co-chair Jonathan Lunine and I are here to represent the National Research Council's Committee on Human Spaceflight, established in response to the NASA Authorization Act of 2010. That act called on NASA to ask the National Academies to review the goals, core capabilities, and direction of our nation's human spaceflight program. After about 18 months of work we released our report on June 5th and Dr. Lunine and I are here today to briefly summarize its contents. The executive summary of that report which you have before you contains a lot more detail than we might cover today. And indeed I would urge interested members to read Chapter 1 of our report, which contains all our detailed findings and recommendations.

As envisioned in the 2010 Act, the background of our committee's membership was very diverse. This committee was not composed solely or even mostly of experts from the human spaceflight community—as might have been the case with other major reports on this topic in the past—but instead had members from fields as diverse as planetary science, astronomy, political science and history, sociology, public opinion and polling, economics, human spaceflight experience, international peace and security, and so on. Although all of us came into this process with open minds and brought to the work divergent points of view, in the end we came to the strong consensus that there is a convincing case to be made for a continuation of our nation's human spaceflight program, provided that the pathways approach and decision rules recommended in our report are adopted.

Why did we come to that position? We did so because we became convinced through lengthy discussion and analysis that a combination of what we call the pragmatic and aspirational rationales, including the human impulse to explore and search for new knowledge in places we have never been, justifies the cost, risk and opportunities associated with sending humans beyond low Earth orbit—especially toward the "horizon goal" we identified as Mars.

Getting humans to the surface of Mars will be a daunting challenge. It is immensely difficult, probably more so than most laymen and even many experts have recognized. Succeeding in this endeavor will require a very different way of doing business than the nation has been practicing in recent decades, particularly as it is likely to take thirty years or more for us to reach our goal.

With this challenge in mind, as its highest priority recommendation, the committee recommends what we call a "pathways approach", which would require the government to come to a consensus on achieving a highly disciplined set of objectives from which the nation would not deviate over time. A pathway in this scenario would involve a pre-defined set of chosen destinations and milestones—stepping stones if you will—each of which would generate technical and engineering requirements which, as much as possible, would feed

forward toward the next step and eventually the horizon goal. The committee does not recommend any specific pathway, but we do note in our report that any pathway that could successfully land humans on the surface of Mars would require funding above constant dollars. Pursuing unwaveringly the consensus choice of a pathway over the long term of multiple decades and the sustained support of the technical advances required by the resulting exploration architecture are the keys to unlocking a sustainable approach to human spaceflight for our nation.

Mr. Chairman, I cannot stress enough how critical it is that this nation takes a new approach that goes beyond the recent way of doing business in space. We need to come to a consensus on the pathway of choice if we are going to decide to continue to pursue human exploration beyond low Earth orbit. Work needs to begin soon on the most difficult and mission-critical technical challenges of any pathway to Mars: out of many such challenges, we single out Mars entry, descent and landing; in-space propulsion and power; and radiation safety for special emphasis. In addition we were in total agreement that achieving the goal of a human presence on Mars will require the U.S. to expand its partnerships with other spacefaring nations, including an openness to working with China with whatever safeguards we might have to put in place. Such international partnerships should include much greater cost-sharing than our partners have provided up to now, but that can only happen if those partners are given the responsibility to provide substantive and substantial elements to the overall architecture, which they will help design and build. Indeed our committee's report clearly states that our human spaceflight program should engage with any partner—governmental or commercial—that can help solve technical and programmatic impediments to pathway progress.

Finally, Mr. Chairman, Ms. Johnson, members of the Committee, before I hand over to my colleague and friend Dr. Lunine, I want to stress here to you, to all our elected representatives and leaders, and to the public, that we all need to recognize that the risks of human spaceflight, including the risks to human life, are high, and setbacks are inevitable. Lives are likely to be lost in pursuit of such a tremendous endeavor, and governing statutes will need to recognize that grim fact. And while we recognize that many of our recommendations will be seen by many as "unrealistic" or perhaps even naive, we would observe that, absent changes along the lines we are recommending, the goal of reaching Mars on any meaningful time frame is itself unrealistic.

Mr. Chairman, it is my personal hope that that our report will carry the national conversation forward in the direction of realism: realism about public opinion, about risk, about cost, and about the incredibly daunting technical challenges of the horizon goal that we believe the world embraces. Most of all, we hope to foster greater realism about the fact that if we really do want to go to Mars then many actors public and private need to change long-standing behaviors and expectations. We are optimistic the public will support a consensus national goal and we believe the rationales justify its pursuit. We believe the achievement would be monumental if it occurred, but we think there is really one and possibly only one approach to get there, and we've offered up ideas in support of that approach in this report.

[Dr. Lunine continues]

As Governor Daniels noted, we would urge members and others to consider—if you cannot read the entire document—to read Chapter 1 of our report, where you will find our major findings and recommendations on issues such as: public and stakeholder opinions about space exploration and human spaceflight in particular; an honest and detailed independent analysis of the technical and affordability realities associated with three possible exploration pathways that lead to Mars; an examination of the rationales for human spaceflight; and most importantly our recommendations on adopting the "pathways approach" we believe will help our nation achieve that next giant leap for humankind.

Let me turn quickly to some of those issues, and Governor Daniels and I would be more than happy to answer any questions members may have following this statement.

Firstly, anyone who reads about the history of space will come quickly to realize that there are many myths that surround both public opinion about human spaceflight, and the proven benefits from human spaceflight. What the committee found was that, if a decision to continue a U.S. human space exploration program were to be based simply on the interests and priorities expressed in public opinion polls taken over the past few decades, it is likely we would not have gone to space. If the decision were based simply on the available data on *proven* benefits that uniquely accrue from a human space exploration, then we would likely not go. However, while the committee felt it was important to examine as closely as possible both public opinion and the historic rationales—and in fact it was charged to do so—we were also aware that such data have numerous limitations and interpretations. We also recognized that by these kinds of criteria alone, we would never have stepped foot on the Moon, yet that achievement is now viewed as a source of inspiration and great pride by Americans.

In fact, Mr. Chairman, it has been leadership at the national level, at a political level, that determines whether our nation will pursue major new ventures. Our elected leaders have shown courage and vision in the pursuit of human endeavor in space and when those visions are implemented—such as with the Apollo program or the Shuttle program—the public is supportive of our government having spent our tax dollars on what are viewed as endeavors of national importance.

In the end it was the judgment of this diverse committee that the more aspirational rationales, when supplemented by the practical benefits associated with the more pragmatic rationales, do argue for a continuation of the nation's human spaceflight program, provided that certain conditions are met. It is not, however, this committee's opinion that is relevant on this issue. Whether to pursue human exploration beyond low Earth orbit in a truly sustainable way is a decision that deserves careful consideration by our nation's leaders, stakeholders both favorable and opposed, and the public at large. And in making that decision it will be important to ask a question posed many times by us to those provided input to this study, "What would a future be like where there was no expectation that Americans will go into space?"

But as such decisions are contemplated, and as Governor Daniels mentioned, we cannot ignore the significant leaps in technical capability that will be required to land and sustain humans on Mars. Achieving those leaps was the motivation behind our recommended pathways approach since only a sustained program that builds upon a sequence of technical and exploration successes can buy down the risk involved in getting to Mars in any reasonable timeframe. As an example, in one of the possible pathways analyzed in detail in the report, one of the goals or milestones was extended human operations on the lunar surface. I stress extended surface operations—not merely a repeat of an Apollo type landing. Why was this included? Because our technical panel realized—and the committee concurred—that extended surface operations on the Moon would make significant contributions to a strategy ultimately aimed at landing people on Mars by allowing for the development and testing of key operational technologies.

Mr. Chairman, Mars is incredibly hard.

Completing any of the pathways described in our report or indeed any other pathway that is likely to succeed, requires the development of a number of mission elements and technological capabilities and a budgetary support that exceeds growth in purchasing power. The report identifies 10 high-priority capabilities that should be addressed by current research and development activities, with a particular emphasis on Mars entry, descent, and landing, radiation safety, and in-space propulsion and power. These three capabilities will be the most difficult to develop in terms of costs, schedule, technical challenges, and gaps between current and needed abilities. And because the challenges are so great our committee came to the conclusion that our human spaceflight program sits at an important juncture. If there is any significant delay in the United States making a commitment to a truly sustainable program of human spaceflight beyond LEO, we risk a long gap in U.S. human spaceflight activity following the decommissioning of the International Space Station—just as the termination of the Space Shuttle led to a hiatus in U.S. capability to launch astronauts into space. The nation needs to decide now whether it will choose to support a sustained national and international endeavor to pursue exploration beyond low Earth orbit.

If the nation does decide to undertake one of the greatest of human technical endeavors it has ever attempted, we have provided in our report what we call Pathway Principles that could help in the choice of a consensus pathway to that goal. In addition we provide a set of decision rules—guidelines on how to manage the pursuit of the chosen pathway when stressors such as diminished budgets or indeed larger than expected budgets might arise.

Mr Chairman, our committee is convinced that these principles and decision rules provide a way for our national leadership to decide on a given pathway, measure progress in its pursuit, navigate moving off one pathway to another, or cease the endeavor altogether.

A key element of those principles is that a pathway's chosen set of destinations and stepping stones would generate technical and engineering requirements which as much as possible would feed forward toward the next step and eventually the horizon goal. The committee does not recommend any specific pathway—we were not charged to do so. But we do feel strongly

that given the cost of human exploration and the potential cost in human life, only a human presence on another world can justify its pursuit and as we have said previously, Mars is humanity's horizon goal.

To reach that horizon goal will require decades of sustained effort and hundreds of billions of dollars to accomplish. To be a sustainable program, it will require a steadfast national commitment to a consensus goal, international collaboration, and a budget that increases by more than the rate of inflation.

Mr. Chairman, Ms. Johnson, members of the Committee: We are not the first to say that our nation's commitment to human exploration cannot change direction election after election. But in the end our elected leaders are not the impediment to achieving great goals in space, you are the critical enablers of our nation's investment in human spaceflight. Only you can ensure that the leadership, personnel, governance, and resources are in place that will assure human beings will one day walk on the red soil of Mars.

Thank you again for the opportunity to testify today and we remain at your disposal for questions.