Testimony of

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Mister Chairman, members of the committee, thank you for the opportunity to speak to you today on issues concerning the nation's human spaceflight program. I represent the Aeronautics and Space Engineering Board of the National Research Council, which was created in 1967 to "focus talents and energies of the engineering community on significant aerospace policies and programs." The ASEB works in concert with the NRC's Space Studies Board (SSB) and over the past decade has undertaken a number of relevant studies concerning human spaceflight, including beyond low Earth orbit. In 2009 I chaired the NRC study "America's Future in Space, Aligning the Civil Space Program With National Needs."[1] In addition, I also speak to you as a former Air Force officer with extensive experience in our nation's national security space programs, including management of complex space systems.

The ASEB has not specifically addressed the question that you are interested in today regarding development of a human space exploration roadmap. We are engaged currently in a congressionally requested review of the "goals, core capabilities, and direction of human spaceflight". That report is due to be released this Spring and I should note I have not seen a draft of the report and my comments are made without prejudice to whatever that committee—chaired by Jonathan Lunine and Mitch Daniels—may recommend. In addition the ASEB has not addressed the question of human Mars flyby missions. However, both the ASEB and the SSB have conducted recent studies that touch on many issues relevant to this

[1] America's Future in Space: Aligning the Civil Space Program with National Needs, National Research Council (NRC), 2009.

question. In particular, in 2012 the ASEB completed reviewing a series of NASA Space Technology Roadmaps that included topics such as long duration life support systems. The previous year, the ASEB and the SSB completed an extensive study of life and physical microgravity sciences.[2] Both studies highlighted the challenges to human spaceflight beyond low Earth orbit, for instance the development of long-duration life support systems. NASA has made progress in these areas aboard the International Space Station, although I would note that even today less than half of the oxygen on the International Space Station is recycled. As the ASEB's Space Technology Roadmaps study indicated, there are several high-priority technologies that require further development in categories such as radiation mitigation for human spaceflight, and environmental control and life support systems. The latter category includes air revitalization, water recovery and management, waste management, and habitation technologies. None of these technologies are currently mature enough to support a long-duration human spaceflight mission.

Many of the issues that NASA is facing as it seeks to send humans to Mars have been addressed in previous NRC reports. For instance, in 2002 the ASEB completed a study called "Safe on Mars" concerning precursor measurements required to safely place humans on the Martian surface. In 2006 we produced a workshop report on space radiation hazards facing astronauts on long-duration space missions.[3] More

[2] NASA Space Technology Roadmaps and Priorities, NRC, 2012; Recapturing a Future for Space Exploration: Life and Physical Sciences Research for a New Era, NRC, 2011

[3] Safe on Mars: Precursor Measurements Necessary to Support Human Operations on the Martian Surface, NRC, 2002.

recent studies have addressed astronaut training as well as the aforementioned roadmaps and microgravity research studies.

Mars Flybys and the Human Exploration of Mars

In my own opinion, the Inspiration Mars proposal is high risk, poses significant challenges to the crew because of radiation and life support concerns, has unidentified cost, and is being proposed at a time that NASA's budget is already over-constrained.

NASA's current long-term goal for human spaceflight is to send humans to Mars orbit sometime in the 2030s. The agency has started some projects that are aimed at making that possible, such as development of the Space Launch System and the Orion spacecraft. However, there are many other steps that NASA will have to take in order to be ready for such an ambitious goal. Tackling some of the technology tasks associated with keeping humans alive for long-duration spaceflight without external resupply (or a large internal supply of spare parts), are important goals if we are ever to send humans to Mars.

NASA already possesses or is developing assets that will play a vital role in future space exploration programs. These would naturally be included in the drafting of any space exploration roadmap leading eventually to Mars. These include the International Space Station, the Orion spacecraft and SLS, and also the various robotic and crewed spacecraft that are in operation or development that could serve vital infrastructure roles in any exploration program venturing beyond low Earth orbit.

There are several options that NASA could pursue to develop the capabilities required to put people safely down on the surface before attempting a human landing, or even a long-duration journey to Mars. Just as Apollo 8 orbited the Moon and Apollos 9 and 10 tested the Lunar Module and procedures prior to a landing attempt, NASA could take steps prior to a Mars landing including orbiting Mars and possibly visiting its two moons. In the past, agency working groups have considered the possibility of landing large craft on Mars without humans onboard to test the new entry, descent and landing technology required for landing large payloads on Mars.

Regarding the Inspiration Mars flyby proposal, NASA considered Mars and even Venus flyby missions during the 1960s. However, the agency ruled them out because of their poor scientific return compared to their cost. In short, they offered all of the risk of a long duration mission without any scientific payoff that was better than a far cheaper robotic mission. Today a piloted Mars flyby mission could in fact demonstrate some of the key required engineering capabilities for an eventual landing mission. Almost as important, it would be a powerful demonstration of capability, assuming that it was successful.

But an important question that should be asked and answered is: if the goal is to develop long-duration human spaceflight capabilities, is a Mars flyby the best near-term method for doing so? Such capabilities could be developed with a spacecraft that is sent to one of the LaGrange points, or orbits the Moon. In that case, if the astronauts encounter problems, they can easily return to Earth and will not have to wait hundreds of days for their orbit to return them.

Risks of This Proposal

Speaking personally, based upon my own experience managing complex space programs, the most immediate challenge for the Inspiration Mars proposal is building and testing flight hardware within the very short time period left, and having confidence that it will work as required. The first launch window for the mission is January 2018. That is less than four years from now. Most major space development programs require at least six to fifteen years before they fly.

I would also add that Inspiration Mars has also evaluated the possibility of a launch in 2021 instead. Although the 2021 date provides more time, it is still a relatively short development period for a new spacecraft and an entirely new mission with demanding requirements for human life support. A launch in 2021 would require a longer flight time and spend significantly more time in space, posing even greater challenges for the design of life support and other systems.

The Inspiration Mars proposal also leaves many questions still to be answered, primarily managerial responsibility for such a mission. If the United States government is to provide the majority of the funding, then this would become a government mission and government officials should be making the decisions and evaluating the options. In addition, after 2021 the launch window does not repeat for a very long time, meaning that if we miss it due to funding or technology challenges, much of the work may be for naught.

This proposal has not been independently vetted technologically or financially. It is entirely possible that there are major show-stoppers in the proposal. For instance, this mission would result in very high reentry velocities for the returning spacecraft. Can the Orion heatshield handle them? Is the state of the art for life support systems sufficient for such a long-duration mission? What about radiation hazards? How many test flights of both the SLS and Orion are required before the nation is willing to risk such a high profile mission using them?

Finally, and just as importantly, what will it all cost, and is this the best way to spend limited resources? Before making any major decisions concerning such a mission, it is vital that the proposal undergo a vigorous independent technical evaluation.

I look forward to answering the committee's questions.