Asteroid Retrieval: A Stepping Stone to Mars

Statement of Dr. Louis Friedman to the Space Subcommittee of the U.S. House of Representatives Committee on Science, Technology and Space

Mr. Chairman, Member of the Subcommittee:

Thank you for the opportunity to once again appear before this Committee to discuss the U.S. space program. I am pleased to present a summary of the Keck Institute for Space Studies Asteroid Retrieval Mission study and its implications for the human space exploration beyond the Moon and specifically to Mars.

I applaud the Subcommittee's consideration of this topic. Even though the nation has not taken and cannot afford to take a specific commitment to send humans to Mars at this time, the very holding of this hearing underscores the fact that human space exploration has a goal and a direction. Mars is the only human-accessible world to study possibilities of either indigenous past life or potential future life.

This Subcommittee does not need me to dwell however on the difficulties, costs and exigencies of a human Mars mission. It will require technical developments and scientific understanding which we do not yet have. There are many steps we must take before we can initiate the humans to Mars project. The Asteroid Retrieval Mission creates a first step (beyond the Moon) – the only one we are now capable of performing and the only one which we can afford within the current space program budget.

This mission may be one of the most exciting and interesting one in the history of exploration; certainly, at least, since the Apollo project. It represents an opportunity to sustain American leadership in robotic and human space exploration with technological innovation and engineering prowess. Since the last heroic Apollo mission, no human has ventured beyond low Earth orbit (a distance roughly equal to that from Los Angeles to San Francisco), let alone back to or beyond the Moon. While other nations dream of duplicating the American achievement of a half century ago, the Administration's new plan has the U.S. looking beyond the Moon on a path that will eventually take humans to Mars later in this century. The new initiative is not a giant-step, Apollo-like crash program; instead it follows a flexible and cost-effective path using stepping stones into the solar system. The stepping stones are literally and figuratively provided by near-Earth asteroids. The special cleverness enabling the first step is to use a robot to go out and capture one of these stepping stones and bring it to just beyond the Moon so that we can reach it without building new rockets or crew systems beyond those already now being developed. There is no other affordable way to step onto the path to Mars.

The scheme is audacious, yet both reasonable and feasible. A robotic spacecraft using solar electric propulsion will rendezvous with a very small asteroid (about 25 feet in diameter, but still relatively heavy at about 1.5 million pounds) in an orbit that is close to the Earth's orbit around the Sun. The asteroid would be captured in a large high-strength bag or container deployed once the spacecraft has rendezvoused with the asteroid. Redirecting the asteroid to the desired orbit in Earth-Moon space will take several years with the highly-efficient, but low continuous thrust provided by the solar electric propulsion system. Solar electric propulsion is now frequently used in space missions, scaling it up to the required in this mission is a technology development step that has been planned for many years. This mission will serve as a key test for even higher levels of power and propulsion for spacecraft of the future needed to support human missions to the lunar surface and ultimately to Mars. Using a gravity assist from the Moon, the asteroid will be put into a high lunar orbit that extends beyond the Moon, and in fact, even beyond the Earth-Moon Lagrangian point. It could then be the target for the first trans-lunar human mission, with a goal of doing this by 2025.

This Asteroid Retrieval Mission can be done soon, with a launch perhaps four or five years from now. It depends of course on finding a good target, but this we can do. Hundreds of asteroids this small have been discovered although they are hard to see and generally have been ignored while observers focus on larger objects. Yet we know there are millions of them and a dedicated observation program will find enough candidates with the right combination of traits to be attractive targets for the retrieval mission. Right now, we have a few – enough to be certain we can do the mission, but still looking for more optimal ones. Currently about a dozen asteroids are discovered per year smaller than 10 meters, and of these perhaps 1-3 have orbits which are accessible and characteristics suitable for a retrieval mission target. Increases in the observation program, particular with the Catalina Sky Survey in Arizona and the Pan-STAARS observatory in Hawaii are expected to increase that rate five to ten-fold over the next few years.

In addition to increased discovery rates, steps are being taken to engage the world-wide professional and amateur communities in rapid follow-up observations which permit the accurate characterization of the object's physical properties. The value of this approach was demonstrated recently with the discovery of asteroid 2013 EC20, found by the Catalina Sky Survey on March 7. Within hours the JPL Near-Earth Object program office had calculated a preliminary orbit and requested follow-up through the Smithsonian Minor Planet Center. Within a day a number of observations, including from the NASA Infra-red Telescope Facility, enabled a description of the asteroid's characteristics to be made including its spin rate. During close passage by Earth one week later, radar observations were obtained allowing its size to be determined. That particular asteroid would be fine for a mission to retrieve it by 2021 except that it is smaller than desired – only 2-3 meters, the size of a SUV. But the process of characterizing this object so quickly after its discovery gives us confidence that we will find excellent target candidates before needing to launch the Asteroid Retrieval Mission.

The small asteroids under consideration for the mission pose no danger to Earth: even if one did impact, it would burn up harmlessly in the atmosphere. In addition, the asteroid would be put on a trajectory that does not intercept Earth, even if control of the spacecraft were lost.

While a 5-10 meter asteroid is a small celestial object, it is still a big enough place for astronauts to conduct science measurements and human operations to study its characteristics and determine its potential as a source of resources They can even bring samples back to Earth. After a 50+ year hiatus (1972 to approximately 2025) humans will again be visiting a celestial body and taking new steps deeper into the solar system. In addition to the scientific benefits, the robotic-human synergy will contribute to industrial and technological advances. But, for me, the biggest advantage will be to the popular interest – we will be doing something important and exciting with humans in space again.

Near-Earth asteroids (those whose orbits intersect or pass very close to Earth's orbit) are a subject of increasing attention and importance. The remnant of one that fell in Chelyabinsk, Russia, last month reminded us of the potential danger of an impact, one that could be a lot larger and inflict much more damage. Those are rare – the last noticeable one to inflict damage on Earth was 100 years ago in Siberia, and the most famous one of all that led to the extinction of the dinosaurs (and thousands of other species) was 65 million years ago. But the significance of these objects in Earth's and human history is undeniable.

Exploring asteroids is important – to understand what they are made of and how they hold together. We may someday have to divert one. Exploring them and discovering new ones is also important scientifically because these small bodies of the solar systems (of which the Near-Earth asteroids are the most accessible) hold vital clues about the origin and history of the planets. Protection and science are two reasons to explore – but these objects offer one more reason for exploration that intrigues many now: prospecting. The asteroids are a potential source of water and volatiles for space ventures (perhaps as fuel depots later this century) and possibly of metals and minerals for commercial exploitation. Two private entrepreneurial companies are currently raising money to begin such prospecting, and one more is raising money to observe such asteroids with a space telescope.

The feasibility of the Asteroid Retrieval Mission caught some in the space community by surprise. But the use of solar-electric propulsion technology, the capture of non-cooperative objects in space, the discovery of Near-Earth objects, and the application of the clever techniques of celestial mechanics that make up the mission are all developments that NASA and other space agencies have been working on for years. Even the idea of re-directing a small asteroid was considered in several studies in the past decade. What was new was that recent advances in solar electric propulsion technology make this mission feasible for the first time in history, enabling these ideas to be applied to the flexible path moving humans beyond the Moon recommended by the Augustine Committee and adopted by the Administration for human space exploration. That we could enable the first step on that path with existing systems, deferring the cost and risk of true interplanetary flights until after these achievements, was the surprise. The robotic asteroid retrieval places the risk of human space flight where it belongs: on new exploration.

In our KISS study we quoted a cost, never independently verified, of $2.6 billion. This was the result of a quick study, actually within NASA, with assumptions never vetted by the study team. I actually applaud the group who did this cost – because they made so many conservative assumptions to really test the idea's feasibility. Our KISS study did not have the resources to examine the cost estimate – but I can tell you that many of us thought it was much too conservative. Based on my 40+ years of experience as an aerospace engineer on many planetary projects I believe that the cost estimate for this project will be less than two billion dollars. Without any of the complications of a Mars landing system, entry or descent, or a rover, or a suite of science instruments, surely this mission will cost less than the Mars Science Laboratory. But that is a question for NASA and JPL to answer.

Most space enthusiasts, like me, wish we could jump to Mars. Unfortuantely, we have neither the money nor the knowledge for such a commitment now. But a series of steps, as outlined in The Planetary Society roadmap and similarly described by the Augustine Committee on Human Space Flight in 2009, can steadily increase capabilities to go deeper into interplanetary space. As we achieve longer flight times, more capable crew habitation modules and life support systems, and more knowledge about both the interplanetary and Martian environment we will bring the Mars goal closer. The asteroid in lunar orbit may be the first stepping stone, asteroids in Sun-Earth Lagrangian points could be the next, then an asteroid further away, closer to Mars, then a Martian moon (Phobos or Deimos) and then Mars itself. I believe this is the direct and only sustainable way to Mars.

This project will not just unify NASA with science, technology, robotic, and human components, but also it will unify many others globally, with a great adventure. Europe, Japan and Russia all have asteroid mission plans and solar electric spacecraft in operation. They could join in the mission development. After the asteroid is in place even private spacecraft developers could be invited to explore and test new prospecting ideas there and maybe create a new commercial industry for utilization of space resources. Meanwhile, NASA will again be leading the world into space, moving on to new accomplishments on more distant asteroids, perhaps on the Martian moons, and then on Mars itself.

Dr. Louis Friedman is Co-Lead of the Keck Institute of Space Studies (KISS) Asteroid Retrieval Mission study and is Executive Director Emeritus of The Planetary Society. KISS is a privately funded institute at the California Institute of Technology, supported by the W.M. Keck Foundation.