NASA Advisory Council Recommendation

Asteroid Redirect Mission
2014-02-02 (Council-02)

Recommendation:
The Council recommends that NASA should conduct an independent cost and technical assessment of the Asteroid Redirect Mission (ARM). NASA should state clearly in advance what the cost and technical criteria are for implementing the mission. These criteria should include affordability within currently projected budgets. The independent assessment should be performed before the downselect between Options A and B. The possible outcomes of this process are: fly Option A, fly Option B, or (if the projected cost is unacceptable) fly neither.

Major Reasons for Proposing the Recommendation:
NASA's current Asteroid Initiative has three elements: (1) the search for and identification of Near Earth Asteroid (NEA) targets; (2) redirection of one NEA target to near-lunar orbit; (3) astronaut crew to cis-lunar space to rendezvous with the target and conduct operations. The cost of the second element (asteroid redirect, e.g., ARM) is poorly defined at present. The other elements of the Asteroid Initiative (target search and flights to cis-lunar space) still have merit even if the redirect mission does not take place. It must also be noted that ARM is not a substitute for a mission to an asteroid in its native orbit, which appears to be possible at a lower launch energy than previously believed based on recent data[2-4]. Such a long duration deep space mission would be a logical step toward the horizon goal of humans to Mars. We have concerns that the ARM mission as currently defined may pose an unacceptable cost and technical risk. A prudent response to such concerns is to conduct and independent cost and technical assessment prior to selection.

Consequences of No Action on the Proposed Recommendation:
A mission of significant cost and technical risk may be implemented without a full understanding of the potential for significant cost overrun or schedule slip.

NASA Response:
NASA concurs that it is important to conduct an independent cost and technical assessment prior to selection of an Asteroid Redirect Mission (ARM) concept. Cost is a key consideration, and the selection decision will also consider other aspects, such as cost risk and the extensibility of the mission concept to future NASA exploration missions. NASA's Mission Concept Review (MCR) is planned for early 2015, and will include an independent NASA technical and cost assessment for the selected mission concept.

To narrow the trade space for the MCR, a robotic mission capture option down-select review was conducted in December 2014, with a decision expected in January 2015. Our use of 'Option A' and 'Option B' describes whether we will redirect a small asteroid from its native orbit or retrieve a boulder from a larger asteroid. In addition to internal NASA concept development, we have awarded 18 six-month study contracts with industry to better inform both the mission concept down-selection and the MCR. Cost projections and development schedules are generally included in these contract deliverables.

The interim reports will be available prior to the mission concept down-selection. The ARM team is refining a detailed cost estimate for both internal capture concept options A and B, which includes a grass-roots estimate of the projected costs for both options. An independent NASA team, using experienced project managers and a combined team of experienced Jet Propulsion Laboratory and Goddard Space Flight Center cost analysts, will assess each cost basis of estimate in support of the down-select.

In the MCR, a mission concept for the selected capture option will be reviewed. Final reports from the Broad Agency Announcements contracts will be included in the proposed mission concept, as well as an independent NASA cost assessment by this same cost analyst team. Given NASA's approach to leveraging ongoing work and the current state of integrated mission definition, we will review the proposed mission concept at MCR and set constraints for design and long lead acquisitions, including mission cost, launch readiness date, risk management approach, descope options, and cost and schedule reserves.

While recent analyses indicate the possibility of astronauts visiting an asteroid in its native orbit at delta velocities on the order of 5 km/s from low Earth orbit (LEO), similar to the ARM Crewed Mission, these candidate asteroids still yield transit times from LEO of over 3.5 months[1]. Shorter missions, of the order of 70 days, may be possible at delta-Vs of around 7 km/s[1]. NASA's reference plan for the ARM crewed mission encompasses a 26-28 day mission, including 5 days in a stable lunar distant retrograde orbit, which is within the capabilities of the Block I SLS/Orion vehicles. ARM can be accomplished prior to the availability of additional capabilities such as longer duration life support. In addition, this beyond LEO mission offers drivers for lower mission risk posture such as early crew and Orion auxiliary thruster contingency returns, including within consumables limits. This makes ARM a more logical early step beyond LEO toward the horizon goal of humans to Mars.

Many other aspects of ARM build capabilities and reduce risk for Mars missions, including:

- Moving large objects through interplanetary space using solar electric propulsion (SEP);
- Integrated crewed/robotic vehicle stack operations in deep space orbits (e.g., integrated attitude control, solar alignment during multi-hour EVAs);
- In-space systems for astronaut extra-vehicular activity;
- Sample selection, handling, and containment;
- Lean implementation of an upgradable deep space operational SEP vehicle; and
- Broad scoped robotic/crewed integration, including crewed system hardware deliveries to and integration and test with robotic spacecraft, and joint robotic spacecraft and crewed mission operations.

Our early 'Proving Ground' missions provide systems and technology testing and operational experience beyond the "Earth Dependent" domain of the International Space Station (ISS). Risk reduction in the Proving Ground, with returns to Earth possible within a few days, complements the important long duration human system risk reduction on the ISS. As presented in the sustainable exploration 'split mission' Mars approach, NASA missions in the Proving Ground will use both chemical propulsion based human transportation systems and high power, long life solar electric propulsion systems as a sustainable path in collaboration with international and commercial partnerships.

Cis-lunar space missions are necessary for risk reduction prior to visiting an asteroid in its native orbit. ARM provides significant contributions in the Proving Ground for future human missions to Mars. ARM also offers an opportunity for interesting science, for less cost and risk, than a crewed visit to an asteroid in its native orbit.

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[1] Regarding the assumptions, as written on the Near-Earth Object Human Space Flight Accessible Targets Study (NHATS) home page at <http://neo.jpl.nasa.gov/nhats/>: *"The list of potential mission targets should not be interpreted as a complete list of viable NEAs for an actual human exploration mission. As the NEA orbits are updated, the viable mission targets and their mission parameters will change. To select an actual target and mission scenario, additional constraints must be applied including astronaut health and safety considerations, human space flight architecture elements, their performances and readiness, the physical nature of the target NEA, and mission schedule constraints."*