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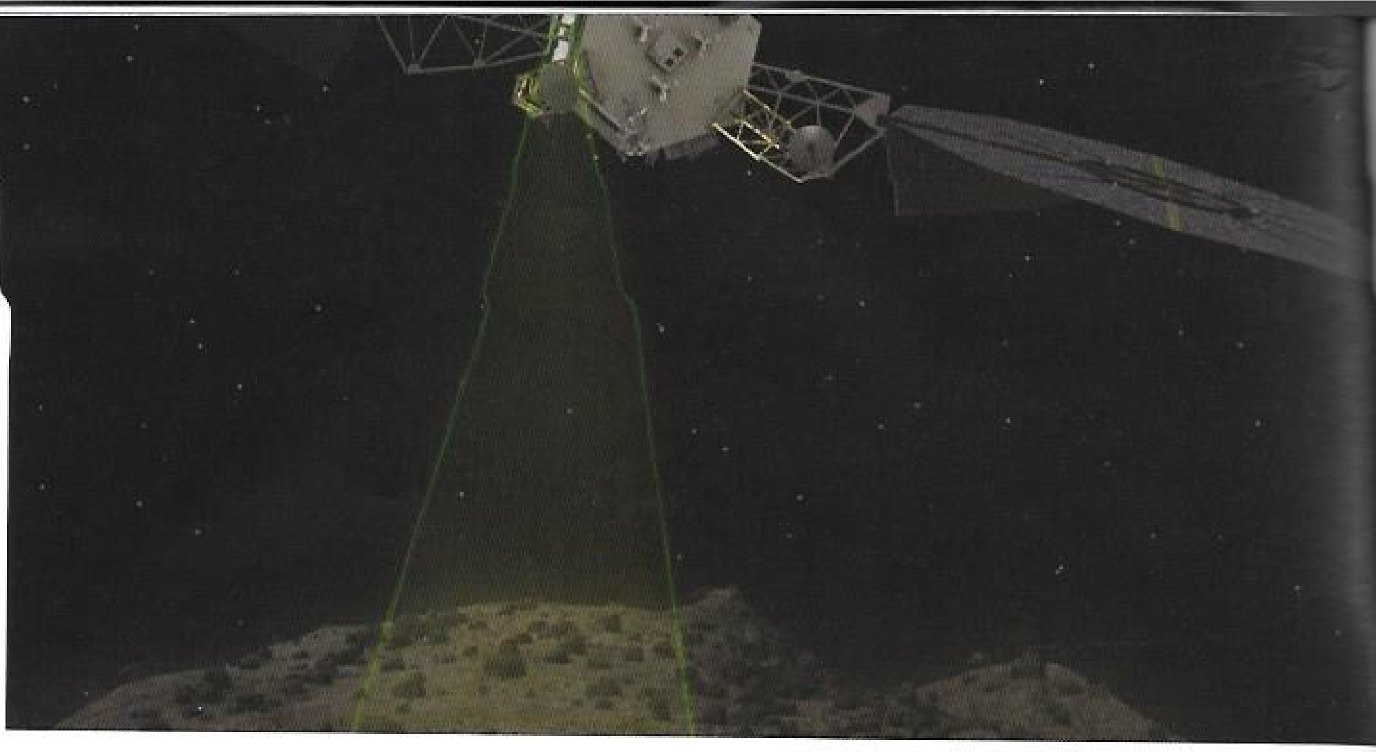
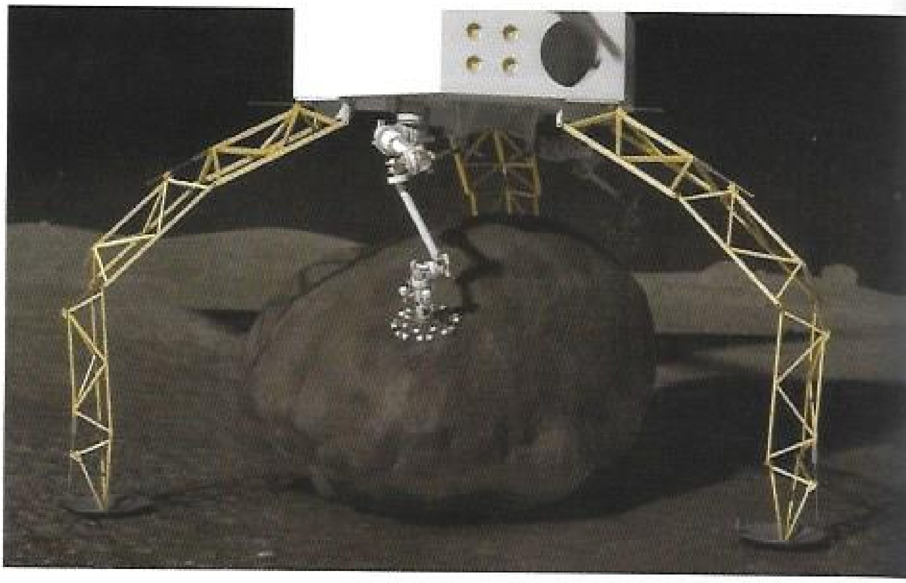


SPACE COWBOYS GO FISHING

By Henry M. Holden

Photos: Courtesy NASA.

ABOVE: *The Asteroid Redirect Vehicle conducts one of the 1 km fly-bys that are used to characterise and image the asteroid with a resolution of up to 1 cm.*
BELOW: *Microspine grippers on the end of the robotics arms are used to grasp and secure the boulder. The microspines use thousands of small spines to dig into the boulder and create a strong grip. An integrated drill will be used to provide final anchoring of the boulder to the capture mechanism.*
BOTTOM: *Once the boulder is secured, the ARV will mechanically push off, or "hop", from the surface and then use thrusters to ascend from the asteroid's surface.* (Photos: Courtesy NASA)



IN 2000, Hollywood produced a film called *"Space Cowboys."* The plot involved four senior citizen former fighter pilots rocketing into space to capture and redirect a former Soviet Union communications satellite that was in a decaying orbit.

They soon learn that the satellite also has six nuclear missiles and it cannot be allowed to enter Earth's atmosphere. The solution: shoot it to the Moon. Great acting on the part of Clint Eastwood, Tommy Lee Jones, and others could not save the film from disaster.

In the January 2015 issue of *World Airnews,* "Orion: a stepping stone to Mars," we briefly mentioned an "asteroid redirect mission." At the time, we said: "The details of this asteroid redirect mission (ARM) are still being worked out. The robotic capture craft may snag an entire small asteroid, or pluck a boulder off a much bigger space rock."

Now NASA has announced the details of ARM. "The Asteroid Redirect Mission will provide an initial demonstration of several spaceflight capabilities we will need to send astronauts deeper into space, and eventually, to Mars," said NASA associate administrator, Robert Lightfoot. "The option to retrieve a boulder from an asteroid will have a direct impact on planning for future human missions to deep space and begin a new era of spaceflight."

NASA HAS TWO OPTIONS

Option A is pitched as game-changing; Option B as a fishing trip in space.

NASA had pitched the asteroid mission as one that would eventually help the agency send humans to Mars, sort of a stepping stone. But it has never really articulated why it makes more sense to land on an asteroid than, say, land on the Moon again.

It seems NASA was not willing to take a chance on actually redirecting an asteroid after all.

But, as a back-up explanation, NASA continues to claim that redirecting an asteroid is going to serve as a good planetary defence mechanism. In a video posted last year, NASA said the mission would "help develop" a capability that could help us defend Earth from impacts in the future."

In making this decision NASA has lost the planetary defence argument as political cover for the mission, and the way NASA is funding it, annually — it puts the whole project at risk. Congress hates NASA's asteroid plan, and Option B is $100-million more expensive than option A.

OPTION B

"Option B, building a robotic capture probe, may have advantages that are worth the price-tag bump," Lightfoot said.

"For example, large asteroids are known to harbour multiple boulders, so the mission will have a number of targets to choose from when it gets to the big space rock.

"Option A is riskier; the capture probe would likely have no recourse if its chosen asteroid proved too large to handle, or otherwise unsuitable.

"The [asteroid] targets [for option A] are hard to describe and the uncertainty around those gave us a little pause," Lightfoot said. "I think we would have found one eventually. It's a one shot deal. We get out there, and it is what it is when we get there, *versus* having the larger asteroid too large to handle, made option B more attractive."

The capture probe will assess the chosen asteroid's boulders, grab one up to 13 feet (4 m) wide and then retreat to a "halo orbit" around the big space rock. The spacecraft will stay in this orbit for 215 to 400 days, long enough for the boulder-toting probe's subtle gravitational tug to influence the orbit of the larger space rock.

The Orion spacecraft with two crew inside approaches to dock with the Asteroid Redirect Vehicle

The capture probe will then turn around and move it into a stable orbit around the moon, where it should end up by late 2025.

Two NASA astronauts will then journey out to meet the robotic spacecraft and the boulder, using the agency's *Orion* capsule and the Space launch system megarocket, both of which are in development. This manned mission will likely last about 25 days," Lightfoot said.

The agency plans to announce the specific asteroid selected for the mission no earlier than 2019, approximately a year before launching the robotic spacecraft. Before an asteroid is considered, a valid candidate for the mission, scientists must first determine its characteristics, in addition to size, such as rotation, shape and precise orbit.

The cost of the robotic component of ARM — that is, the capture/redirect mission, without any astronaut visits — will be capped at $1,25-billion, and does not include the launch vehicle.

Lightfoot said technologies developed using Option B would be "more extensible" to a future Mars mission, though he did not explain how the mission would be useful for landing humans on Mars.

The logic is difficult to follow. Landing on an asteroid that is hurtling through space seems to have little to do with landing on Mars, where there is a thin atmosphere that makes landing on it more technically challenging than landing on something without an atmosphere, such as the Moon.

So now, NASA has made an already unpopular, expensive mission even more expensive and has lost the whole "we're-doing-this-to-save-the-planet" thing. Surely, there is something to be gained from the mission, it is still a new frontier, it is still something NASA wants to do—but will Congress see it that way?

SOLAR ELECTRIC PROPULSION

Throughout its mission, the ARM robotic spacecraft will test a number of capabilities needed for future human missions, including advanced solar electric propulsion (SEP), a valuable capability that converts sunlight to electrical power through solar arrays and then uses the resulting power to propel charged atoms to move a spacecraft.

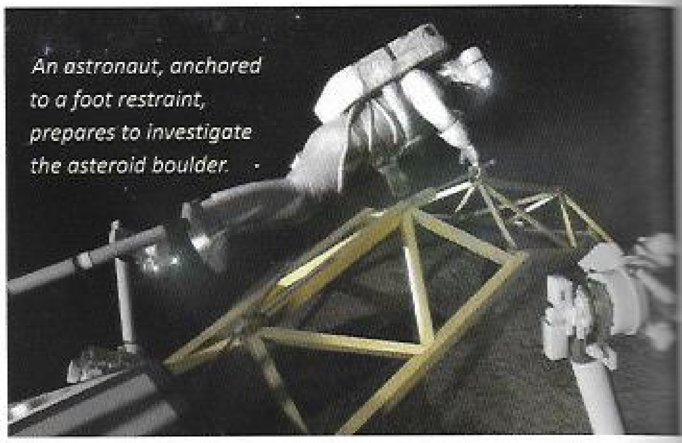
This method of propulsion can move massive cargo very efficiently. While slower than conventional chemical rocket propulsion, SEP-powered spacecraft require much less propellant and fewer launches to support human exploration missions, which could reduce costs.

Future SEP-powered spacecraft could pre-position cargo or vehicles for future human missions into deep space, either awaiting crews at Mars or staged around the moon as a waypoint for expeditions to the Red Planet.

ARM's SEP-powered robotic spacecraft will test new trajectory and navigation techniques in deep space, working with the moon's gravity to place the asteroid in a stable lunar orbit called a distant retrograde orbit.

REDIRECT A NEAR-EARTH OBJECT

Before the piece of the asteroid is moved to lunar orbit, NASA will use the opportunity to test planetary defence techniques to help mitigate potential asteroid impact threats in the future. The experience and knowledge


An astronaut, anchored to a foot restraint, prepares to investigate the asteroid boulder.

acquired through this operation will help NASA develop options to move an asteroid off an Earth-impacting course, if and when that becomes necessary.

In 2005, NASA's Deep Impact comet science mission tested technology that could assist in changing the course of a near-Earth object using a direct hit with a spacecraft. The ARM robotic spacecraft opens a new and second option for planetary defence using a technique called a "gravity tractor".

All mass exerts and experiences gravity and, in space, the gravitational attraction even between masses of modest size can significantly affect their motion. This means that by rendezvousing with the asteroid and holding a halo orbit in the appropriate direction, the ARM robotic spacecraft can slowly pull the asteroid without touching it. The effectiveness of this manoeuvre is increased, moreover, if mass is moved from the asteroid to the spacecraft by the capture of a boulder.

Astronauts will conduct spacewalks outside Orion to study and collect samples of the asteroid boulder wearing new spacesuits designed for deep space missions.

Collecting these samples will help astronauts and mission managers determine how best to secure and safely return samples from future Mars missions. And, because asteroids are made of remnants from the formation of the solar system, the returned samples could provide valuable data for scientific research or commercial entities interested in asteroid mining as a future resource.

"Asteroids are a hot topic," said Jim Green, director of NASA Planetary Science. "Not just because they could pose a threat to Earth, but also for their scientific value and NASA's planned mission to one as a stepping stone to Mars."

But, when did the last asteroid hit Earth?

Perhaps to bolster their "we're here to save the planet" rhetoric, NASA also announced it had increased the detection of near-Earth asteroids by 65 percent since launching its asteroid initiative three years ago.

NASA has identified more than 12 000 NEOs to date, including 96 percent of near-Earth asteroids larger than 0.6 miles (1 kilometre) in size. NASA has not detected any objects of this size that pose an impact hazard to Earth in the next 100 years.

Smaller asteroids do pass near Earth, however, and some could pose an impact threat. In 2011, 893 near-Earth asteroids were found. In 2014, that number was increased to 1 472.

Originally, astronauts would have fully captured a small asteroid and moved it to orbit around the moon. During a follow up mission, astronauts would have visited the asteroid.

In option B, astronauts will still visit the rock, but it will just be a rock, a part of an asteroid that, if it is misdirected during its redirection and hit Earth, could do serious damage. →