BOARDING AN ASTEROID

By Henry M. Holden

IN THE May 2015 issue of World Airnews we talked about "Space Cowboys Go Fishing," a NASA plan to capture a small asteroid and drag it back to a near-moon orbit for study. Well it seems that NASA has another plan to study asteroids, to board one.

The OSIRIS-REx Mission will seek answers to questions that many of us ask: Where did we come from? What is our destiny? OSIRIS-REx (short for The Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer) is going to Bennu, a carbon-rich, near-Earth asteroid that may have within it the earliest history of our Solar System. Bennu may contain the molecular precursors to the origin of life and the Earth's oceans.

TheOSIRIS-REx mission will be the first US mission to retrieve a pristine sample of an asteroid, and return it to Earth for further study.

"This is an exciting time for the project," said Mike Donnelly, OSIRIS-REx project manager from NASA's Goddard Space Flight Centre. "Years of effort are coming to culmination.

"Studying Bennu will revolutionise our understanding of the early Solar System and reveal much about planetary history and the origin of life. The mission will also expand our knowledge of the hazards and resources in near-Earth space and will serve as a template for future asteroid missions."

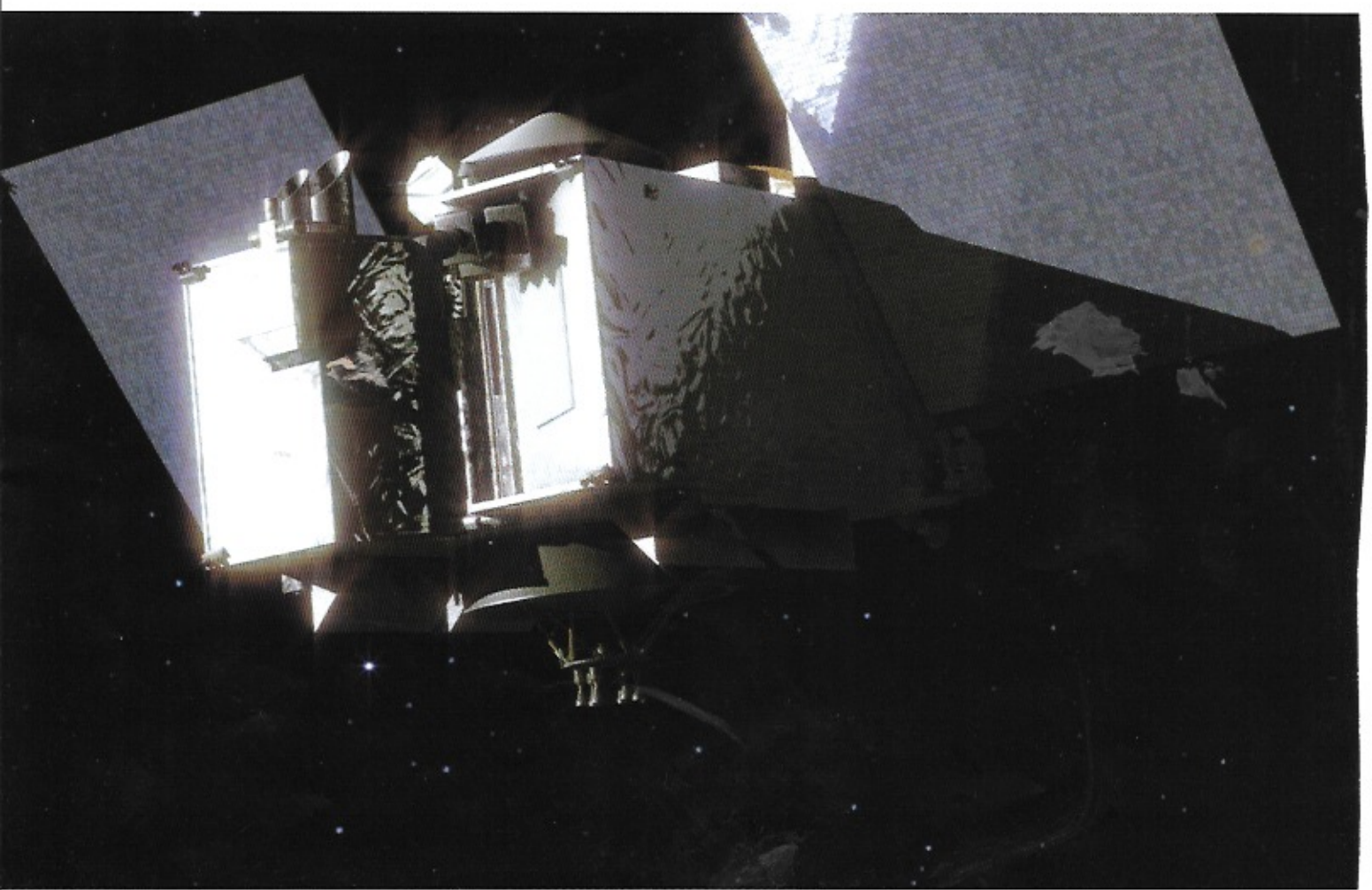
Bennu is also potentially a very hazardous asteroid and has a relatively high probability of impacting the Earth late in the 22nd century. This mission will determine Bennu's physical and chemical properties, which will be critical for future scientists to know when developing an impact plan.

LAUNCH

The OSIRIS-REx launch window opens on September 3, 2016. The launch period will last 39 days, with a 30-minute window available each day. The spacecraft will launch from Cape Canaveral, Florida, on an Atlas V rocket, in the 411 configuration.

The 411 configuration adds a single strap-on solid booster rocket to the first stage. The Atlas V rocket uses a Russian-built RD-180 engine burning kerosene and liquid oxygen to power its first stage, and an American-built RL10 engine burning liquid hydrogen and liquid oxygen to power its upper stage.

After OSIRIS-REx orbits the Sun for a year, it will make a flyby of Earth. Earth's gravitational field will pull the spacecraft towards the planet where it can "borrow" a small amount of Earth's orbital energy. This additional energy will be used to



increase the spacecraft's orbital inclination and sling it back into space for a rendezvous with Bennu.

PRECISION APPROACH

Bennu travels around the sun at an average speed of 63 000 mph. To reach Bennu, OSIRIS-REx will perform a series of braking manoeuvres, slowing down by 0,53 km/s (1 186 mph), resulting in a relative approach velocity of 20 cm/s (approximately 0,45 mph).

The precision approach begins when Bennu is a point of light more than two million km away from the spacecraft, in August 2018.

As the spacecraft approaches the asteroid, it will use small rocket thrusters to match the velocity of Bennu in its orbit around the Sun. The rendezvous requires the spacecraft to reach the same location as the asteroid, and at the same time the asteroid gets to that location.

It must also move at the same speed and in the same direction as the asteroid, all using star-based navigation.

ORBITAL SURVEY OF BENNU

"We'll orbit Bennu to analyze its surface and select a sample site," said Dr. Joseph Nuth an OSIRIS-REx Project Scientist.

"This will give us experience with operating spacecraft in the vicinity of an asteroid, experience that will be useful if we ever have to send a mission to deflect one."

OSIRIS-REx will be formation flying with Bennu during the asteroid encounter.

Moving into position for sample acquisition late 2019, the total change in velocity is just over 20 cm/s (0,45 mph), minute compared to the large manoeuvres required to arrive and depart the asteroid.

A preliminary survey will search for asteroid plumes, natural satellites, and measure the Yarkovsky acceleration of Bennu.

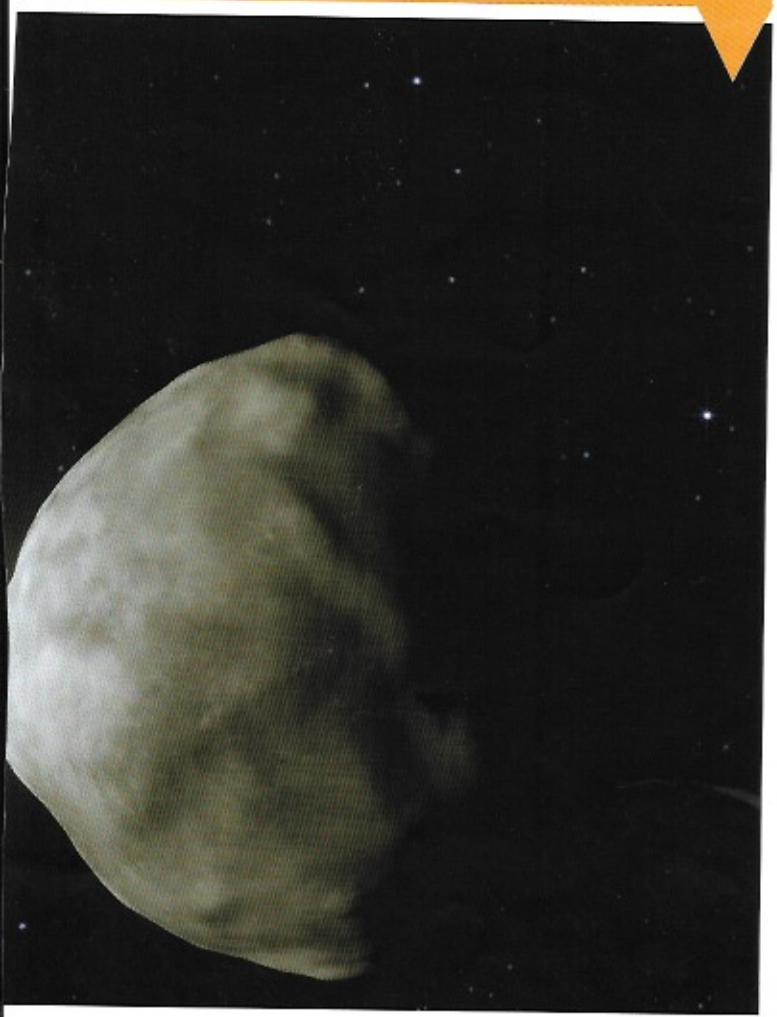
The mission will also help to better track the orbits of asteroids that might hit Earth by accurately measuring the "Yarkovsky effect" for the first time.

The Yarkovsky effect is a small push on an asteroid that happens when the asteroid absorbs sunlight and emits heat.

The small push adds up over time, and it is uneven due to an asteroid's various surface materials, wobble, and rotation.

"There's no sure way to predict an Earth-approaching asteroid's orbit unless you can factor in how the Yarkovsky effect will change that orbit," according Nuth.

"It's like trying to make a complex, banking shot in a game of pool with someone shaking the table and kicking the legs."



Artist's rendition of the spacecraft approaching the near-Earth asteroid called Bennu. As planned, the spacecraft will reach its asteroid target in 2018, and return a sample to Earth in 2023.
(Image Credit: NASA/Goddard/University of Arizona)

TOUCH-AND-GO

The Touch-And-Go Sample Acquisition Mechanism (TAGSAM) is a simple sampler head with an articulated arm. Once the sampler head makes contact with the surface of Bennu, a burst of pure nitrogen gas will push surface regolith into the sampler's chamber. Surface contact pads on the exterior of TAGSAM will also collect fine-grained material as the sample collector touches down on the asteroid.

TAGSAM has three separate bottles of gas, which allows up to three sampling attempts.

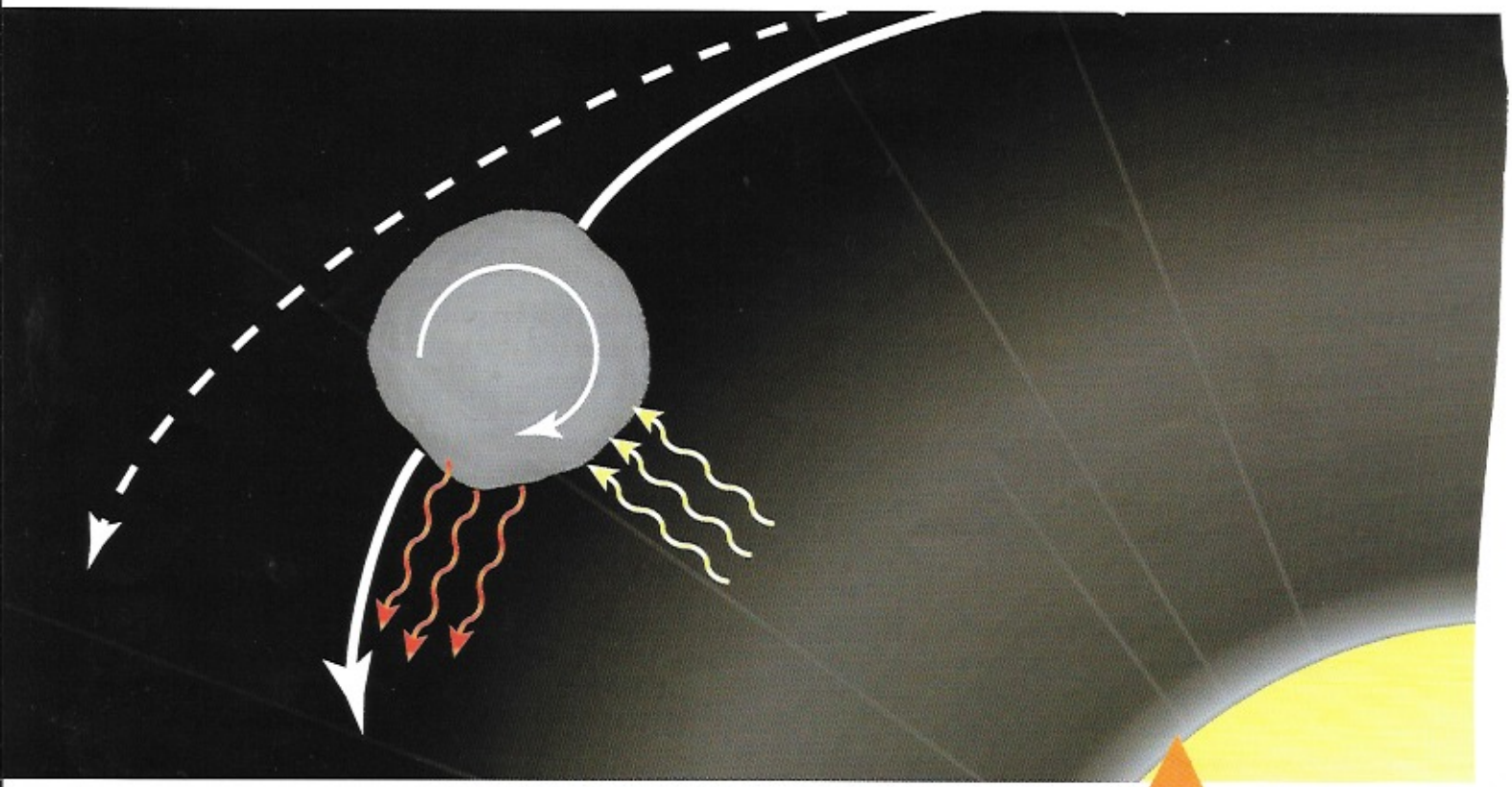
"Piloting a spaceship near an asteroid is not easy," said Nuth. "Most are lumpy and rotate more rapidly than planets, which makes for challenging landings. These small objects have feeble gravity; so other forces can significantly influence the spacecraft's position.

"Gravity on this asteroid is so weak, if you were on the surface, held your arm out straight and dropped a rock, it would take about half an hour for it to hit the ground. Pressure from the sun's radiation and the solar wind on the spacecraft and the solar panels is about 20 percent of the gravitational attraction. It will be more like docking than landing," added Nuth.

INVENTING NEW PHYSICS

"Our biggest concern, is focused on how the asteroid will respond during the sampling event. We will perform a slow-motion (10 cm/s) touch-and-go manoeuvre to grab a sample of Bennu. We will then open a bottle of high-pressure nitrogen gas to agitate the regolith and collect it in a large air filter.

"We worry about sending too much material up towards the spacecraft, potentially coating our optical surfaces with dust and damaging important components. We have learned that in order to model this process we will have to invent some new physics to describe an expanding gas in a micro-gravity environment interacting with



regolith grains. Our results to date suggest that all the equipment necessary for the return journey home is safe."

The OSIRIS-REx Sample Return Capsule (SRC) is an aero shell design container with a heat shield and parachutes. Once the sample of Bennu is collected, the TAGSAM arm places the TAGSAM head into the SRC. At the end of the mission, the SRC containing the TAGSAM head and sample of Bennu will be the only part of the spacecraft to return to Earth.

The plan is to keep the sample of Bennu under nitrogen purge to avoid contaminating it with terrestrial microbes after Earth return. NASA does not expect any microorganisms on Bennu and considers finding one a very unlikely. The asteroid is too small and the radiation doses on its surface would kill any living organism in a very short time.

"We hope to find organic molecules that may have led to the origin of life on Earth," said Nuth. "We will focus on measuring the organic molecular inventory of the samples but don't have any plans for biological assays."

The window for departing Bennu opens in March 2021. At this time OSIRIS-REx will fire the main engines and leave Bennu with a speed of 0,32 km/s (716 mph). This burn will place the Sample Return Capsule on a ballistic trajectory that intersects the orbit of the Earth in September 2023. →

The Yarkovsky effect is a small push on an asteroid that happens when the asteroid absorbs sunlight and emits heat. The small push adds up over time, and it is uneven due to an asteroid's various surface materials, wobble, and rotation.

(Photo: NASA)

The spacecraft will collect a sample of at least 60 grams (2,1 ounces) and return it to Earth for study. Scientists expect Bennu may hold clues to the origin of the solar system and the source of the water and organic molecules that may have made their way to Earth.

(Photo: NASA/GSFC/UA)

A size comparison of the OSIRIS-REx spacecraft next to a six-foot tall person .

(Photo: UA/OSIRIS-REx mission)