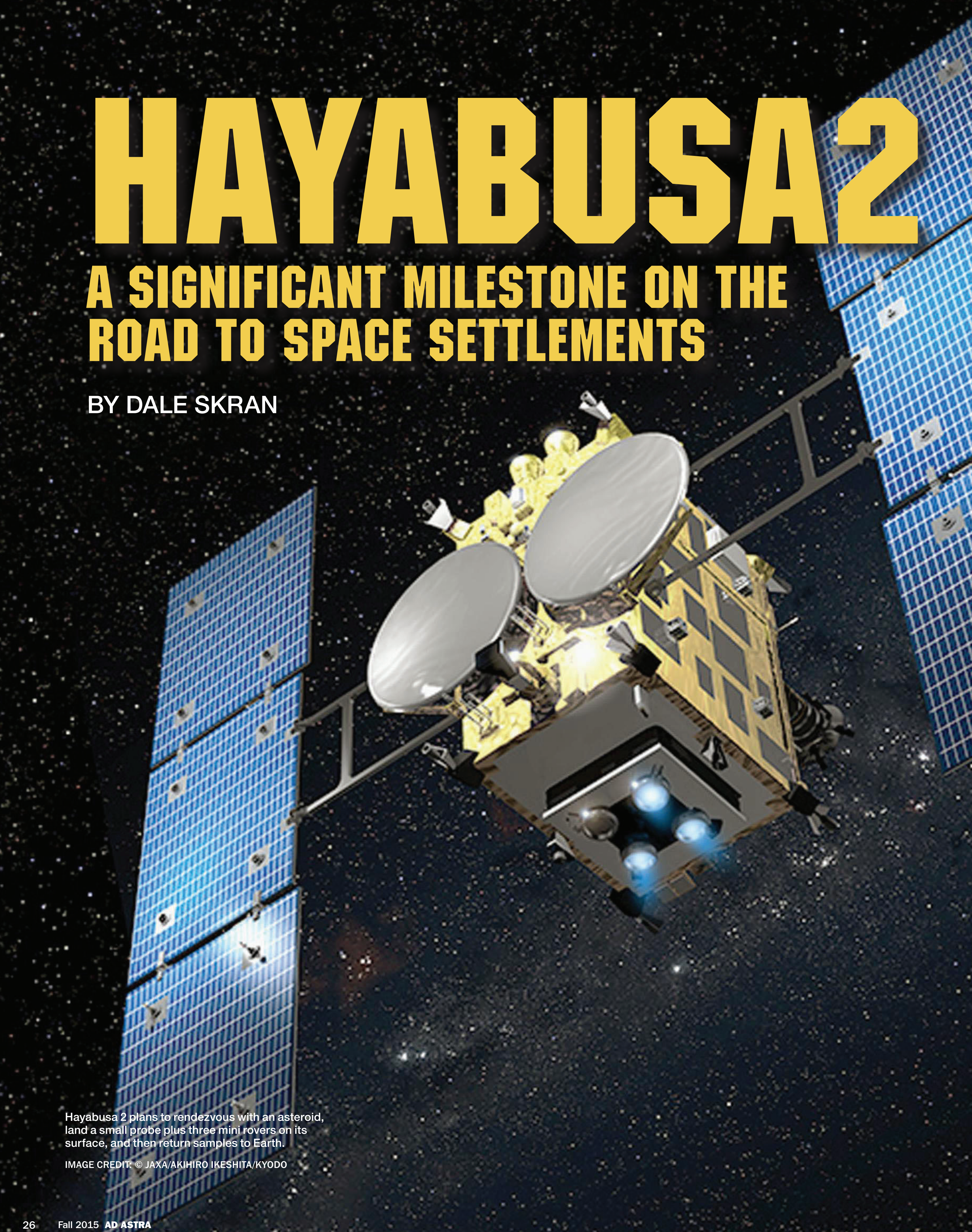
HAYABUSA2

A SIGNIFICANT MILESTONE ON THE ROAD TO SPACE SETTLEMENTS

BY DALE SKRAN

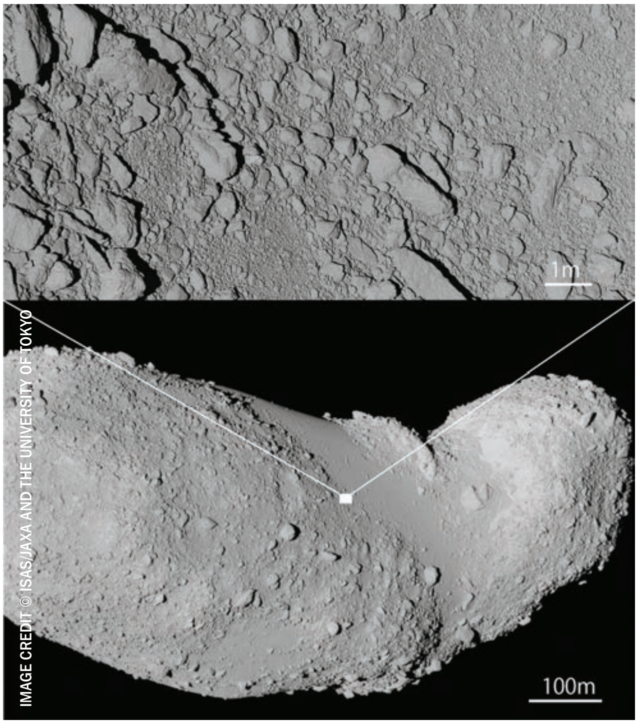


Hayabusa 2 plans to rendezvous with an asteroid, land a small probe plus three mini rovers on its surface, and then return samples to Earth.

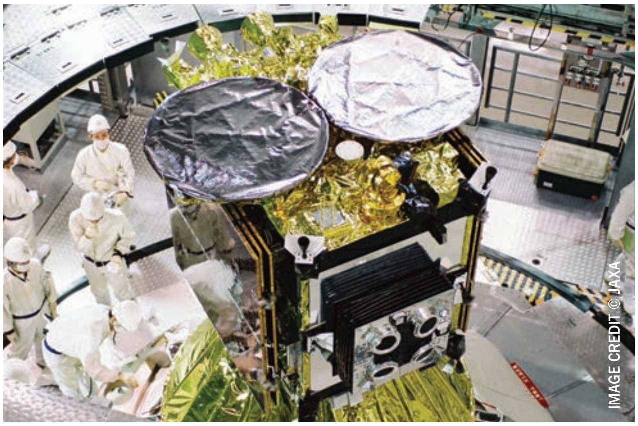
IMAGE CREDIT: © JAXA/AKIHIRO IKESHITA/KYODO

Milestone 18 in the NSS Space Settlement Roadmap is titled "Exploration, Utilization, and Settlement of Asteroids" (*http://www.nss.org/settlement/roadmap/RoadmapPart6.html*). Asteroids have long beckoned as potential sources of easily reached resources in space. Since asteroids have extremely small gravity fields, mining them at low cost becomes a real possibility. When this is added to the fact that many asteroids orbit the Sun in such a fashion that they can be more easily reached energetically (i.e. using less fuel) than the lunar surface, mining becomes an even more attractive idea. The third enabler for asteroid mining lies in the diverse composition of asteroids, which includes carbon, water, iron, and the platinum-group metals. Mining the asteroids is clearly a long-term project, but every journey starts with a single step. Or two steps. Hayabusa2 is one of those second steps.

Launched December 3, 2014 on a Japanese H-IIA rocket from the Tanegashima Space Center, Hayabusa2 is the second in a series of Japanese asteroid sample return missions. Although there have been a number of missions to asteroids, including Galileo, NEAR Shoemaker, Deep Space 1, and Dawn (now orbiting Ceres), encountering 12 different targets in total, none of these missions returned samples until the first Hayabusa (Japanese for "Falcon") probe in 2010. Launched May 9, 2003 toward 25143 Itokawa, the Hayabusa's xenon ion engines fired for two years to reach the target, an S-type ("Stony") "rubble-pile" asteroid. After overcoming many technical difficulties, Hayabusa returned a small sample to Earth on June 13, 2010. Hayabusa



This image of asteroid Itokawa was taken by Hayabusa with a blow-up at high resolution of a small part of the viewing area.



Engineers with the Japan Aerospace Exploration Agency work on Hayabusa 2 as the asteroid probe is attached to its H-2A rocket ahead of a December 3, 2014 (JST) launch target at the Tanegashima Space Center.

demonstrated an impressive final feat of engineering while returning to the desert in Woomera, Australia, when the sample return capsule underwent peak deceleration of 25 G, with heat about 30 times that experienced by the Apollo Command Module.

Hayabusa2 is now cruising under power from its four ion engines toward a July 2018 encounter with the asteroid 1999 JU3, an Apollo asteroid about 500 m x 300 m x 200 m. The Apollo asteroids are a group of near-Earth asteroids named after 1862 Apollo, the first asteroid in the group to be discovered. The Apollo asteroids, of which more than 5,700 are known, orbit the Sun mostly between Earth and Venus in such a fashion that they can get very close to the Earth and become potential threats. The February 15, 2013 Chelyabinsk meteor, which exploded over the city of Chelyabinsk, Russia and injured thousands of residents, was an Apollo asteroid.

Asteroid 1999 JU3 is of special interest because spectrographic analysis reveals that it has characteristics of both S-type and G-type asteroids. G-type asteroids are similar to C-types ("carbonaceous") but often have spectra that suggest the presence of clays or silica in addition to carbon and water. Asteroid 1999 JU3 is about 1000 m in size, significantly larger than 25143 Itokawa. Hayabusa2 is scheduled to orbit the asteroid for a year and a half, leave the asteroid in December 2019, and return to Earth in December 2020.

Hayabusa2 generally follows the design of Hayabusa and has numerous improvements. The ion engines have been increased in power from 8 milli-Newtons to 10 milli-Newtons, and countermeasures against neutralizer degradation have been added to avoid the engine failure that troubled the first probe. In order to create a small crater on the asteroid so that samples from below the surface may be collected, a 2 kg copper object will be dropped toward the asteroid at a velocity of 2 km/sec. The impact probe is pure copper so that any sample contamination can be easily disregarded

Hayabusa 1

during analysis, because the asteroid is believed to be copper-free.

Hayabusa2 will use a Near InfraRed Spectrometer (NIRS3) and a Thermal Infrared Imager (TIR) to map the asteroid from a 20 km orbit. Hayabusa2 also carries three small rovers (MINERVA-II) that will explore the asteroid by hopping over the surface. Finally, the MASCOT small lander will convey instruments provided by France and Germany to the surface for further studies. MASCOT is capable of making a single hop so that two locations can be sampled.

The U.S. plans to enter the asteroid sample return game with OSIRIS-Rex, a NASA New Horizons mission targeted for a 2016 launch to the Apollo asteroid 101955 Bennu, a C-type asteroid, returning samples to the Earth in 2023. 101955 Bennu is of special interest as it is currently second on the Sentry list of objects most likely to impact the Earth between 2175 and 2199, albeit with only a cumulative probability of impact of 3.7 x 10-4 (see *http://neo.jpl.nasa.gov/risk/*). Part of the OSIRIS-Rex mission will include physically mapping the asteroid, which will allow for more accurate calculation of the impact probabilities. The National Space Society has issued a position paper entitled "Protecting Earth from Cosmic Impacts" (*http://www.nss.org/legislative/positions/NSS_Position_Paper_Planetary_Defense_2014.pdf*), which provides more information on how we can protect ourselves against 101955 Bennu and other potential threats. Although not specifically called for in "Protecting Earth," missions like Hayabusa2 and OSIRIS-Rex support the main theme of the paper, which is that we need to gather as much information as possible about the locations and impact probabilities of potentially threatening asteroids and comets. Additionally, Hayabusa2 and OSIRIS-Rex will gather data on the internal structure of asteroids on which future technologies for threat mitigation can be established.

By focusing on asteroid sample return missions, Japan has become the world leader in this exciting area. Such missions are key steps toward the utilization of asteroid resources and the eventual settlement of the asteroids, and have the side benefit of providing us with better knowledge of potential asteroid threats.

Dale Skran is a technology entrepreneur currently serving as NSS executive vice president and chair of the NSS policy committee while also serving on the NSS board of directors. In addition, he represents NSS on the Alliance for Space Development board of directors.