HITCH HIKERS IN THE SOLAR SYSTEM

By Henry M. Holden

NASA IS pioneering space travel, exploration and human expansion across multiple solar system destinations, including to an asteroid and Mars.

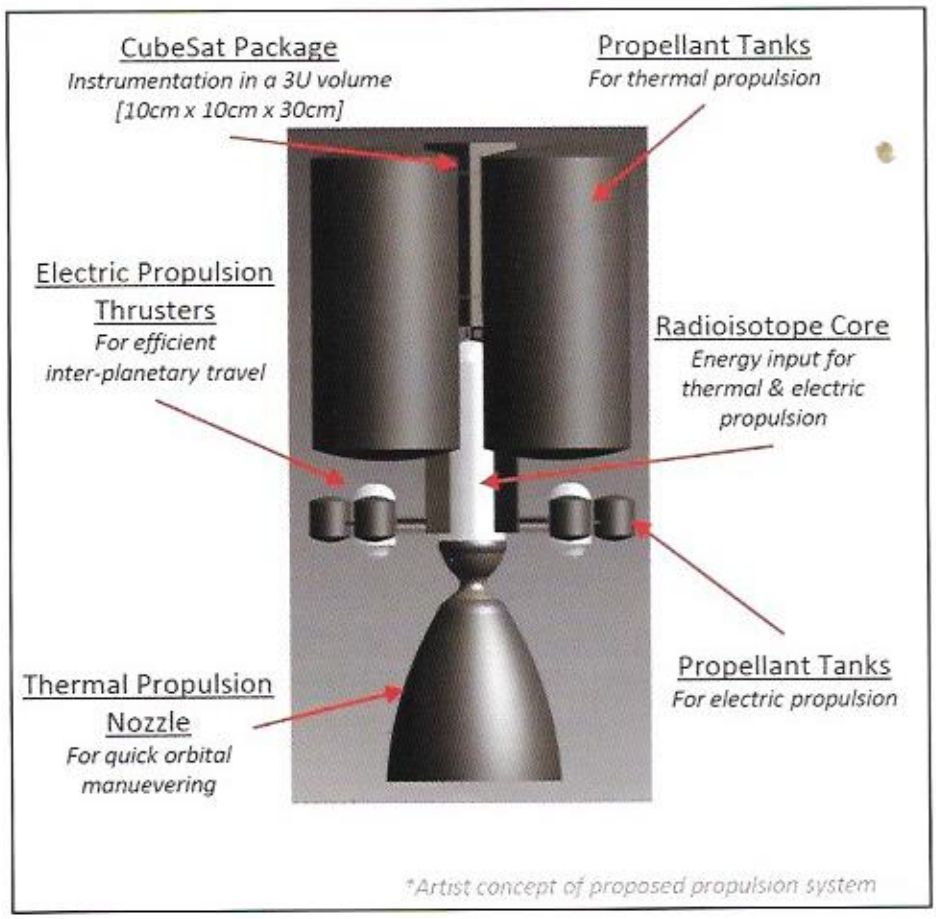
The longest human duration in deep space to date was the 12,5 days the Apollo 17 crew spent on a round trip mission to the moon, and the longest low-Earth orbit (LEO) duration will be one year spent on the International Space Station by two crew members between 2014-2015.

NASA plans to send humans further into space than ever before, but before they do that it has to understand the effects of the deep space environment on biological systems and devise counter-measures to lessen the risks associated with deep space travel. So, instead of sending humans into dangerous and unknown conditions in space, NASA will be sending hitch-hiking Nano satellites called CubeSats.

Although unmanned, the first flight of the Orion spacecraft in December 2014 was the first step in demonstrating its ability to safely ferry astronauts beyond Earth into deep space.

The next critical demonstration of NASA's deep space exploration capabilities will be on Exploration Mission (EM)-1 in 2018. This first flight of NASA's space launch system (SLS) rocket flight will

Above: *Several tiny satellites are featured in this image photographed by an Expedition 33 crew member on the International Space Station. The satellites were released outside the Kibo laboratory using a Small Satellite Orbital Deployer attached to the Japanese module's robotic arm on Octpber. 4, 2012.*
Below: Artist's concept of CubeSat propulsion.
(NASA images)



launch an uncrewed Orion spacecraft to a distant retrograde orbit around the moon, and return it to Earth.

In addition to demonstrating NASA's new heavy-lift capability, SLS has the capacity to accommodate 11 CubeSats, which will deploy once the Orion spacecraft separation is confirmed and on a specified timeline based on their mission objectives.

About 10 minutes after Orion and its service module escape the pull of Earth's gravity, the two will disconnect and Orion will proceed toward the moon. Once Orion is a safe distance away, the small payloads will begin to be deployed, all at various times during the flight depending on the particular missions.

SLS is the largest and most powerful American rocket made since the Saturn V and this heavy lifter will eventually send humans father into space than before.

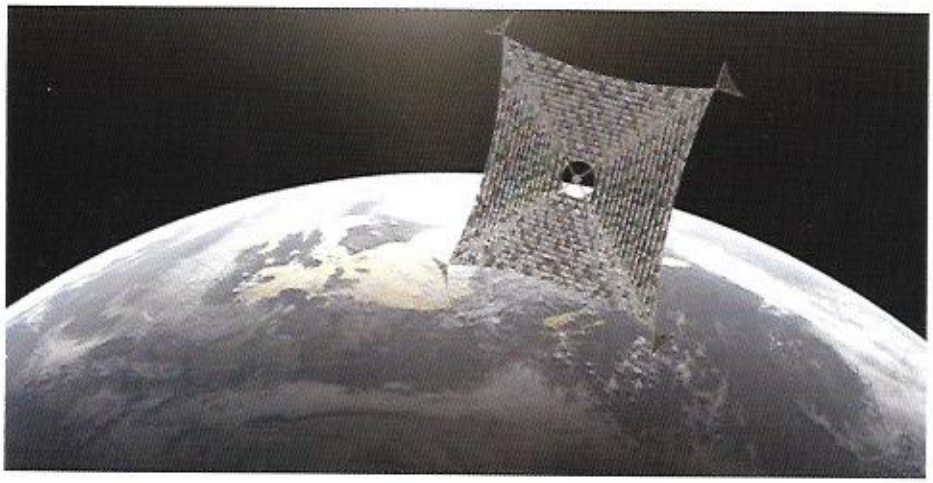
Tucked inside the stage adapter — the ring connecting Orion to the top propulsion stage of the SLS — will be 11 self-contained CubeSats, each about the size of a large shoebox.

"NASA is taking advantage of a great opportunity to conduct more science beyond our primary focus of this mission," said Jody Singer manager of the Flight Programmes and Partnerships Office at the Marshall Space Flight Centre in Huntsville, Alabama. "While this new vehicle will enable missions to go well beyond Earth orbit, we're taking steps to increase the scientific and exploration capability of SLS by accommodating small, CubeSat-class payloads."

The dispensers on the adapter ring will be built with commercially available materials. No pyrotechnic devices will be a part of the payloads and each will be ejected with a spring mechanism – similar to opening a lid on a toy jack-in-the-box.

These CubeSats are designed to be efficient and versatile. The mass of these secondary payloads are about 14 kg — and will not require any extra power from the vehicle to function. They will essentially be hitch-hiking on the SLS flight, providing what otherwise would be costly access to deep space.

"We are expanding the capabilities of this particular SLS test flight," said Joseph Pelfrey, deputy manager of the Exploration and Space Transportation Development Office at Marshall. "The rocket will be the strongest ever built by NASA and we want to take advantage of that design. Flying secondary payloads is something we plan to do for missions to come and provide the science community an opportunity they haven't had before."



Top: *The CubeSat Ambipolar Thruster is a new design for a permanent magnet helicon generated plasma thruster. Its small plasma volume (~10 cm³) and low power requirements (<100 W) make it ideal for propelling nanosatellites (<10 kg). The source is powered by a novel DC to RF oscillator with air-core inductors suitable to be flown on small spacecraft.* (Photo: University of Michigan Department of Aerospace Engineering)
Above: *Artist's conception of Sunjammer Sail in flight above Earth. Giant sails propelled by the Sun or a laser's energy could be the most viable option for unmanned interstellar spaceflight in the not-too-distant future.*
(Image: Space Services Holdings, Inc.)

NASA Headquarters in Washington is soliciting inputs for the available EM-1 secondary payload slots, and three have already been selected for further development: Near-Earth Asteroid (NEA) Scout, Lunar Flashlight and BioSentinel.

Before sending astronauts to any new space environments, it is important to send robotic scouts to survey the destination and learn about the risks they may pose to future human explorers.

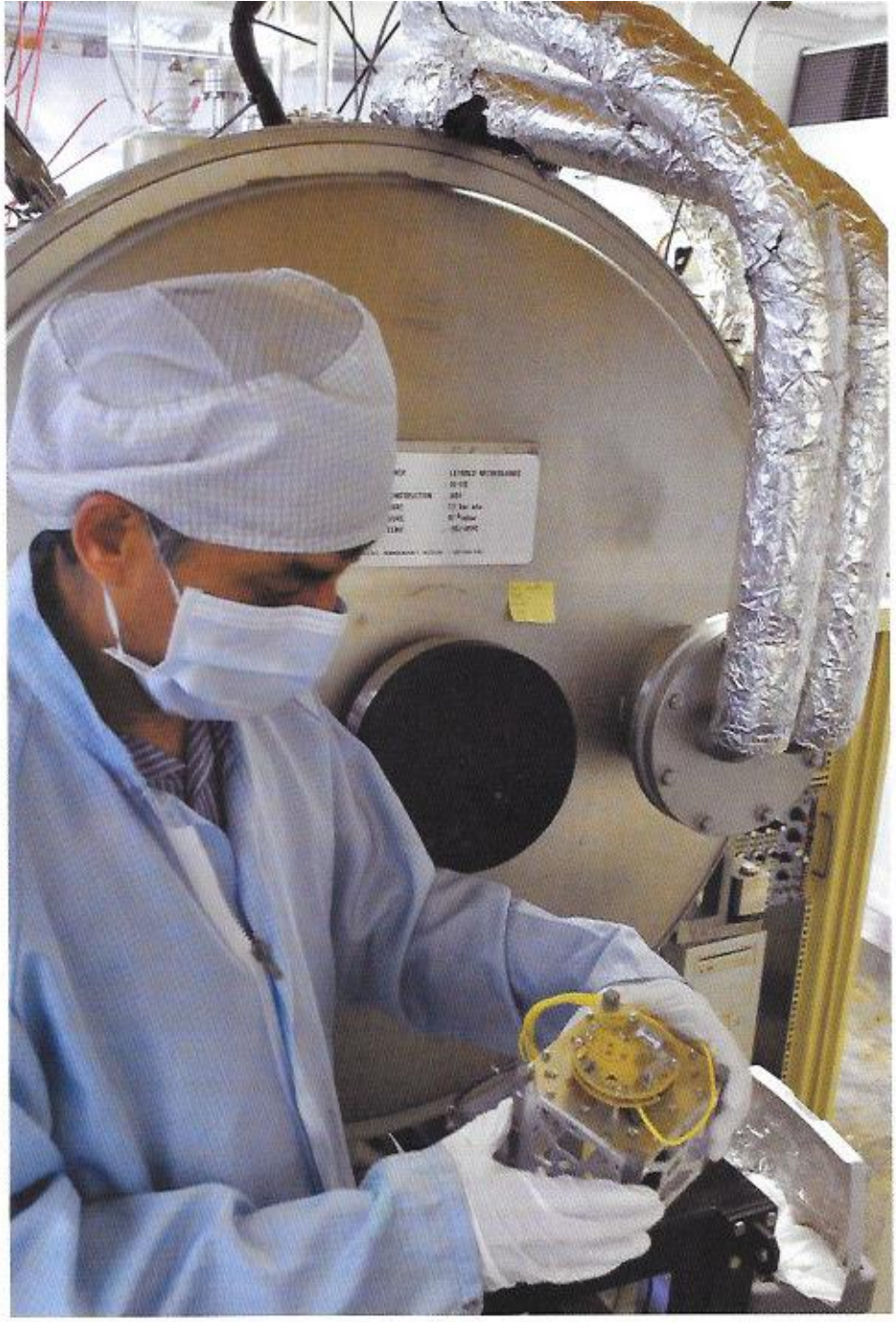
The Near-Earth Asteroid Scout, will perform reconnaissance of an asteroid using a CubeSat and solar sail propulsion, which offers navigation agility during cruise for approaching the target.

Propelled by sunlight, NEA Scout will flyby and observe a small asteroid (less than 100-metres in diameter), taking pictures and observing its position in space, the asteroid's shape, rotational properties, spectral class, local dust and debris field, regional morphology and regolith properties (layers of loose, heterogeneous superficial material covering solid rock).

NEA Scout's observations will directly assist in retiring the strategic knowledge gap (SKG) related to human exploration of asteroids. The data collected will enhance the current understanding of asteroidal environments and will yield key information for future human asteroid explorers.

BIOSENTINEL

"The BioSentinel mission will be the first time living organisms have travelled to deep space in more than 40 years and the spacecraft will operate in the deep space radiation environment throughout its 18-



A scientist holds a CubeSat illustrating its relative size. (NASA)

month mission,' said Les Johnson, a principal investigator at Marshall.

"BioSentinel will use yeast to detect, measure and compare the impact of deep-space radiation on living organisms over long durations beyond LEO.

"Since the unique deep space radiation environment cannot be replicated on or near Earth, the BioSentinel mission is one way to help inform us of the greatest risks to humans exploring beyond LEO, so that appropriate radiation protections can be developed and those dangers can be mitigated."

LUNAR FLASHLIGHT

NASA's Lunar Flashlight will scout for locations on the lunar surface that are rich in resources that, once broken down into their component molecules, could be used in future exploration, such as building materials, propellant, oxygen and water," said Johnson.

"Lunar Flashlight will use a large solar sail, similar to the NEA Scout sail, to reflect sunlight and illuminate the moon's permanently shadowed craters and then the science instruments will measure the surface water ice."

Pioneering space will only be possible if humans can learn to live off the land. Resources at destinations in space, such as atmospheres, water ice and regolith, can be broken down into their component molecules and used for building materials, propellant, oxygen for humans to breathe and drinking water.

This capability, known as *in-situ* resource utilisation, or ISRU, is most useful for human explorers if the ISRU "power plants" are deployed to locations that are rich in the required resources.

NASA's Lunar Flashlight will demonstrate this scouting capability from lunar orbit by performing multiple passes of the surface to look for ice deposits and identifying favourable locations for *in-situ* resource extraction and utilisation. A spectrometer will then observe the reflected light to measure the surface water ice.

The spacecraft will continue to make repeated measurements over multiple points in the craters, creating a map of the surface ice concentration. This data will be correlated with previous mission data, providing crucial guidance to future mission planning.

SOLAR SAIL

After the CubeSat is ejected from the SLS, solar panels will deploy which will provide the power. Next, an 85 m^2 solar sail will be deployed and unfurled.

The sail is the length of a school bus and is the largest solar sail ever deployed by the United States. It will reflect sunlight into the craft's propulsion system. This CubeSat will fly by the moon which will help send it on its way to the target asteroid.

A solar sail-powered spacecraft does not need traditional propellant for power, because its propellant is sunlight and the sun is its engine. Light is composed of electromagnetic radiation that exerts force on objects it comes in contact with. NASA researchers have found that at one astronomical unit (the distance from the sun to Earth, equal to 93-million miles, sunlight can produce about 1,4-kilowatts (kw) of power. If you take 1,4 kw. and divide it by the speed of light, you would find that the force exerted by the sun is about nine Newtons (N)/square mile, namely 0,78 lb/mi^2).

In comparison, a space shuttle main engine produced 1,67 million N of force during liftoff and 2,1 million N of thrust in a vacuum. Eventually, however, the continuous force of the sunlight on a solar sail could propel a spacecraft to speeds five times faster than traditional rockets.

"A solar sail works best when deployed in deep space and SLS will get us there," said Les Johnson, principal investigator for NEA Scout at Marshall. "It will take us out of Earth orbit and to interplanetary space — where we need to be to deploy the solar sail.

"It's a perfect ride to begin our mission," he said. →