Science & Technology Briefs

Odysseus Lands on the Moon

On Feb. 22, the *Odysseus* spacecraft landed softly and intact on the Moon, becoming the first U.S.-built spacecraft to do so since Apollo 17 in 1972. Three recent attempts, by *Peregrine* (U.S.), *SLIM* (Japan), and *Beresheet* (Israel), failed. *Odysseus* launched from Launch Complex 39A at NASA's Kennedy Space Center in Florida, atop a Falcon-9 rocket provided by the commercial company SpaceX.

Odysseus was built by NASA contractor Intuitive Machines (IM) in Houston. According to its website, "IM provides critical lunar infrastructure in lunar orbit delivery, surface access, and communications." This year, NASA has awarded IM contracts for science and exploration missions to the Moon's South Pole. Commercial delivery is part of NASA's Commercial Lunar Payload Services (CLPS) initiative and the Artemis program.

At a press conference Feb. 23, IM CEO Steve Altemus revealed that in attempting its vertical touchdown, *Odysseus* used guidance provided by a NASA on-board Navigation Doppler Lidar, instead of radar. Lidar (light detection and ranging) offers several advantages over radar, notably that a laser transmits a pencil beam of visible light that can give a more precise and accurate measurement.

But because *Odysseus* was also moving horizontally—and a little too quickly, it appears—it's likely that one of its legs caught on something or broke, causing it to tilt over; it is therefore now lying on its side. The good news is that most of its payloads are not on the downward-facing panel. IM later confirmed that the major subsystems, including the solar arrays that provide power to the spacecraft and the payloads, are operational. A detailed account of the landing and its problems is found here in the *New York Times*.

NASA, employing around 17,000—down from around 40,000 in the heyday of the Apollo missions—now contracts with commercial partners to provide services and hardware/software. The scientific objectives of the IM-1 mission include studies of plume-surface interactions, radio astronomy, and space weather interactions with the lunar surface. It has already demonstrated precision landing technologies and communication and navigation capabilities.

Odysseus, a hexagonal cylinder 4.0 meters tall and 1.57 meters wide, perched on 6 landing legs with a launch mass of 1908 kilograms, is capable of carrying approximately 100 kg of payload to the surface. Its solar panels generate 200 watts of power, using a 25 amp-hr battery and a 28-volt DC system. Propulsion and landing are accomplished with liquid methane as fuel and liquid oxygen as an oxidizer, powering the main engine mounted on the bottom of the lander. Communications are via microwave frequency.

The scientific payload: the Laser Retro-Reflector Array (LRA); Navigation Doppler Lidar for Precise Velocity and Range Sensing (NDL); Lunar Node 1 Navigation Demonstrator (LN-1); Stereo Cameras for Lunar Plume-Surface Studies (SCALPSS); and Radio wave Observation at the Lunar Surface of the photo-Electron Sheath (ROLSES). Also on board are four commercial payloads.

A Coin-Sized Nuclear Battery from Beijing

As reported Jan. 16 by *Nuclear Engineering International*, Beijing-based start-up Betavolt New Energy Technology has achieved a significant milestone. It successfully developed a 3-volt miniature nuclear battery that produces direct current by combining nickel-63, a radioisotope which releases a high energy electron as it decays to the stable isotope copper-63, with a diamond semiconductor as the energy converter. This combination of these two leading-edge technologies enabled miniaturization to the size of a coin, modularization, and thereby, cost-effectiveness. This nuclear battery boasts 50 years of stable self-generation without the need for recharging or maintenance. Betavolt has begun a pilot program to mass-produce them for the market.

Betavolt expects this revolutionary technology to meet the power needs of various sectors, including aerospace, AI devices, medical devices, MEMS (micro-electro-mechanical systems) advanced sensors, small drones, and micro-robotics, among others. Betavolt plans to continue its research into other isotopes such as strontium-90 and promethium-147, to develop even more powerful batteries.

Human-Generated VLF Radio Waves Affect Earth's Radiation Environment

We have long been shaping the Earth's surface landscape, but now scientists have discovered that we are also shaping our near-space environment. A type of technology—Very Low Frequency (VLF) radio waves—have been found to interact with particles in space, affecting how and where they move.

This new knowledge is discussed in a comprehensive paper,

"Anthropogenic Space Weather," published April 13, 2017 in *Space Science Reviews*.

Very Low Frequency (VLF) electromagnetic radiation (radio waves) are those classified by the International Telecommunication Union as having frequencies from 3 to 30 kHz (a bandwidth of 27 kHz), corresponding to wavelengths of 100 to 10 km respectively. Due to the limited bandwidth, voice communication is not practical, and therefore only low data rate signals are used. Since the 1950s, due to their ability to penetrate at least 40 meters into seawater, military services have used VLF waves to communicate with submarines.

Studies of data collected by NASA's two Van Allen Radiation Belt satellite probes showed that VLF transmissions from Earth were creating a shield-like impenetrable barrier in space that scatters high-energy electrons (cosmic rays), preventing them from coming closer to our planet. The outward extent of the VLF bubble corresponded almost exactly to the inner edge of the Van Allen radiation belts, a layer of charged particles held in place by Earth's magnetic fields.

Daniel Baker, Director of the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics, dubbed this lower limit the "impenetrable barrier" and speculated that without human VLF transmissions, the boundary would likely stretch closer to Earth. (The International Space Station and other low Earth-orbiters could then be damaged by the Van Allen Belts.)

Sunquakes and Solar Flares

The activity of the Sun ebbs and flows in an 11-year cycle. Now, in Solar Cycle 25, activity is expected to peak this year or in 2025.

After steadily increasing activity, on May 13, 2022, the first "sunquake" of Cycle 25 was observed. Since the Sun has no solid surface, it's not the same as an earthquake.

Space Weather reported May 13, 2022:

"Twenty-six years ago, researchers discovered seismic activity on the Sun. A team led by Dr. Alexander Kosovichev, then at Stanford University, found circular waves rippling from the core of some solar flares, like the ripples in a pond."

"They named the tremors 'sunquakes'—much like earthquakes except incredibly more powerful. A typical sunquake contains 40,000 times the energy released in the great San Francisco earthquake of 1906. These solar seismic waves appear to be compression waves like the 'P' waves generated by an earthquake. They travel through the Sun's interior and probably recombine on the opposite side of the Sun to create a faint duplicate of the original ripple pattern."

"Kosovichev and colleagues have since observed hundreds of sunquakes. Not all flares produce them, which is a mystery. Moreover, the ripples behave strangely. A typical wave starts off at an initial speed of approximately 20,000 mph, then accelerates to a maximum of 250,000 mph before disappearing. No one knows exactly why."

Kosovichev is now a professor at the New Jersey Institute of Technology (NJIT).

A video of a similar previous solar flare/sunquake combination is available here:

Solar Cycle 25 activity is intensifying and many more sunquakes are expected, which could enable scientists to learn a great deal about the magnetic underpinnings of sunspots and how they produce strong flares.

Given the current decrepit state of the U.S. electrical grid, all it would take to bring it down—along with the Internet and GPS satellites—might just be one solar eruption that resulted in a coronal mass ejection (a massive blob of magnetized gas) that came our way. Such electromagnetic pulses have happened, but a bigger one could cause a collapse of the grid.

Ancient Star Chart Discovered in Italy

Archeologists recently uncovered a stone disk dating from approximately 2,400 years ago, on which man-made markings appear to correspond to the stars in constellations such as Cassiopeia, Orion, the Pleiades, and Scorpius. This was reported Dec. 31, 2023 in *Sputnik International*. The stone was found at an ancient hill fort in Rupinpiccolo, in northeastern Italy.

A study of those markings, "Possible Stellar Asterisms Carved on a Protohistoric Stone," published in Nov. 22, 2023 by *Astronomical Notes*, described the stone disc, roughly the size of a car tire, as having 29 chisel markings, with 24 on the obverse and five on the reverse that corresponded to the above-mentioned constellations. However:

"A unique marker above Orion's northern region puzzled … astronomers because it does not correspond to any familiar star today. This marker might point to a star that has since experienced a supernova—a star's powerful and luminous explosion—resulting in an elusive black hole that advanced astronomical methods might one day reveal."

Stars and their constellations were well-known and studied in ancient times, most especially by ancient Greeks, and extensively referenced in the Sanskrit *Vedas* of ancient India. Many early civilizations around the globe developed some form of astronomical observations. The oldest known star chart depicting the constellation of Orion has been claimed to be recognized in a carving on a section of a mammoth tusk, dating back some 32,500 years. Cave paintings depicting constellations such as the Summer Triangle and the Pleiades, in what is now France, have been dated to about 16,500 years ago.