DEEP SPACE STATION 14 (DSS-14), THE 70M ANTENNA AT GOLDSTONE DEEP SPACE COMMUNICATIONS COMPLEX IN GOLDSTONE, CA. *IMAGE COURTESY NASA/JPL-CALTECH*

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"We came to Kevin with an idea that involved a complicated two sided transaction where timing and quality of execution were of paramount importance. He helped us to evaluate the quality of competing offers, while keeping the entire transaction on schedule against a ticking clock.

His expertise with regard to managing the 2 escrows, and especially his sensitivity to the historic nature of both properties helped to uncomplicate a very complex transaction. Thanks to Kevin, we are living in the home of our dreams."

BRAD AND CYNTHIA T., PASADENA

COMPASS

DEEP SPACE NETWORK

Enabling spacecraft to phone home

BY SKYE HANNAH

In an age where digital devices surround us, it's easy to take the ubiquity of that technology for granted. With a simple cell phone, we can easily contact loved ones around the globe, an ability that was unheard of until not that long ago. Spacecraft, however, require a bit more than the newest hand-held phone technology to communicate back to earth as they orbit distant planets and zip across the far-reaches of our solar system. This is the calling of the Deep Space Network (DSN), which serves as a type of cell phone network from the Earth to approximately 40 missions beyond our moon.

The DSN consists of a network of 12 large-scale antennas spread across three stations around the globe: Goldstone, California; Madrid, Spain; and Canberra, Australia. At each of its three sites, the DSN operates one 70-meter-diameter antenna (close to the size of a football field) and three 34-meter-diameter antennas. Based on their geographical positioning, the antennas are able to overlap coverage so spacecraft can have continual communication with Earth as our planet rotates in space.

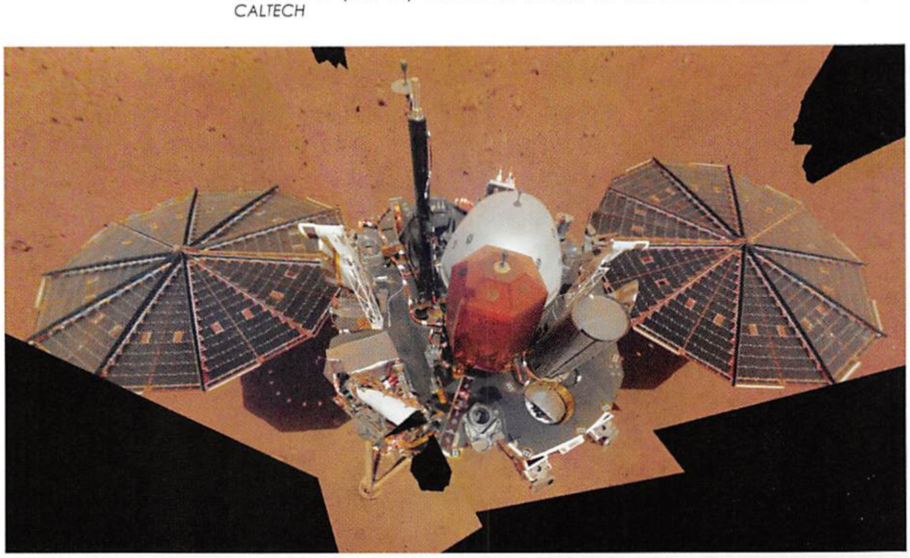
Established in 1963, the DSN is a part of the National Aeronautics and Space Administration (NASA) and operated by the Jet Propulsion Laboratory (JPL) in Pasadena, best known for crafting and operating satellites, landers and rovers. Currently, JPL manages the InSight lander that is hunting for marsquakes on Mars and the Juno space probe, which is investigating Jupiter's composition and magnetic field.

This local organization has a rich history. One of the most impressive missions of which the DSN has been a part is Voyager—two spacecraft (Voyager 1 & 2) launched in 1977 that are responsible for the first images of all the outer plan-

THE MADRID DEEP SPACE COMMUNICATIONS COMPLEX NEAR MADRID, SPAIN. *IMAGE COURTESY NASA/JPL-CALTECH*

THE CANBERRA DEEP SPACE COMMUNICATIONS COMPLEX NEAR CANBERRA, AUSTRALIA. THE MOST PROMINENT ANTENNA PICTURED IS DEEP SPACE STATION 43 (DSS-43) WITH A DIAMETER OF 70M. *IMAGE COURTESY NASA/JPL-CALTECH*

ets in our solar system beyond Mars. The images and science produced by the Voyager mission have helped shape scientists' understanding of the solar system. From the first images of the outer planets, to the discoveries of volcanoes outside of Earth and information about the composition of Saturn's rings and Jupiter's giant red spot, Voyager has defined Earth's neighborhood in space. Forty-two years after launch, the DSN is still communicating with both Voyagers, which have now crossed out of Earth's solar system and into interstellar space.



NASA INSIGHT'S FIRST FULL SELFIE ON MARS, DISPLAYING THE LANDER'S SOLAR PANELS AND DECK. THE SELFIE WAS TAKEN ON DEC. 6, 2018. *IMAGE COURTESY NASA/JPL-CALTECH*

Another important job of the DSN is providing support when things go wrong. When Galileo, a NASA mission launched to study Jupiter and its moons, failed to deploy its high gain antenna in 1991, the DSN had to adapt how it communicated in order to get more data out of an unexpectedly slower transmission speed due to the failure. If the DSN had been unable to adapt, there would never have been Galileo's extensive study of Jupiter and its moons or the first direct observation of a comet colliding with a planet.

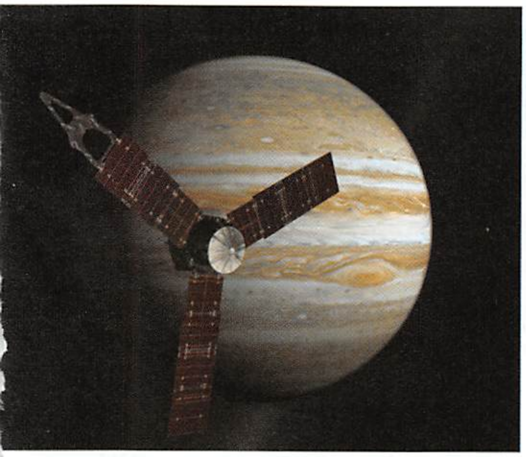
The DSN also played a crucial role in the rescue of the Apollo 13 astronauts in 1970. When the Apollo crew was on its way to the moon, the spacecraft's ability to point its antenna at Earth was compromised. The mission was originally supposed to be tracked with NASA's 26-meter antennas, but the DSN used its larger antennas with more resolving power in order to maintain constant communication with Apollo 13 during the mission.

Local resident Peter Hames is the manager of the Antenna Front End, Facilities and Infrastructure Office at JPL for the DSN project. Involved with the DSN for 38 years, Hames lights up when discussing the intricacies that go into operating the massive antennas.

"We're incredibly unique," said Hames. "Nobody else anywhere, even other people who do radio telescopes, does what we do. We have the most powerful transmitters, we have the quietest low-noise amplifiers, we have some of the largest steerable antennas. It's all very unique." That power and precision enables the DSN to track and communicate with incredibly far-out spacecraft. For instance, the Voyager spacecraft are now more than 11 billion miles away and counting from Earth. At that distance, their signals are about 20 billion times weaker than that of a digital wristwatch, according to NASA.

To capture these weak signals, the DSN antennas use their parabolic "dish" surfaces. The waves are then reflected back up to a sub-reflector at the top of the support legs and sent down to an amplifier so the information can be analyzed. In order to communicate back to Earth, the spacecraft have their own antennas, although much smaller and therefore weaker, hence the need for the DSN antennas to be so massive.

The DSN routinely uses a single antenna to send instructions to a



AN ARTIST'S RENDITION OF THE JUNO MISSION, CURRENTLY STUDYING JUPITER. *IMAGE COURTESY NASA/JPL-CALTECH*

spacecraft and receive data in return through radio waves. The return signal also provides the relative distance between the tracking station and the spacecraft, which is determined with an incredible accuracy of just one meter.

To determine the other components of the spacecraft position, the DSN tracks the spacecraft using two antennas simultaneously. This forms triangles between the spacecraft and antennas, which allow the DSN to pinpoint precise locations of spacecraft within 300 meters at a distance of one astronomical unit from Earth, the typical distance for an encounter in the inner solar system. This level of precision is necessary to successfully maneuver and land on faraway celestial bodies.

Anyone can watch the real-time status of the DSN spacecraft communications thanks to DSN NOW, a website accessible at eyes.nasa.gov/dsn. The site is easy to navigate and highly interactive, allowing users to select specific antennas at each location and see what spacecraft is being contacted at that time.

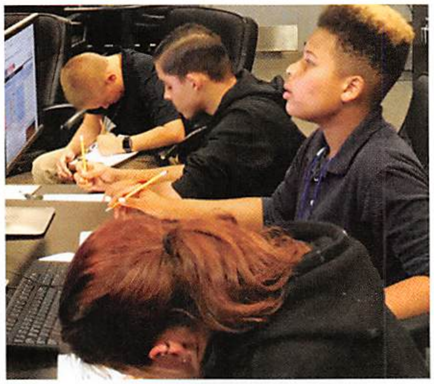
This highly specialized technology is now accessible to the next generation of scientists and engineers thanks to the Goldstone Apple Valley Radio Telescope Program (GAVRT), a free global program that provides students K-12 with direct access to a 34-meter antenna at Goldstone previously used by the DSN.

GAVRT is a collaboration formed between NASA, JPL and the Lewis Center for Educational Research (LCER) in Apple Valley, CA. With free training provided by LCER, teachers can guide their students to work directly with scientists and a mission control operator, either in-person or from the comfort of their own classroom.

Students have the opportunity to design an observing campaign, take down data and results from their observations with the antenna and then work alongside a scientist to publish their own papers. Programs include the Search for Extraterrestrial Intelligence (SETI) and readings of Jupiter.

In this day and age where digital connection is all the rage, the antennas of the DSN connect us to space and ultimately to each other in the vast cosmos that we live in. Every piece of information we have about deep space—temperatures, mineral compositions on other planets, and all images of space—has, at one time, been compressed into radio waves and sent home via the DSN. Without the DSN, we would have no images of space, no exploration of other planets, and no information about what is outside our solar system. Thanks to the DSN, humankind gets a glimpse of what lies beyond our small planet we call home. •

THE JET PROPULSION LABORATORY'S SPACE FLIGHT OPERATIONS CENTER, A NATIONAL HISTORIC LANDMARK, HAS BEEN OPERATIONAL AND STAFFED EVERY DAY SINCE 1964. HERE ENGINEERS SEND AND RECEIVE COMMANDS THROUGH THE DEEP SPACE NETWORK FOR ANY SPACECRAFT IN, AND BEYOND, OUR SOLAR SYSTEM. *IMAGE COURTESY NASA/JPL-CALTECH*



STUDENTS MAKE OBSERVATIONS AND OPERATE A 34M ANTENNA THROUGH THE GAVRT PROGRAM AT THE LEWIS CENTER FOR EDUCATIONAL RESEARCH (LCER) IN APPLE VALLEY, CA. *IMAGE COURTESY OF LCER*

To learn more about the Deep Space Network, visit deepspace.jpl.nasa.gov. For more information about GAVRT and how to participate, contact GAVRT Mission Control at mc@lcer.org or visit www.gavrt.org.