

Bring us a rock

Unprecedented game plan for JPL-led mission to asteroid

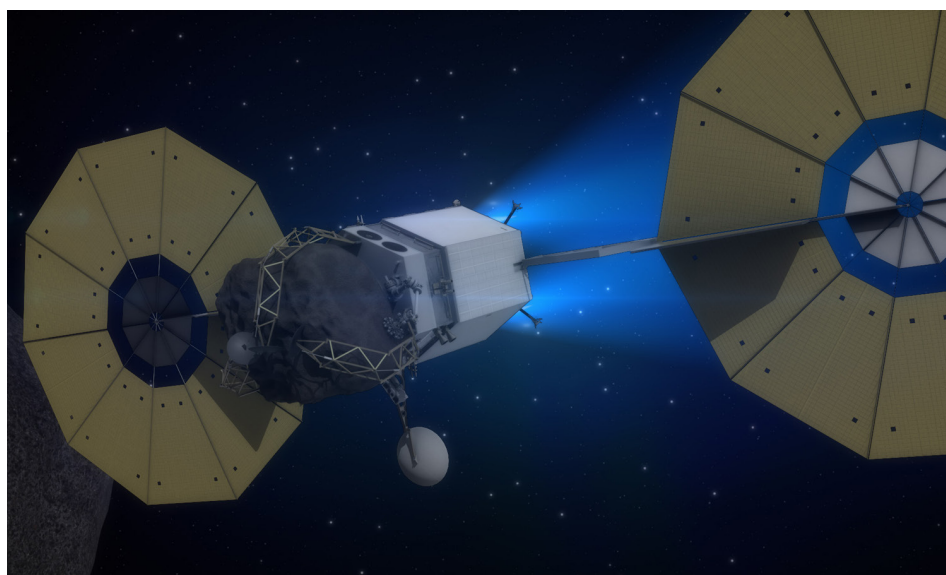
A JPL mission that will launch in the early 2020s will take on what the lab is known for: doing what has never been done before.

In this case, the project is the Asteroid Robotic Redirect Mission, and it will take on a unique challenge. Rendezvousing with a near-Earth asteroid, the spacecraft will extract a multi-ton boulder and redirect it into orbit around Earth's moon, where it can be visited by future astronaut missions.

The JPL-led project, which involves six other NASA centers, was recently approved to proceed to the preliminary design stage, known as Phase B. Launch is targeted for December 2021.

The technology that will enable ARRM to pull off its first-of-a-kind challenge is one initially proven on Deep Space 1 and used on the Dawn mission to the asteroid belt—ion propulsion. While the spacecraft's three ion engines exert a small force—roughly equivalent to the weight of six silver dollars—over time that can produce big results. Ion propulsion, notes Project Manager Brian Muirhead, is 10 times more fuel-efficient than the best chemical engines.

"This is the most sophisticated advancement in low-thrust propulsion and mission design we've ever done," said Muirhead. "Dawn did an extraordinary job



Solar-electric propulsion will power the Asteroid Redirect Robotic Mission, targeted for launch in five years.

exploring Vesta and Ceres, but ARRM will take low-thrust-based exploration to a new level."

The spacecraft will reach a near-Earth asteroid about a year and a half after launch. Plans call for it to spend a total of about seven and a half months at the rocky body—including rendezvous and mapping before landing. It will then collect a multi-ton boulder and, in about three years, redirect it to a crew-accessible orbit around the moon, using the moon's gravity for an assist. NASA plans then call for one of a series of proving-ground astronaut missions to visit and sample the boulder later in the 2020s.

Parked at the boulder, astronauts will be

able to extract, collect and return samples (at least 50 kilograms), and conduct other human-robotic and spacecraft operations that will validate concepts for possible human missions to Mars.

Muirhead said that when the crewed mission is completed, the ARRM spacecraft and boulder will be moved to a distant retrograde lunar orbit "which is very stable for a very long time." "There will certainly be the possibility of an extended mission where other spacecraft, crewed or robotic, could come and visit the ARRM spacecraft and boulder," he added.

Muirhead said that ARRM will dem-

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onstrate a major advancement in solar-electric propulsion technology, operating at 40 kilowatts to prepare for future missions that could require as much as 150 to 300 kilowatts, which could be used to move very large payloads between Earth and Mars.

The demonstration of precision landing and liftoff with a multi-ton mass from a never-explored, low-gravity planetary body will be uniquely challenging given the unknowns associated with the properties of the asteroid and boulder. In addition, ARRM will conduct a demo of a planetary-defense concept—using an enhanced gravity tractor (a very weak “tractor beam” enabled by the low thrust of the ion propulsion system) to deflect the asteroid’s orbit by a tiny but measurable amount.

“We will likely be using a lunar gravity assist going out as well as coming back,” said Muirhead. “We’re maneuvering a 10-ton spacecraft going out and up to 25 tons of boulder plus spacecraft coming back. JPL’s mission designers will be pushed to new limits.”

Ground- and mission-operations systems will work closely with NASA’s human program. During joint operations when astronauts visit the boulder, JPL will be operating the ARRM spacecraft, while the crew and Johnson Space Center mission operations staff are operating Orion.

“We’re coordinating, very carefully, how we operate these two machines, which first are independent, then are coupled,” said Muirhead. “That’s a unique challenge, representing a mode of operations that’s likely to be needed in the future.”

He said that doing a mission like ARRM at the distance of Earth’s moon is a good way to build up capabilities needed for long-duration human spaceflight to destinations including Mars. “There will need to be a number of advancements in capabilities,” he said. “For example, when the

“We’re maneuvering a 10-ton spacecraft going out and up to 25 tons of boulder plus spacecraft coming back. JPL’s mission designers will be pushed to new limits.”

— Brian Muirhead
Asteroid Robotic Retrieval Mission project manager

astronaut crew is not there, you have a robotic machine that has to be managed and controlled, and its health has to be known and maintained crew-safe.”

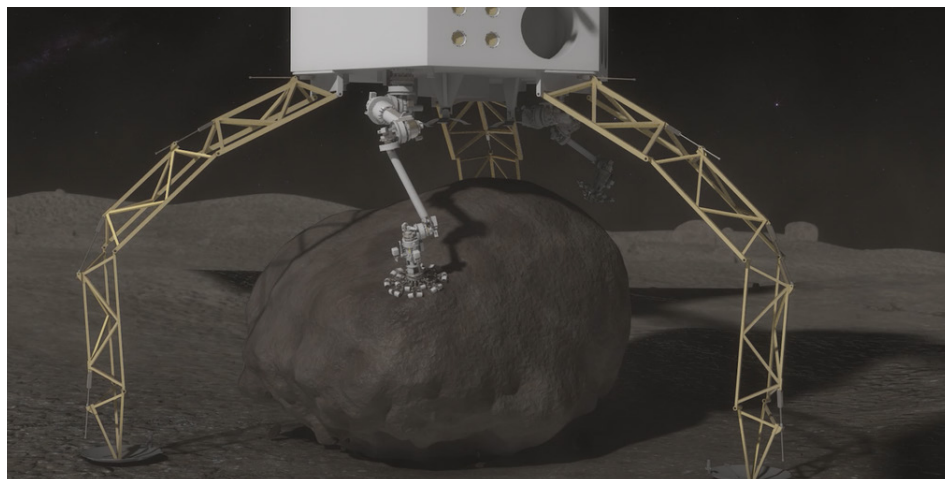
Capabilities and skills across multiple JPL directorates will be called upon for ARRM, with JPL peak staffing at about 100 to 120 employees. Goddard Space Flight Center, supported by Langley Research Center and JPL, is responsible for the capture module, using technologies developed for the Restore-L satellite servicing mission to land, extract and hold the 3- to 4-meter boulder. Glenn Research Center is responsible for the electric propulsion thrusters and power-processing units—supported by JPL—to be delivered to the spacecraft contractor.

JPL provides overall project management, systems engineering, mission design, the mission system (operations, ground systems) and spacecraft procurement. The spacecraft will be built by a contractor; a request for spacecraft proposals was issued on Sept. 8. The

project’s preliminary design review is scheduled for December 2017, with a plan to transition into phases C and D early in calendar 2018.

ARRM’s approval to proceed comes at a time when NASA has launched another mission, Osiris-Rex, designed to obtain a small sample from asteroid Bennu and bring it to Earth in 2023. “Every mission we send to asteroids gives us valuable new information about these time capsules from our early solar system,” said Muirhead. “The real focus of ARRM is the experience it will give us to enable future human space exploration missions, but it will also provide extraordinary science opportunities.”

He added, “We’re pathfinding a number of new capabilities essential for future human and robotic exploration as well as a way for how robotic machines and human-operated machines could work cooperatively in deep space. It’s a really important, challenging and exciting opportunity for JPL and NASA.”



The Asteroid Redirect Robotic Mission will aim to capture a multi-ton boulder and move it to lunar orbit.

A universe of inspiration

Interns share their experiences of being a JPLer for the summer, or beyond

By Kim Orr

It's no secret when summer internship season arrives at JPL. The number of people ambling through the gates swells. There are backpacks and excited conversations. And the mall seems to be bursting with energy and enthusiasm.

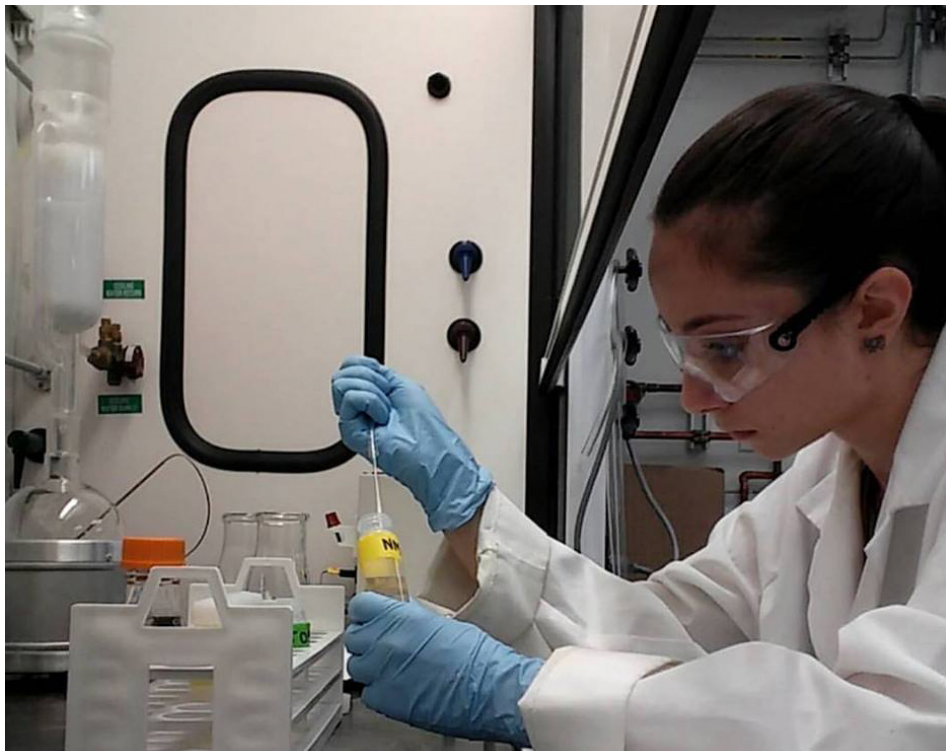
But what JPLers often don't see are the unique and very real contributions interns are making to the Lab's missions, science and technology—or the ways their futures are being shaped by JPL.

Enter the "Universe of Inspiration [<http://www.jpl.nasa.gov/edu/share/inspired-by>]," a web page started last year on the JPL Education website where, like an online yearbook, interns are providing a window into their experiences at the Lab through comments and photos.

"Knowing that the spectral camera mounts I designed are currently in use in field tests gives me great pride," wrote Ryan D'Ambrosia of Florida State University, who interned in the Computer Vision Group this summer. "My mentor has given me responsibility and ownership over my projects, which has helped me grow as an engineer."

Over the last several years, there's been increasing demand for interns from JPLers seeking students who can work on shorter-term projects while offering fresh skills and unique perspectives.

"We would like to thank Ken [Williford] and Michael [Tuite] for the opportunity to work with them this summer," wrote a team of interns in the Astrobiogeochemistry Lab, featuring students from UC Irvine, UC Riverside, USC, Montana State University, the University of Tennessee and Santa Barbara City College. "This



Intern Erica Gaspari, a Montana State University student, worked this summer in the Astrobiogeochemistry Lab.

internship has brought together a group of amazing women from diverse disciplines and backgrounds. We've been working on exciting and fun projects while making long-lasting friendships."

For some mentors, internships can even serve as an audition of sorts for full-time jobs. That's good news for JPL's Education Office, which manages the Lab's internship programs, and hopes to see more students coming through the career pipeline—from early education in science, technology, engineering and math to internships and eventually a career at JPL. This year, more than 60 former JPL interns made the transition to full-time employees, a record.

"My odyssey as a launch systems engineering intern under Chishma Derewa

was a huge learning curve and a life-changing stint of my academic journey," wrote Priyanka Srivastava, a University of Michigan student and one of the interns-turned-JPLers. "Can never thank him and my group supervisor, Ken Diaz, enough for giving me this opportunity to actually 'dare mighty things' at JPL and now work as a full-time employee in a world-class, dream organization!"

Read more comments from JPL interns and see their photos at <http://bit.ly/jplinspired> [<http://www.jpl.nasa.gov/edu/share/inspired-by>].

And see how internships are contributing to JPL's career pipeline: <http://www.jpl.nasa.gov/edu/news/2016/8/22/paving-a-pathway-to-diversity-at-nasa-and-jpl>.

News Briefs

Research honors to Halpern

Senior Research Scientist David Halpern in August received the Committee on Space Research's 2016 Distinguished Service Medal in recognition of extraordinary services rendered to the organization and the international space research community.

The committee was established just after the launch of Sputnik 1 to promote, at an international level, scientific research in space.

Halpern was also elected vice president of the Scientific Committee on Oceanic Research, which was also formed at the beginning of the space age to promote international cooperation in planning and conducting oceanographic research.



David Halpern

Derenski is 'Rising Star'

Federal Computer Week, a weekly magazine covering technology within the federal government, has named JPL cloud and cybersecurity engineer Matt Derenski as one of this year's Rising Stars.

The award recognizes individuals in the federal information technology community who are both making a difference today and establishing themselves as the leaders of tomorrow, the organization said.

Derenski and his fellow winners will be honored at an Oct. 13 awards gala in Tysons Corner, Va.

Minority colleges talk business

Ten schools were matched with 15 JPL contacts and large business partners during a two-day outreach initiative event on Lab with Historically Black Colleges and Universities and Minority Institutions.

JPL's Acquisition Division and Small Business Programs Office hosted the event. Educational organization guests met with JPL technical and project representatives to discuss needs and capabilities.

Topics of discussion included a program where JPL serves as mentor and the college is the protégé. Also covered were contract requirements, small-business technology transfer and a faculty research/internship program.

According to Acquisition Division Manager Karl Bird, the event saw great attendance from colleges as well as from JPL's technical community.

Safety performance noted

Two JPL employees have received the first-ever JPL Exceptional Safety Performance Award.

Arturo Aguayo of the Inventory, Cryogen and Flight Hardware Logistics Program Services Group and Judith Pons of Interplanetary Network Directorate business administration received the honor Aug. 17.

Passings

Herbert Phillips, a retired systems engineer, died Feb. 24.

Phillips joined JPL in 1957 and contributed to numerous missions including Ranger, Mariner, Surveyor, Viking, Magellan, Galileo and Cassini. He retired in 1998.

Phillips is survived by his wife, Zina; daughters Carla, Shannan and Merritt, and three grandchildren.

Betty Jean Dick, 85, a retired Deep Space Network communication specialist, died June 27.

Dick worked at JPL from 1966 to 2003. She is survived by her husband, Roger; daughters Sue and Darcel; son Roger Jr. and five grandchildren.

Douglas O'Handley, 79, former JPL employee and NASA deputy assistant administrator for exploration, died July 28.

O'Handley's 40-year career in space exploration spanned the Naval Observatory, JPL, TRW and NASA Ames. At JPL and on detail at Headquarters, from the late 1960s to the mid 1980s he

managed a group focusing on robotic vision and navigation and the JPL Biomedical Application Office. From 1989-92 he served as NASA deputy assistant administrator for exploration. He founded the NASA Astrobiology Academy at Ames, a program that developed more than 200 young space professionals.

O'Handley is survived by his wife, Christine, stepsons Jeffrey and Kevin, and three granddaughters.

A memorial service was held Sept. 7 at St. Bede's Catholic Church in La Canada.



Doug O'Handley

Letters

I would like to thank my Division 27 co-workers and the many friends here at JPL for their kind words and condolences at the passing of my brother, Kevin. You all have made this very difficult time easier for me to accept. Thank you, JPL, for the plant.

Dennis Ferren

Classifieds

Ads submitted Aug. 24 to 31.

For Sale

DESK for student, with 7 drawers, \$50. 818-957-8614, Mina.

FURNITURE: set of 4 restaurant chairs, \$100 for all 4, \$30 per chair; West Elm entertainment console, 22"H x 54"W x 20"D, \$400; sleigh-style, solid-wood queen bed frame w/storage and mattress, 57"H x 65"W x 96"L, \$1,000; standing liquor cabinet, 75"H x 31"W x 18"; holds 30 bottles of liquor, 20-30 bottles of wine, glassware, \$200; luxury sofa and chair by ZGallerie, see <http://www.zgallerie.com/p-10686-chic-combo-stella-sofa-chair.aspx>, \$1,600 together, \$1,000 sofa alone, \$700 chair alone. 818-949-8274.

MISC.: Mini steam iron, Rollerblades (men's 8), Bloody Mary set, stemless decanter set, board games. 818-272-3262.

TV, Panasonic 37" plasma, TH-37PX60U, clean, works great, with remote, would make a great second TV, \$120. Redgordon2@gmail.com.

WASHING MACHINE, 5 years old but still in excellent condition; Miele brand (W1213), front loading, white, requires 208-240 volt, 15 amp (34 1/8 H x 23 1/2 W x 26 1/2 D), ask \$400. David: 818-521-5774 mobile, 661-702-9738 office.

Wanted

SPACE INFO/memorabilia from U.S. & other countries, past & present, for personal use (see <http://www.youtube.com/watch?v=S7PvjGp7mCU>). mrayman@alumni.princeton.edu, 818-790-8523, Marc Rayman.

UPRIGHT BASS CASE, hard, 3/4 size, for air travel. 818-437-3513, Susan.

For Rent

ALTADENA, furnished rm. w/awesome view for lease; non-smoker to share a beautiful 4-bedrm., 3-bath house across from community garden; close to colleges/schools, route to Kaplan, walk to JPL; utilities incl., cent. air/heat, internet access; nr. 210/134/110, bus stop, shopping, banking, restaurants; \$800/mo. 818-370-0601.

ALTADENA (91001), share furn. 2-bedrm., 1 3/4-bath condo; security access & gated, security alarm ready, central air/heat, internet access, well maintained, carport parking, nice closet organizers, kitchen w/marble floors, refrigerator/stove/microwave, washer/dryer, den, fireplace, patio w/garden and hot tub, community pool, more; utilities incl., trash & water; \$1,290/mo. 626-798-6185.

ALTADENA (91001), furn. loft w/awesome view for lease; non-smoker to share a beautiful 4-bedroom, 3-bath house across from community garden; close to local colleges, Pasadena schools, walk to JPL; utilities incl., cent. air/heat, internet access; near 210/134/110 /bus stop/shopping/bank/entertainment/restaurants; \$740/mo. 818-370-0601.

ALTADENA (91001), 2-bedrm, 1 3/4-bath condo; security access & gated, alarm, cable internet ready, central air/heat, well maintained, carport parking, nice closet organizers, kitchen w/marble floors, washer/dryer, den, fireplace, patio w/garden + hot tub, community pool and more; you pay

utilities excld. trash; \$1,875/month. 626-798-6185.

PASADENA (91101), 3-bed 3-bath condo, walking distance to Whole Foods on Arroyo, Old Town and the Gold Line; 2 underground parking spaces, high ceilings, patio, bamboo hardwood floors, gas fireplace, community spa; master bedrm. has walk-in closet and en suite 2-level unit sits towards the back of the historic complex; \$3,200/mo. 626-243-4155, taylor@bevenandbrock.com.

PASADENA, 2 furn. rooms in a lovely 4-bd./2-bath house, big backyard, hardwood floor, big closet, shared bathrm.; kitchen/laundry privileges; 2 miles to JPL, close to public transport; short- or long-term lease avail.; must like dogs and be very clean; \$800 and \$850 + \$800 deposit. 818-960-8654.

Vacation Rentals

BALBOA ISLAND, 2 bedrooms, 1 bath, deck w/BBQ, sleeps 5, remodeled in 2010, walk to main street restaurants, shopping, bay and ocean; special weekly rates for JPLers; Bettyrs@earthlink.net or 626-429-3677.

JACKSON HOLE, WY: Luxurious bed & breakfast on 3 acres of solitude on Snake River near Jackson Hole Mountain Resort and Grand Teton Natl. Park; see <http://www.bentwoodinn.com/>; JPL discount. info@bentwoodinn.com, 307-739-1411.

MAMMOTH, Snowcreek, 2 bd., 2 ba. + loft, sleeps 6-8, fully equip'd kitchen incl. microwave, D/W, cable TV, VCR, phone, balcony w/mtn. vw., Jacz., sauna, streams, fishponds, close to Mammoth Creek, JPL discount, no pets. 626-798-9222, 626-840-3749 or valeriee@caltech.edu.

MAMMOTH, Snowcreek, beautiful updated condo, 2 bd., 2 ba. + loft (sleeps 6-8), great location by pond/meadow, new appliances, TVs, DVD players, free wireless Internet and washer/dryer, no pets. 818-952-2696 or BigMtnPrettySky@gmail.com.

MAMMOTH, remodeled 2 bed/2 bath + loft, short walk to Canyon Lodge; Courchevel 6 features full kitchen, cable/Internet TV, DVD, Blu-Ray, wireless hi-speed Internet, 2-car garage, Jacuzzi, grill, pool; no pets. <http://Courchevel6.com>.

MEXICO (1 bedrm.): Mayan Palace: Acapulco, Nuevo Vallarta, Riviera Maya, Puerto Vallarta; Sea Garden: Acapulco, Nuevo Vallarta, Mazatlan; trades available with II and RCI. 818-272-3262.

OCEANSIDE white-water view beach condo; see <http://www.previewfirst.com/mls/33034>; 2 bd., 2 ba., sleeps 6; newly decorated and equipped: boogie boards, wet suits, full kitchen, all linens, beach towels; Wi-Fi ready, new flat-screen TVs, daily paper, grocery stores nearby; 2-min. walk to the sand, no roads or stairs; rates: winter \$1,495/week, summer \$2,495/week; JPL discount, monthly and nightly rates available; January 2017 is \$3,000/mo., Feb. and March are booked.; no pets or smoking unit; mostly Sat. to Sat. in summer, 4-nt. min. all year: video (patio shots) <http://www.warmfocus.com/video/k/1402-999npacificstc213/video.php>; reserve with \$500 credit card refundable security/reservation/cleaning deposit. Grace, 760-433-4459 or Ginger 831-425-5114.

SAN FRANCISCO, Inn at the Opera; Opera Unit can sleep 4 people, 1 bd., 2 sitting rooms, 2 bath, 498 sq.', buffet b/fast included; available 4 nights beginning Dec. 31, 2016; see www.shellhospitality.com/Inn-at-the-opera. margialden@sbcglobal.net.



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Universe

Universe is published by
the Communications and
Education Directorate of the
Jet Propulsion Laboratory,
4800 Oak Grove Drive,
Pasadena, CA 91109.