Telescope Operators

Katherine Kornei

These men and women are the experts that make discoveries at big professional observatories possible.

CONTROL ROOM COLLABORATORS Astronomer Diana Da Cunha (left) and telescope operator Francisco Cacenes work together at the European Southern Observatory's 3.6-meter instrument at La Silla in Chile. The 3.6 meter's instruments include the exoplanet-hunting HARPS spectrograph. ESO / S. BRUNIER FOR SKYPIX

Part scientist, part engineer, and part therapist — that's the job of telescope operators. Many large research telescopes — from the W. M. Keck Observatory in Hawai'i to the Boeing-borne Stratospheric Observatory for Infrared Astronomy (SOFIA) — employ these jacks- and jills-of-all-trades. TOs, as they're commonly called, are tasked with ensuring the perfect performance of a telescope and its cadre of instruments. They spend their nights working on remote mountaintops and airborne observatories as the liaisons between data-hungry astronomers and complex telescopes worth millions of dollars.

TOs are an integral part of a big-scope observing run because professional astronomers, for all their scientific expertise, often use a particular telescope and instrument combination no more than a few nights each year. These guest observers accordingly lack the day-in, day-out practice of working with a specific telescope — they might know the instrument's strengths, but not its quirks. Focusing and locking on an astronomical target are manageable tasks with your own backyard setup, but navigating the complex software that research observatories use to accomplish these tasks is another matter. Furthermore, safely moving domes than can be 30 meters across or larger, and knowing local weather well enough to decide when to close down, takes a familiarity guest observers don't have. And then there's the setup and maintenance required to accommodate different observing programs, from switching out equipment to refilling cryogenic instruments with liquid nitrogen or liquid helium. These needs are similar at most observatories, and having full-time staff on hand to address them — as opposed to sleep-deprived astronomers unfamiliar with a telescope and its instruments — is critical.

"We're really the expert users of the telescope," says Jesse Ball, a TO at the Gemini North telescope in Hawai'i. "We're expected to learn how all of the instruments and telescope subsystems work together to be able to quickly and effectively troubleshoot any issues at night." Coupled with the vision and curiosity of the observers, TOs' skills help make astronomical discoveries possible.

Hands-on at the Telescope

Observing sessions can depend upon a TO's quick thinking and arsenal of skills. Not surprisingly, many TOs hold undergraduate degrees in physics, astronomy, or engineering, and have often completed additional coursework in computer science. TOs are accordingly well prepared to tackle a range of engineering and software problems.

Their astronomy knowledge also enables TOs to better understand the telescopic data and work collaboratively and diplomatically with astronomers. Given the scarcity of observing time available at large observatories, astronomers treat their nights on a telescope as a precious resource, something that can make or break a graduate student's thesis or pave the way to a successful career.

JESSE BALL

TOP OF THE WORLD Jesse Ball *(top)* shepherds telescopes at Gemini North in Hawai'i *(bottom, at sunset)*. Here he stands on the observing deck; in the background, left to right, are the Subaru Telescope, the twin Keck scopes, and the Infrared Telescope Facility.

GEMINI OBSERVATORY


GARY PUNAWAI / KECK OBSERVATORY

BIG SCOPES Joel Aycock stands with Keck I. The primary mirror is behind him and the attached 1.8 meter f/15 secondary is to his left and reflected in the primary.

"We sometimes work with a few astronomers who are high strung and occasionally need some calming to make the night go more smoothly and productively," says Joel Aycock, a veteran TO at the W. M. Keck Observatory on Mauna Kea. Then there are graduate students working feverishly on their dissertations, who have "an awful lot" riding on the few hours of large telescope time available to them. "You could consider me a therapist in helping them through these crises."

With their academic backgrounds, many TOs could pursue graduate studies in astronomy en route to working as a professional astronomer. However, TOs often find that working with astronomers to make new discoveries satisfies their scientific curiosity.

"The competitive publish-or-perish attitude in academia really dissuaded me," says Ball, who finished his bachelor's degree in physics. "But I really love to learn about the physical processes in our universe, and I'm very hands-on at the telescope."

After completing his undergraduate degree, Ball accepted a job running a college observatory, which entailed managing public outreach, running lab courses, and overseeing student projects. His experience with the college observatory prepared him for TO work first in Albuquerque, New Mexico, and then in Hawai'i, where he has been for the last 8 years.

Aycock echoes Ball's sentiment of being passionate about astronomy and yet not wanting to be a professional astronomer. "I love discovering how things work, solving problems, and helping the real experts develop new techniques and equipment to do the job," Aycock says.

Becoming a TO wasn't Aycock's original plan; he had a computer job lined up in New Zealand after he finished his bachelor's degree in physics at Reed College in Portland, Oregon. "I arrived in Honolulu in the summer of 1974 with a visa and job offer in Christchurch, $1,300 in the bank, two pairs of jeans and three shirts," Aycock explains. He had planned to lay over in Hawai'i for a while to enjoy the sun, but he ran through his savings in just weeks. Since he was stuck in Honolulu, Aycock enrolled in graduate astronomy courses at the University of Hawai'i, Manoa, and discovered the telescopes on Mauna Kea.


ESO / MAX ALEXANDER

ESO / M. MARCHESI

ROLLING OUT THE ANTENNAS *Left:* When astronomers want to change the configuration of the 66 antennas that make up the Atacama Large Millimeter/submillimeter Array (ALMA), they don't do it by hitting a button: transporter operators move the antennas for them. Here, Patricio Saavedra drives the 28-wheel transporter "Otto" across the ALMA site — while wearing an oxygen tube to keep his mind sharp at an elevation of 5,000 meters. *Right:* Here, Otto carries the array's final 12-meter antenna, delivered to ALMA in 2013. The driver's cab is the box in front. The antenna weighs about 100 tons.

ESO / G. HÜDEPOHL (ATACAMAPHOTO.COM)

ESO / MAX ALEXANDER

NIGHT CLASSES ***Left:*** **One of the 8.2-meter telescopes of the four-scope Very Large Telescope at Paranal, Chile.** ***Right:*** **Telescope instrument operator Claudia Cid (left) gives data-handling administrator Cecilia Cerón a crash course on how TOs prepare for the night's observations, while sitting in the Very Large Telescope's control room. Cerón and her colleagues oversee the observatory's data flow, beginning when the instrument takes an image in Chile and ending when it's delivered to ESO staff in Germany.**

Hawai'i would become Aycock's home as he built his career as a TO: first on Maui to work for NASA's Lunar Laser Ranging Experiment, and later on the Big Island with the United Kingdom Infrared Telescope and Keck Observatory. In the 1990s, Aycock helped astronomers collect the first science data from the new Keck I telescope, and he also participated in the construction and commissioning of Keck II. He has now worked as a TO on Mauna Kea for over 30 years. "Once I found a place with the Hawai'i astronomical observatories, I was hooked," he says. "There was no turning back."

Call the Operator

One night while holed up in the control room during an observing session at Gemini North, Ball heard a thunderous BANG from the dome floor overhead. The lights flickered. He hustled up the three flights of stairs into the dome — where the temperature was approximately –10°C — and encountered a mini catastrophe: the 2-inch-thick, solid piece of steel that transmitted power to the dome had snapped in half. Gemini's massive dome moves azimuthally on a track containing high-voltage power lines, which supply the power to all the vent gates, dome, shutter, and lights. The connection to one of those lines had failed, creating a massive arc of electricity that snapped the steel.

"I was frantically trying to dismantle the assembly so we could get the dome closed," says Ball. While he was working, the fog rolled in and a light dusting of snow and ice started to fall on the dome floor. "I'm standing there in the dark and fog with a flashlight, frozen-stiff fingers, numb face, and maneuvering my way around damaged pieces of this dome track, all the while working against the clock!"

Luckily, Ball was able to close the mirror cover to preserve the optics during the bad weather. After engineers guided him by phone in re-arming the power breaker and resetting the telescope's interlocks, he restored power to the dome so he could properly close down the telescope. "The day crew was able to check the system the next day," he says, "so we were back to normal operating conditions as soon as we re-opened the next night."

Such incidents are thankfully rare. Some observing sessions are relatively easy, such as when there are only a few, long-exposure targets. But TOs are the first line of defense when something goes wrong at a telescope.

"We always must be aware and on the alert for any small problem that might stop operations altogether," Aycock says. "No lives will be lost, but an astronomer's life career could be jeopardized."

In 2009, Ball helped astronomers observe NASA's Lunar Crater Observation and Sensing Satellite (LCROSS) smash into the Moon. The impact, in which LCROSS and its Centaur rocket intentionally crashed into Cabeus Crater at the Moon's south pole, was designed to eject material that astronomers could study spectroscopically for signs of water and hydrocarbons.

Preparing for the crash took lots of planning. The TOs coordinated with astronomers and engineers to figure out where to point the telescope and which filters to use so that observers caught the expected flash without saturating the detector. "The fact that it was only going to happen once and we didn't get any second chances really made it exciting and challenging — and we pulled it off!"

Sometimes, TOs have to make choices about whether to proceed with observing or not — regardless of how unpopular it will make them with the astronomers. But holding out can have its rewards, too. One night at

S&T: KELLY BEATTY

GABRELLE SAURAGE

FASTEN YOUR SEAT BELTS ***Left:*** **Telescope operators aboard SOFIA have to not only watch the telescope controls but also pay attention to turbulence and airspace restrictions.** ***Right:*** **Telescope operator Gabrelle Saurage stands on the gangway to SOFIA's 747.**

Gemini North, Ball and some astronomers were observing in extremely windy conditions, probably 20 meters per second (45 mph). All telescopes have different "closing limits," and Gemini North's is 22.5 meters per second. "As you can imagine, an 8-meter piece of glass can really catch the wind," Ball says. "We could barely hold onto a guide star and were just about to give up and close the dome."

But right then Ball and his team received word of a gamma-ray burst, a short-lived event for which follow-up at other wavelengths really matters. They decided to go ahead and attempt to observe the burst. "We didn't see anything in the visible filters, but we decided to try our near-infrared imager just in case," remembers Ball. "Sure enough, we got it!"

Thanks to these observations, as well as data from several other observatories, astronomers determined that the gamma-ray burst was one of the most distant sources ever imaged, with a redshift of 8.2. That means the star that died to produce the gamma-ray burst blew up less than 650 million years after the Big Bang.

In Thin Air

TOs like Ball and Aycock, who work on mountaintop observatories, must be prepared to do their jobs in thin air. Mauna Kea, home of the Keck and Gemini North telescopes, among others, is 13,796 feet (4,205 meters) high; there's 40% less oxygen at the summit than at sea level. But TOs don't live at the summit; they have to constantly push their bodies to acclimatize to changes in altitude. Visiting astronomers, on the other hand, only work at mountaintop summits for a few nights each year. Some observatories, such as Keck, even limit astronomers to observing from lower-elevation, remote-observing rooms.

Because TOs generally work a few days at a time and then have a few days off, they're always changing elevation. Ball and Aycock commute regularly from their homes, first to Hale Pohaku — the mid-level facility on Mauna Kea at 9,200 feet where they eat and sleep during their shifts — and then to the summit for each night's observing run. "I calculated my 'average' elevation once — the number of hours I spend at sea level, at Hale Pohaku, and on the summit — and it worked out to something like 9,000 feet," says Aycock. That's well into the high elevation range that can trigger mild altitude sickness if people don't take time to acclimate.

A typical work schedule for Aycock involves driving to Hale Pohaku from his home — a 90-minute commute — at the beginning of his 5-night shift. He eats an evening meal in the Hale Pohaku common room with other TOs and astronomers and then departs for the summit at roughly 5 p.m., depending on the season. The drive to the Keck telescopes takes 20–30 minutes, mostly by dirt road. Aycock makes sure to arrive at the summit at least 30 minutes before sunset to ensure that the telescope, dome, and instruments being used that night are ready to go.

Since TO work often involves acclimatizing to significant changes in elevation — not to mention disruption of circadian rhythm — the job isn't for everyone. But some TOs couldn't think of a better job and savor the freedom that the work affords.

Not Your Average Observatory

All observatories function slightly differently, and many TOs work at several telescopes over the course of their careers. Gabrelle Saurage, who holds an undergraduate physics degree with an emphasis on astrophysics, has been a TO for four different observatories over the course of 14 years: McDonald Observatory in Texas, W. M. Keck Observatory in Hawai'i, Apache Point Observatory in New Mexico, and now the SOFIA telescope aboard a Boeing 747SP jumbo jetliner (*S&T:* April 2015, p. 60).

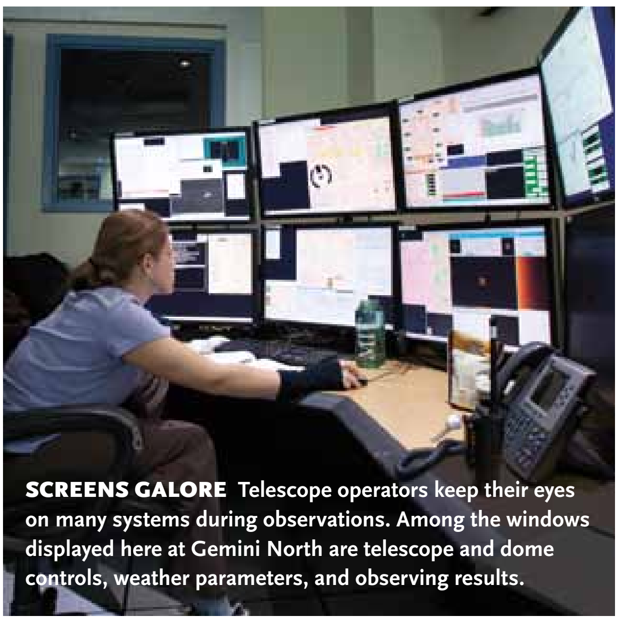
"Working on a 747 is nothing short of awesome," says Saurage. "We wear flight suits, talk on headsets, and see exotic lands."

NASA

OVERSIZED CARRY-ON SOFIA is a modified Boeing 747 that flies high above the atmospheric water vapor that interferes with ground-based telescopes. Its 2.5-meter reflecting telescope peeks out from the rear fuselage.

SOFIA is a modified jetliner with a 2.5-meter telescope installed in its rear fuselage. It flies above most of Earth's atmospheric water vapor, collecting infrared photons that would otherwise be absorbed by water. The aircraft is based in Palmdale, California, but its flights, which last about 10 hours, often take its crew far over the continental United States, the Pacific, Canada, or beyond; two summers ago, they deployed to New Zealand. Working on an airplane, instead of in a windowless control room, has allowed Saurage to see spectacular astronomical sights, such as the aurora at both poles.

Unlike on the ground, where TOs usually operate solo, TOs onboard SOFIA work in pairs during an observing session. One TO is responsible for locating the target in the sky and keeping the target centered in the telescope's field of view, a challenge when SOFIA encounters air turbulence. The other TO communicates with scientists about the goals of the observing session, checks the quality of incoming data, and makes sure that the telescope and instruments are functioning properly.



JOY POLLARD / GEMINI OBSERVATORY / AURA

SCREENS GALORE Telescope operators keep their eyes on many systems during observations. Among the windows displayed here at Gemini North are telescope and dome controls, weather parameters, and observing results.

SOFIA has certain advantages of both a ground-based telescope and a space-based telescope, which affect how Saurage functions as a TO. "We get up to the edge of the stratosphere and thereby above most weather and in a region best suited for far-infrared observations, but then again we can come home every day for repairs, upgrades, and, importantly, switching instruments," she explains. "We are never limited by hardware or weather."

But Saurage finds that her work is more demanding than at other observatories she's worked at, simply because the telescope and its instruments are aboard a flying airplane. "There are the familiar set of commands most telescope operators use to manipulate the telescope — slewing, tracking, and guiding to set up on the desired field," she says. But since they're on a plane, she adds, they have to coordinate with a host of aviation concerns. While a ground-based observing session is affected by weather, TOs onboard SOFIA have to take into account movements of the plane through air turbulence, FAA regulations, airspace restrictions, and pre-determined flight plans. "Setups for observations are significantly more complicated if the observatory is in motion," Saurage concludes.

Saurage, like all TOs, relishes a night of successful observing. And unlike guest observers, TOs have the chance to enjoy these nights regularly — more like amateurs, although TOs' nightly adventures are largely planned by someone else. After some much-needed rest away from their mountaintop or airborne posts, TOs return to take on the roles of scientists, engineers, and therapists for another night. ✦

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