The first cable slipped out of its socket and smashed panels at the edge of the dish, but the second broke in half and tore huge gashes in a central portion of the dish.

If any more cables fail – which could happen at any time – the entire platform could crash into the dish below. The US National Science Foundation (NSF), which owns the Arecibo Observatory, is working on plans to lower the platform in a safe, controlled fashion.

But those plans will take weeks to develop. "Even attempts at stabilization or at testing the cables could result in accelerating the catastrophic failure," said Ralph Gaume, director of the NSF's astronomy division, at a 19 November media briefing.

So the NSF decided to close the Arecibo dish permanently. "This decision is not an easy one to make, but safety is the number-one priority," said Sean Jones, head of the NSF's mathematical- and physical-sciences directorate.

The closure comes as a shock to the wider astronomical community. A social-media campaign with the hashtag #WhatAreciboMeansToMe sprung up almost immediately, with astronomers, engineers and other scientists – many from Puerto Rico – sharing stories of how the observatory had shaped their careers. "Losing the Arecibo Observatory would be a big loss for science, for planetary defence and for Puerto Rico," said Desireé Cotto-Figueroa, an astronomer at the University of Puerto Rico Humacao, in an e-mail before the closure was announced.

What went wrong

NSF officials insist that the cable failures came as a surprise. After the first, engineering teams spotted a handful of broken wires on the second cable, which was more crucial to holding up the platform, but they did not see it as a major problem because the weight it was carrying was well within its design capacity. "It was not seen as an immediate threat," says Ashley Zauderer, programme director for Arecibo at the NSF.

But that main cable, which was installed in the early 1960s, had apparently degraded over time. Over the years, external review committees have highlighted the ongoing need to maintain the ageing cables. Zauderer said that maintenance in recent years had been completed according to schedule.

Before this year, the last major cable problems at the observatory were in January 2014, when a magnitude-6.4 earthquake caused damage to another of the main cables, which engineers repaired. The ageing structure has sustained other shocks in recent years, including damage to an antenna and the dish caused by Hurricane Maria in 2017.

There is no estimate yet for the cost of decommissioning the telescope.

The science that has ground to a halt includes Arecibo's world-leading asteroid studies. The telescope pinged radio waves at near-Earth asteroids to reveal the shape and spin of these threatening space rocks. Not having it "will be a big loss", says Alan Harris, an asteroid scientist in La Canada, California. (China's Five-hundred-meter Aperture Spherical Telescope (FAST), which opened in 2016, does not currently have the ability to do such radar studies.)

Broken wires on the second failed cable.

ARECIBO OBSERVATORY/UNIV. CENTRAL FLORIDA

Some of the observatory's scientific projects could be transferred to other facilities, Gaume said – and he expects scientists to propose where to move their research. Much of the work conducted at Arecibo, however, could be done only with its unique array of astronomical instrumentation. "The Arecibo Telescope is irreplaceable," said a statement from two major US radio-astronomy organizations, the National Radio Astronomy Observatory in Charlottesville, Virginia, and the Green Bank Observatory in West Virginia.

Small amounts of science will continue at other portions of the Arecibo observatory, which encompasses more than the 305-metre dish. For instance, two lidar facilities shoot lasers into the skies to study atmospheric phenomena.

The Arecibo telescope had been upgraded regularly, with several new instruments slated for installation in the coming years. "The telescope is in no way obsolete," says Christopher Salter, an astronomer at the Green Bank Observatory, who worked at Arecibo for years.

Planned upgrades are now presumably on hold, including a US$5.8-million antenna that was being developed for the telescope's platform and would have massively increased its sensitivity. Brian Jeffs, an engineer at Brigham Young University in Provo, Utah, who heads the project, says his team expects to discuss options for its future with the NSF eventually. "Our greatest concerns are for the wonderful scientific, technical, management and support staff" of the observatory, he says.

The observatory is a major centre for science education in Puerto Rico, where it has fostered the careers of many astronomers and engineers. And it has become a part of the pop-culture lexicon, featuring in major movies such as *Contact* (1997), which was based on a novel by astronomer Carl Sagan, and the 1995 James Bond film *GoldenEye*.

The most recent major radio-telescope disaster happened in 1988, when a 300-foot-wide antenna at the Green Bank Observatory collapsed one night, owing to structural failure.

CAN DOGS SMELL COVID? HERE'S WHAT THE SCIENCE SAYS

Canines seem to detect infections accurately, but researchers say large-scale studies are needed.

By Holly Else

Asher is an eccentric, Storm likes sunbathing and Maple loves to use her brain. All three could play a part in controlling the COVID-19 pandemic, but they are not scientists or politicians. They are dogs.

And they are not alone. Around the world, canines are being trained to detect the whiff of COVID-19 infections. Dog trainers are claiming extraordinary results – in some cases, they say that dogs can detect the virus with almost perfect accuracy. Scientists involved suggest that canines could help to control the pandemic because they can screen hundreds of people an hour in busy places such as airports or sports stadiums, and are cheaper to use than conventional testing methods such as the RNA-amplification technique RT-PCR.

But most of these findings have not yet been peer reviewed or published, making it hard for the wider scientific community to evaluate the claims. Researchers working on more

conventional viral tests say that initial results from dog groups are intriguing and show promise. But some question whether the process can be scaled up to a level that would allow the animals to make a meaningful impact.

On 3 November, groups working with the animals took part in an online workshop called International K9 Team to share preliminary results from experiments and to improve how their research is coordinated.

"No one is saying they can replace a PCR machine, but they could be very promising," says veterinary neurologist Holger Volk at the University of Veterinary Medicine Hanover in Germany, who is leading an effort to train and study COVID-sniffing dogs and did not speak at the event.

FATEMEH BAHRAMI/ANADOLU AGENCY/GETTY

Research groups around the world are testing whether dogs can detect COVID-19 by smell.

Sense of wonder

Humans have taken advantage of canines' superior sense of smell for decades. Dogs' noses bear 300 million scent receptors, compared with humans' 5 million or 6 million. That enables them to detect tiny concentrations of odour that people can't. Sniffer dogs are already a familiar sight in airports, where they detect firearms, explosives and drugs. Scientists have also trained dogs to detect some cancers and malaria, but the animals are not routinely used for this purpose. Researchers don't know for sure what the dogs are smelling, but many suspect that these illnesses cause the human body to let off a distinct pattern of volatile organic compounds (VOCs). These molecules readily evaporate to create scent that dogs can pick up. Previous work with non-COVID viruses has suggested that viral infections might also cause the body to do this.

Many sniffer-dog scientists turned their attention to COVID-19 early in the pandemic. They have trained their canines to smell samples, most often of sweat, in sterile containers, and to sit or paw the floor when they detect signs of infection. Trials at airports in the United Arab Emirates, Finland and Lebanon are using dogs to detect COVID-19 in sweat samples from passengers; these are then checked against conventional tests. According to data presented at the K9 meeting, dogs in Finland and Lebanon have identified cases days before conventional tests, suggesting that they can spot infection before symptoms start.

Riad Sarkis, a surgeon and researcher at Saint Joseph University in Beirut, is part of a French–Lebanese project that has trained 18 dogs. Sarkis used the best two performers for the airport trial in Lebanon. The dogs screened 1,680 passengers and found 158 COVID-19 cases that were confirmed by PCR tests. The animals correctly identified negative results with 100% accuracy, and correctly detected 92% of positive cases, according to unpublished results. "This is very accurate, feasible, cheap and reproducible," says Sarkis, who has been approached about using the dogs in schools, banks and prisons.

Low-income countries with limited lab space could particularly benefit from the approach, says Isabella Eckerle, a virologist at the University Hospitals of Geneva in Switzerland.

Sample sizes

But there is just one published journal article on dogs' efficacy at sniffing out COVID-19, by Volk's group[1]. The researchers trained eight dogs on samples taken from the mouths and windpipes of seven people hospitalized with COVID-19 and seven uninfected people. The dogs identified 83% of positive cases and 96% of negative ones.

"It's important not to go out too early with grand claims and small data sets."

The false positive and negative rates of the standard PCR lab test vary depending on the brand of test used and the timing of the test. A systematic review published as a preprint[2] on medRxiv found the false-negative rate of RT-PCR tests to be 2–33% if the same sample is tested repeatedly. Up to 4% of UK PCR test results could be false positives, according to government documents.

Critics say the German dog study used samples from too few patients. The dogs could be learning to identify the specific scent of the samples rather than of COVID-19, says Cynthia Otto, who leads the Penn Vet Working Dog Centre at the University of Pennsylvania in Philadelphia and is also working with COVID-19 sniffer dogs. In her work, which is unpublished, she has found that the dogs can tell the difference between samples of either urine or sweat from people with COVID-19 and those from people without the disease. She is working with chemists to understand which VOCs the dogs are picking up; a paper describing this is under review. "The dogs can do it. The challenge is the ignorance that we have as humans as to what can confuse the dogs," she says.

A group led by veterinary scientist Dominique Grandjean at the National Veterinary School of Alfort near Paris, posted its work[3] on the preprint server bioRxiv in June. The researchers, who included Sarkis, trained 8 dogs to detect COVID-19 in 198 sweat samples, around half of which were from people with the disease. When these were hidden in a row of negative samples, the dogs identified the positive samples 83–100% of the time. The paper does not say how well the dogs identified negative test results.

Those data look promising, says Fyodor Urnov, a gene-editing scientist who is working on COVID testing at the University of California, Berkeley. But he would like to see larger data sets on how well dogs identify positive and negative samples. He also notes that there is variation in how well individual dogs perform.

Groups need to boost their sample size, agrees James Logan, an infectious-disease researcher at the London School of Hygiene & Tropical Medicine who is training and studying COVID-19 dogs, including Storm, Maple and Asher. "It's important not to go out too early with grand claims and small data sets," he says.

1. Jendrny, P. *et al. BMC Infect. Dis.* **20**, 536 (2020).
2. Arevalo-Rodriguez, I. *et al.* Preprint at medRxiv https://doi.org/10.1101/2020.04.16.20066787 (2020).
3. Grandjean, D. *et al.* Preprint at bioRxiv https://doi.org/10.1101/2020.06.03.132134 (2020).