Is space the next frontier for archaeology?
What does the Huygens lander have in common with Stonehenge? More than you expect.
Kiona N. Smith

*This photo of Buzz Aldrin at Mare Tranquillitatis is one of the most iconic images ever committed to film. Visible in Aldrin’s visor is the reflection of Neil Armstrong taking the photo.  NASA*

In the past 60 years, humans have left a lot of stuff on other worlds or floating in space. We’ve landed (or crashed) spacecraft on Mercury, Venus, the Moon, Mars, Comet 67P/Churyumov–Gerasimenko, and Titan. Along with the hundreds of objects in orbit around Earth, the Moon, and Mars, those spacecraft provide a physical record of human activity that could outlast some of the most ancient ruins here on Earth.

“There's stuff in orbit, particularly in middle to high orbits, that's up there for thousands or even millions of years,” said Flinders University space archaeologist Alice Gorman.

*Aldrin after deploying the Solar Wind Collector experiment. Visible behind Aldrin is the Lunar Module, Eagle. NASA*

Luckily, just as archaeologists back here on Earth take interest in the remains of decades past beneath us, some in the industry have started pursuing a similar curiosity in what's above our pale blue dot. And, accordingly, a branch of archaeology has emerged that wants to bring the study of humanity’s past into the future.
In 1969, Buzz Aldrin and Neil Armstrong spent their last eight minutes on the lunar surface on the steps of the Eagle tossing things overboard: armrests, overshoes, urine containers, and anything else they thought they wouldn’t need for the trip back. They’d been instructed to discard as much unneeded weight as possible to make up for the 50kg of lunar rock and regolith samples they had picked up, and their lives depended on getting it right.

Aldrin faces the United States flag the astronauts planted. Looking at Aldrin's visor, you can see he's looking to his left, toward Armstrong.  NASA

There’s no detailed official inventory of everything they threw overboard, although New Mexico State University archaeologist Beth O’Leary and her colleagues have compiled a thorough list in retrospect. The pile of discarded objects to the west of the Apollo 11 landing site offers physical evidence of the astronauts’ thought process in those crucial moments. It also forms a tangible link to a life-or-death human drama. And that, according to the growing number of archaeologists interested in off-world sites, underscores the value of archaeology in space.

The vast majority of surface images from Apollo 11 that include an astronaut show Buzz Aldrin. This is due to the allocation of tasks to each astronaut; Armstrong had more opportunities to take photos. As a result, this is the only high-quality Hasselblad photograph of Neil Armstrong on the lunar surface.  NASA

“Looking at these technologies as an archaeologist rather than an engineer gives you a whole other perspective—you fall in love with the stories rather than the bits of metal,” said Gorman.
Space archaeologists acknowledge their field is similar to recent excavations of the Antarctic base camps of Shackleton and Mawson. Those explorers, too, left behind extensive written accounts of their adventures, but much of the unwritten story is left behind in the places they lived and the objects they used—and discarded.

And there are Space Age archaeological discoveries yet to be made—lost spaceship wrecks and gleaming metal ruins waiting to be found and explored. Among the lost ships of the Space Age are the first spacecraft ever to land on the Moon, the Soviet Luna 9 lander, and the American Surveyor 4 lander, one of the precursors to the Apollo missions. Finding these missing spacecraft can solve some historical puzzles about their fate and fill in gaps in the story of space exploration. For instance, no one is sure why Surveyor 4 crashed; perhaps it plummeted the final 20 kilometers to the Moon’s surface or maybe it executed a perfect landing only to have its radio transmitter malfunction.

“Neil Armstrong after the Apollo 11 moonwalk. The Ohio native was 38 years old when he became the first person to walk on another world. NASA

“We don't know what happened to it, and being able to find it might answer that question,” said Western University geographer Phil Stooke, who maps human activity on Mars and the Moon.

In that sense, the emerging field of space archaeology may share a common thread with nautical archaeology. After all, shipwrecks, polar base camps, and abandoned spacecraft are all pieces of the same broad, sweeping story: human exploration. Humans evolved as tool-users and explorers, and eventually we built the tools to cross oceans and then travel to other worlds. The lunar landers are part of the same human story as the first rough-hewn stone tools, the first campfire, the first boat, and the first domestic animals.
Buzz Aldrin in the LM. Visible on his left wrist is his NASA-issued, space-certified Omega Speedmaster watch.

NASA

“We can't pin down when the first human learned to use fire and changed the world,” said Charles Sturt University cultural heritage management professor Dirk Spennemann. “We don't have any location or point in time we can pinpoint as nicely for one of the big steps of human evolution. We have rough dates and locations, but we don't have a date, a point, and a person. We do have that for Apollo 11, so everything associated with that one is of significance for all of humanity.”

Archaeologists in spacesuits?

Looking out Eagle's window toward the lunar horizon. The Moon's small size makes its horizon appear oddly close.

NASA
Scientists have been part of NASA missions since geologist Harrison Schmidt joined the Apollo 17 crew as an expert to study lunar geology. And there's hope future space missions may include archaeologists as science specialists, just as today’s missions include engineers, chemists, or biologists. “I think at some point they’ll need an archaeologist,” said O’Leary. “I'm a little old to go up there, but I would go.”

Although there has never been an archaeologist in space, astronauts may have already done archaeological work on the Moon. On the Apollo 12 mission, astronaut Alan Bean removed the television camera and other components from the Surveyor 3 lander, which had been on the Moon since April 1967. Pennsylvania State University archaeologist P.J. Capelotti wrote in his 1996 dissertation that the Surveyor 3 salvage was the first example of lunar archaeology.

Of course, not everyone sees it that way. Capelotti once ran the idea by Pete Conrad—the astronaut who photographed Bean at work.

“I said, ‘Did you realize you were doing archaeology on the Moon?’ and there was this long pause at the other end of the phone, and he finally said no,” said Capelotti. “He considered it a kind of kooky idea.”
human disturbance, weathering, and other forces. Those studies of site formation help other archaeologists pin better dates on artifacts and more accurately interpret what has happened at a site over the years.

Today, the study of site formation in space is one of the big questions on space archaeologists’ minds, because it will lay the groundwork—pardon the pun—for future work. If he were writing a proposal for fieldwork on the Moon or Mars, New Mexico State University archaeologist Edward Staski said, “My immediate concerns would be with formation processes and preservation—what are the actual and potential adverse impacts on the archaeological resources and how best might these impacts be mitigated?”

Objects on the Moon or in orbit are bombarded by radiation, extreme heat and cold, and tiny meteorite impacts. On Mars, wind can eventually bury objects in a shifting blanket of fine red dust, creating the kind of dig site that might make terrestrial archaeologists feel right at home. Of course, future space archaeologists may not be digging at all, since many of their potential sites and artifacts aren’t even on a planet or a moon, but in orbit.

“Typically, we think of an artifact as being a stone tool embedded in some archaeological site that’s a million years old,” said Capelotti. “But [in space] you’ll have to change the definition of excavation to encompass studying an artifact that’s still moving.”

Here's what a traditional archaeology work site looks like: With the Cahokia team, archaeologist Sarah Baires looks at the mysterious EB 3. Student Emma Wink shows her the layer of yellow soil, which the team hypothesizes is part of a ramp leading into a borrow pit.

The more familiar image of archaeological work involves a neat grid laid out over a dig site, with archaeologists in shorts and t-shirts meticulously working their way through soil with trowels, brushes, and formidable patience. But you can’t lay out a site grid in orbit, and hands-on excavation would require spacewalks. Even on planetary surfaces, archaeologists would be forced to do the delicate work of excavation in spacesuits. In either context, future archaeologists face a risky, expensive, and time-consuming new kind of field work.

In that, space archaeology shares another similarity with nautical archaeology: the work of excavation takes place in an environment foreign to humans, in which archaeologists must move in three dimensions, with the aid of specialized equipment and in the face of increased risk. In orbit, however, the danger—and the sheer strangeness of working in extra dimensions, mapping sites with trajectories instead of grid squares—will be magnified.
Future space archaeology worksites, however, may be a bit more treacherous. (Pictured: During the second crewed Gemini mission, Ed White performed the first US spacewalk.) NASA

Gorman has given some thought to how archaeologists might approach the challenges of orbital sites. “Probably in the future we'll have new methods of propulsion and tiny orbital drones that can do the mapping for us,” she said. “We'll conduct surveys from spacecraft or remotely from planet- or Moon-side.”

Remote archaeology

For the foreseeable future, of course, space archaeology isn’t likely to be a hands-on science. Instead of trowels and sieves, space archaeologists will rely on orbiters, deep-space data links, and high-resolution imagery to study humanity’s spacefaring past.

That’s the same toolset that other sciences use to study distant worlds, and it’s familiar territory for archaeologists who have used aerial photography for nearly a century to survey for sites and map the outlines of long-buried buildings. More recently, a handful of archaeologists has even come to rely on satellites to look for sites. And in fact, the same methods are already being used to search for missing spacecraft, though very few people are calling them archaeological surveys—yet.

In 2014, NASA’s Mars Reconnaissance orbiter sent home a few pixellated photos of the ESA’s Beagle 2 lander, which had been missing on the Martian surface for over a decade. Two years later, engineers in the UK used those images to piece together the lander’s fate. Long thought to have crashed, Beagle 2 turned out to have made a perfect landing, but one of its solar panels failed to deploy completely, blocking an antenna.

And the Lunar Reconnaissance Orbiter (LRO) is already providing thousands of images of the lunar surface, which enables archaeologists, like scientists in other disciplines, to search the lunar landscape for signs of missing spacecraft or to study known sites. Stooke spends his workdays scrolling through hundreds of those images to search for lost landers, including the Soviet Luna 18 lander, which vanished somewhere on the lunar surface in September 1971.

Those images are often detailed enough to recognize spacecraft and follow trails left by astronauts and rovers, and already archaeologists are using LRO images to ask interesting questions about what people did on the Moon.
“There's one image where there's a small rise between one of the instruments that had been laid out and the lunar module, and the humans always walk around the rise. They don't walk over it, which I find interesting,” said Capelotti. "It's like, ‘Don't you, just once, want to walk up that hill and get the view from a little bit higher up?’ Were they told not to? Did they do that because they wanted to walk on flat earth? There's all sorts of questions you could ask."

O’Leary is interested in asking a similar set of questions about how, and why, astronauts’ moonwalks changed over the course of the Apollo program. She wants to understand how astronauts moved around on the lunar terrain, what they explored on foot instead of with rovers, and how rovers and a growing familiarity with the lunar surface changed those patterns.

“I would take a look at the Apollo sites, looking at specific ways [each mission] used astronauts to explore and understand the terrain. You would do a comparison among those six sites on the Moon,” she said. “They went from walking a very short distance to riding in the lunar rover. How did the exploration of the Moon change through time with the advancement of that technology?”

But for other questions, LRO images don’t offer enough detail. To map everything in the Apollo 11 “toss zone,” for instance, archaeologists would need much higher-resolution imagery—or a surface mission.

“We can see the LEM. We can see the descent stage, but we can't see the smaller artifacts,” said O’Leary. “Right now they're not at quite the resolution we would need to do a complete archaeological mapping of everything.”

Buzz Aldrin's footprint in the regolith, while iconic, isn't exactly preserved with care or full legal protections. NASA

Preserving the future, today

In the absence of high-resolution images, space archaeologists say that preserving these sites for future study is crucial. With private companies on the verge of putting landers and rovers—and someday in the foreseeable future,
even space tourists—on the lunar surface, archaeologists are worried about vandalism or accidents wiping out the
only physical traces of some of humanity’s most significant moments.

“Those of us interested in advancing space archaeology and the preservation of related resources argue that we
better start making our case now, before such disturbance and loss are underway,” said Staski.

And at the moment, there’s no legal protection for those sites. Here on Earth, you can’t spray-paint your name onto
the side of the Great Pyramid or chisel out the rock formations in Carlsbad Caverns, because those sites are
protected by the laws of their respective countries. But under the 1967 Outer Space Treaty, no person, company, or
country can own land on the Moon. The artifacts and spacecraft themselves are still the legal property of the
governments (and eventually companies) that put them there. Footprints, rover tracks, and impact craters, however,
aren’t objects you can take away, and they’re not protected by the law.

A few states, including California, Hawai’i, and New Mexico, have listed the Apollo landing sites as protected
historical sites, but there’s no real authority backing up those symbolic gestures. Similarly, several advocates,
including O’Leary, have called for sites like the Apollo landing sites to be designated as UNESCO World Heritage
sites, but nations can only nominate sites that fall within their borders, which excludes any site that’s not actually
on Earth.

“So we are stuck here that the most important place we have, at this point, is potentially under threat by some idiot
walking there and putting their footprints in. There's no legal protection,” said Spennemann.

In 2011, NASA issued guidelines asking all future visitors to the Moon to keep a safe, respectful distance from the
first lunar landing sites, but those guidelines are a polite official request, not a law or regulation that NASA can
actually enforce. Several of the X-Prize competitors have said they’ll abide by the 2011 guidelines, but there’s
nothing holding them to it.

“We always fall into a gray legal area, which has made my mission pretty tricky,” said O’Leary.

Despite the uncertainty, preservation is a challenge archaeologists say we have to meet. And space archaeology in
particular pushes the boundaries of this, given that archaeology generally doesn’t consider something an artifact
until it’s at least 50 years old (in fact, the industry often looks askance at anything younger than a century).

“We do have documentary and orbital records to help us establish what things are, but you could imagine a time in
the future where we don't have so much of that and might use the weathering of spacecraft surfaces as a way of
telling how old they are,” said Gorman. “Perhaps there will be classic time periods for orbit like we have for
cultures on Earth: Early Space Age, Middle Space Age, Late, Commercial, Post-Apocalypse.”

Although space archaeology is starting to gain some traction, preservation and study of off-world sites is still a
tough sell. That’s especially (and perhaps surprisingly) true when pitching the idea to other archaeologists, who are
competing for limited budgets and facing dire threats to important sites here on Earth.

“Many archaeological resources on Earth are threatened now, and the profession just doesn't have the money or the
time to save it all,” said Staski. “I’m guessing that many archaeologists might see our efforts as foolhardy, given the
realities we face.”

Despite the lingering questions about resources, uncertainty over protections, and the lack of age for many artifacts
to be viewed as traditional archaeological material, the space archaeology industry continues to gain steam and
push forward. After all, as this field's proponents might say, space archaeology is simply the future of humanity’s study of the past.

“As a child I really loved astronomy and astrophysics, as well as archaeology, and they are really about the same question,” said Gorman. "How did we come to be here and what does it all mean?"