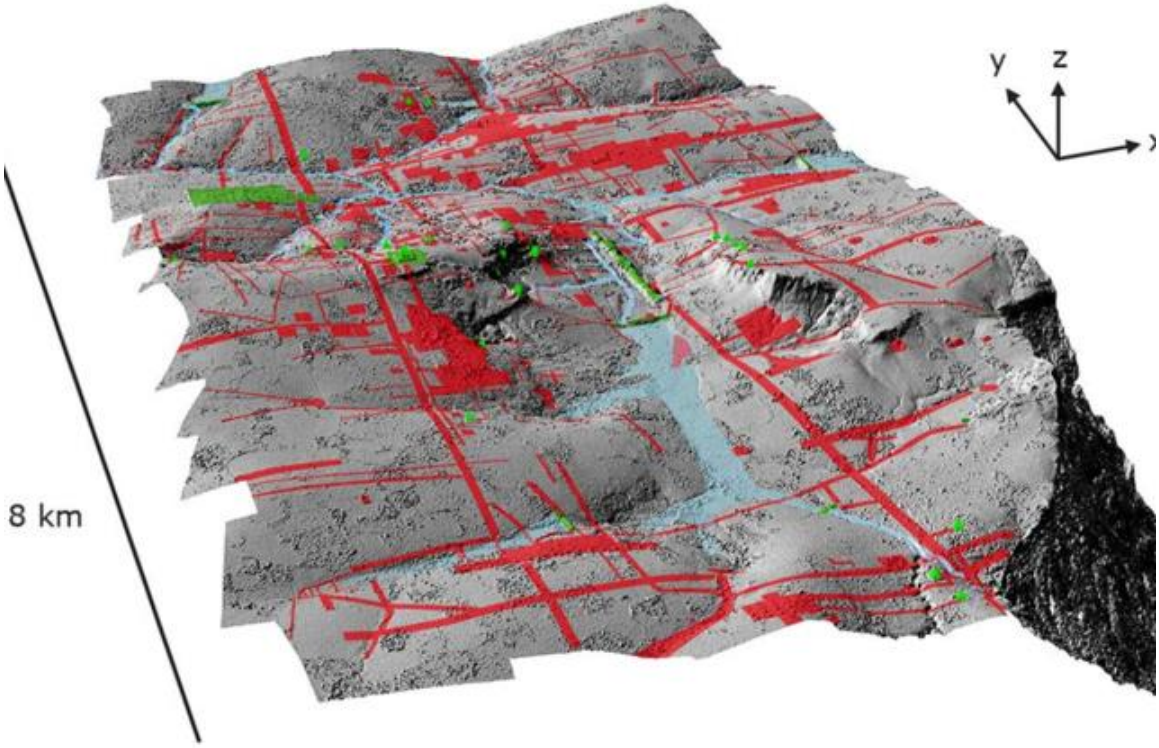
Uncovering the past using the future: how lasers are revolutionizing archaeology

HIGH-TECH TOOLS ARE NOW GIVING ARCHAEOLOGISTS AN UNPRECEDENTED GLIMPSE INTO LOST CIVILIZATIONS

By Jared Keller on June 21, 2013 10:15 am 7**Comments**



A map of the lost city of Mahendraparvata, created using lidar technology (Credit: Archaeology and Development Foundation — Phnom Kulen Program)

Indiana Jones was onto something. In *Raiders of the Lost Ark*, everyone's favorite fictional archeologist infiltrates a Nazi dig on the outskirts of Cairo and lowers himself into the Map Room, an ancient chamber alleged to hold the location of the titular Ark of the Covenant. Jones raises the Staff of Ra — a golden medallion embedded with an amber gem at the end of a long wooden pole — above his head. The Egyptian sun, streaming into the underground

chamber, is refracted through the staff's headpiece, forming a coherent beam of light that reveals the Ark's location.

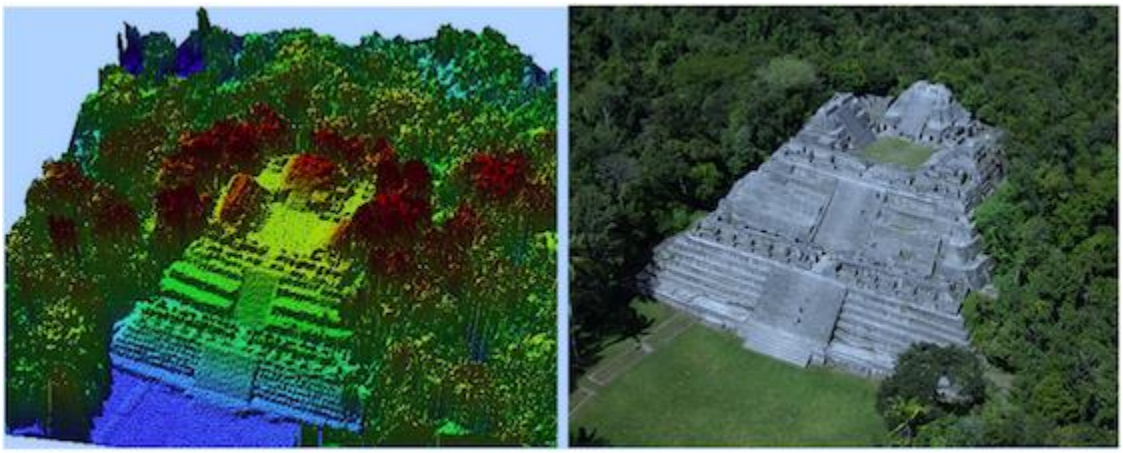
Sure, the Staff of Ra is a thing of fiction. But archaeologists are now relying on their own, more refined lasers, to uncover the remnants of ancient civilizations.

"We saw an immediate picture of an entire city that no one knew existed."

Last week, an expedition led by Australian archaeologist Damien Evans came upon the ruins of Mahendraparvata, a 1,200-year-old city in the Cambodian jungle. The breathtaking discovery was only enabled by the use of lidar, an airborne remote sensing technology that uses lasers to create detailed topographical maps. Using a lidar system mounted on the skid of a helicopter, Evans and his team surveyed a 143 square mile area, uncovering sprawling, highly structured settlements that would have remained hidden from satellite imaging or ground surveys by the jungle canopy. In a forthcoming paper submitted to the *Proceedings of the National Academy of Sciences* (*PNAS*), Evans and his team say that this discovery, guided by their lidar data, will necessitate "comprehensive re-evaluation of the nature of urban space" in the study of Southeast Asian settlement patterns. "With this instrument — bang — all of a sudden we saw an immediate picture of an entire city that no one knew existed," Evans told *The Age*.

Illuminating a target zone with lasers affixed to an aircraft

Lidar, also known as Laser Imaging, Detection, and Ranging, works by illuminating a target zone with lasers affixed to an aircraft. The light is reflected off target objects — whether foliage, buildings or even clouds — and captured by a receiver that measures the duration of each pulse's trip to the target. The data is then used in conjunction with GPS to create a digital, 3D map. Lidar technology was initially developed in the 1960s and used for atmospheric research, meteorology and geological surveys by government agencies like the National Oceanographic and Atmospheric Association (NOAA) and US Geological Survey (USGS). And NASA has since 1994 been experimenting with orbital lidar systems to help scientists better understand climate patterns. More recently, New York City used lidar to create a 3D map of Manhattan that served as the framework for updated flood plans.



Lidar imagery adjacent to a photograph of "Cana," a key structure in Caracol that was documented by Arlen and Diane Chase. (Credit: Arlen and Diane Chase)

Interest in lidar for archaeological research was only catalyzed in 2010, when husband-and-wife team Arlen and Diane Chase from the University of Central Florida used it to uncover a vast swath of ruins at Caracol, the ancient Mayan city just outside Belize. The Chases collected more topographical data in 10 hours of lidar scans than countless ground expeditions had yielded over almost three decades of hacking through the jungle with machetes: between 1983 and 2000, archeologists had mapped around 7.7 square miles of the Caracol site. With lidar, the Chases mapped 77 square miles.

"Archaeologists are no longer restricted to limited sampling from a largely unknown universe."

But lidar mapping doesn't only reveal overgrown buildings. It can also offer clues to how entire urban systems were structured, by uncovering markets, arenas, and other public spaces. In a 2011 paper in the *Journal of Archaeological Sciences*, Chase and their colleagues predicted that lidar would eventually replace traditional methods of archaeological mapping. "This technology permits archaeologists to document the landscape in the same way that it is experienced by people — in multiple dimensions," the same team wrote in a 2012 *PNAS* paper. "Archaeologists in the tropics are no longer restricted to limited sampling from a largely unknown universe covered by enveloping canopy."

"This really is a paradigm shift in archaeology," Arlen Chase told *The Verge*. "In archaeology, you don't always have an understanding of how big your total sample really is. A lot of the time, you're basically just making estimates. Lidar allows us ... to properly imagine a universe for modeling and interpretation."

An animation of lidar imagery indicating the possible ruins of Ciudad Blanca.

The Caracol discovery was enabled by the National Center for Airborne Laser Mapping (NCALM). Founded by the National Science Foundation in 2003, it's the only non-commercial organization to provide lidar mapping services to the scientific community. In addition to working with the Chases in Belize, NCALM also enabled the 2012 discovery of ruins in Honduras thought to be those of "Cuidad Blanca," or the legendary White City. Since the remarkable findings of both projects, NCALM representatives say they've seen a surge of interest from archeologists. "Nobody wants to see a photograph anymore, they just want to see a lidar image," William Carter, a research professor at the University of Houston and co-principal investigator at NCALM, told *The Verge*. "Nature doesn't really make regular geometric patterns on the ground. That's what humans do: they make building or plazas or pyramids. When lidar imaging captures these things, they jump out at you."

Cut costs by installing LIDAR systems into UAVs

Archeologists are enthused at lidar's potential, but a few obstacles prevent the technology from seeing widespread adoption. For one, it's extremely expensive: Carter says that a single survey using NCALM's lidar typically runs around $150,000 (the initial Caracol site

scan cost $170,000). And because NCALM receives a mere $750,000 in base funding from the NSF each year, they can only finance a few archeological proposals at a time. The center's long-term goal? Cut costs by installing lidar systems into UAVs, which would be able to operate for days at a time over a broader area than the Cessna 337 that NCALM currently uses.

The other challenge is more technical: airborne lidar surveys collect vast amounts of data, and most archaeologists don't have the ability to process it. "You need to be able to write algorithms to look for very specific patterns in this cloud of data," Chase said. "At first glance, the data is literally just billions of points in space." Chase had an advantage: his son, a graduate student at Arizona State University who studied computer science and archeology, wrote an algorithm to identify water systems at the Caracol site. Combined with other algorithms, like one designed to spot caves, the Caracol team was able to turn their glut of lidar data into a robust portrait of an ancient city.

The precise makeup of a survey area — right down to types of grass and soil composition

Of course, the role of lidar in archeology is still in its infancy. Researchers are currently developing new, more refined algorithms, and NCALM leaders are hoping to acquire more sophisticated lidar that can provide insights into the precise makeup of a survey area — right down to types of grass and soil composition. Eventually, Chase anticipates, lidar will revolutionize not only how archeologists around the world conduct research, but what that research allows them to glean. "Lidar allows you to see the total scale, the true size of your universe," he said. "Radiocarbon data gave archaeologists control of time. Lidar gives archaeologists control of space."

From The Verge, a science and technology web site based in New York. There is an animation on the web site.