



# A NEW VIEW OF RAPA NUI

STUDIES OF EASTER ISLAND GO FAR BEYOND ITS ICONIC STATUES. UNMANNED AERIAL SOLUTIONS ARE PROVIDING NEW INFORMATION AND EFFICIENCY FOR SCIENTISTS AND ISLAND RESIDENTS, WRITES ERIK DAHLBERG

It's one of the most isolated and intriguing places on the planet. Sitting alone in the South Pacific, Easter Island (traditionally known as 'Rapa Nui'), has long been the source of fascination – and disagreement – for historians and archaeologists. However, an important scientific tool is missing: in spite of years of research, there is no comprehensive geospatial dataset for Rapa Nui. A team of US scientists is working to solve the problem.

Formed by volcanic activity, Rapa Nui lies more than 3,500km off the South American coast. The nearest inhabited land is Pitcairn Island, 2,000km to the west. Rapa Nui's original inhabitants arrived from Polynesia around AD1200, the first European explorers landed in 1722 and the island was annexed as a territory of Chile in 1888. However, roughly 60% of the island's 5,800 residents are direct descendants of the Polynesian settlers.

Rapa Nui's most famous occupants are the more than 900 stone statues (known as 'moai') located around the island. Carved from exposed outcrops of basalt and volcanic tuff, the moai were walked to their present locations, where they sit on massive stone platforms called 'ahu'. On average, the statues are roughly 4m high and weigh 12 tonnes, but some are as large as 10m and weigh more than 74 tonnes. In 1935, the Chilean government established the Rapa Nui National

Park covering about 40% of the island's 160sq km. In 1995, the park was designated as a UNESCO World Heritage Site.

The significance of the moai, together with questions of how they were created, moved and placed, attracts tourists and scientists from around the world. For many researchers, understanding the moai requires gaining a bigger picture of the lives of the prehistoric residents of Rapa Nui. According to Carl Lipo, professor of anthropology at California State University Long Beach (CSULB), US, the entire island is a mystery.

"Rapa Nui has very few natural resources," Lipo says. "There are no streams, poor soils, few native species of birds and only a tiny reef to provide marine resources. When you look at it from a European perspective, it's surprising that people lived there for any length of time."

Learning about the prehistory of the island begins with the land itself. Rapa Nui is dotted with evidence of its prehistoric inhabitants, including ruins of houses, ovens, gardens and cultivation features. While Lipo has conducted significant research on the moai, his current research focuses on freshwater resources and its relations to archaeological settlements.

"The topography is the key to understanding the archaeological record," he explains. "It helps you locate where the water and arable





A group of moai at Ahu Tongariki, Rapa Nui National Park (© Carl Lipo, CSULB)



Christopher Lee and Eliza Pearce launch the Trimble UX5. In the background, moai rest horizontally on an ahu. The UAV collected data in visible colour and near-infrared spectra (© Carl Lipo, CSULB)



Christopher Lee and Eliza Pearce prepare the Trimble UX5. The team could conduct multiple flights from a single launch/landing site (© Carl Lipo, CSULB)



land were located." He adds that good topographic data helps to spot ancient roads and building sites that are undetectable from the ground.

"The entire island is an archaeological resource," explains Suzanne Wechsler, an associate professor in geography at CSULB. "Understanding the features and their spatial relationships requires a systematic landscape-scale survey."

### Archaeology from above

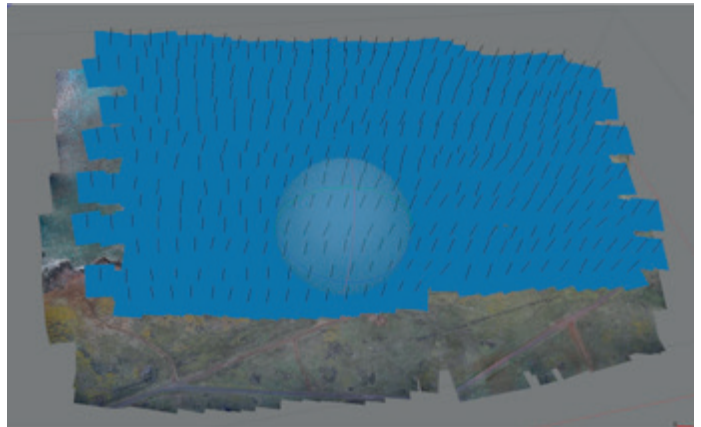
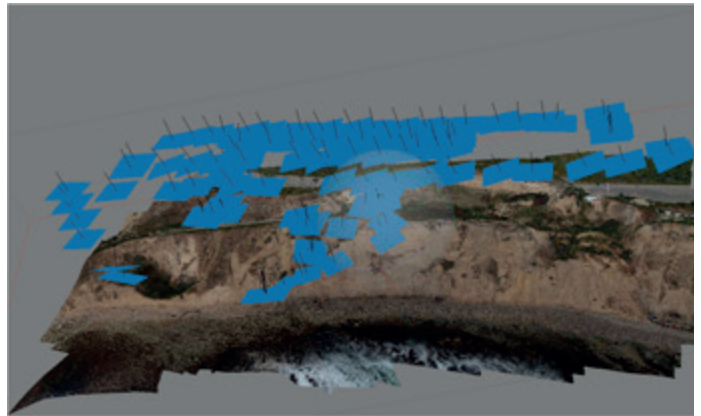
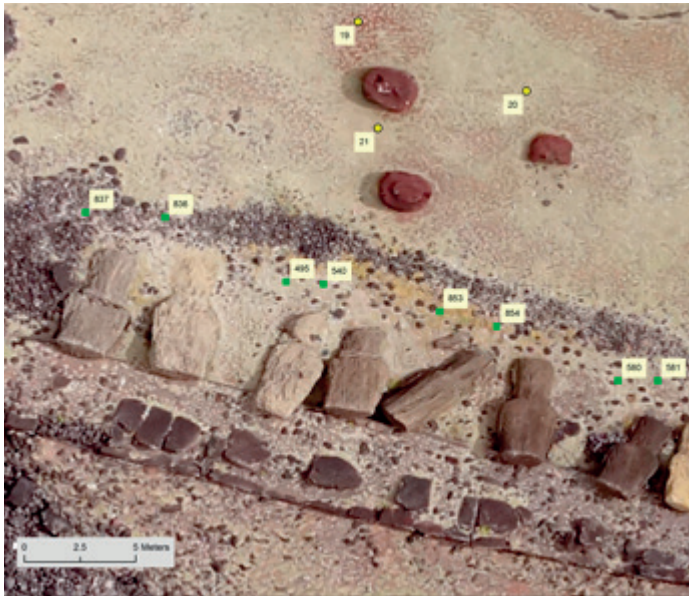
In most locations around the world, aerial imagery is used to supply the high-resolution topographic information that Wechsler describes. But isolation and limited research budgets have thwarted effective aerial photography on Rapa Nui. Satellite imagery is available, but it doesn't provide the needed resolution.

In attempts to collect useable imagery, CSULB research teams have experimented with a variety of aerial platforms including kites, blimps, and hobbyist-grade fixed-wing and quadcopter aircraft. The resulting images could provide visual reference over limited areas, but were not suitable to develop digital elevation models (DEM) or provide accurate measurement of objects and features.

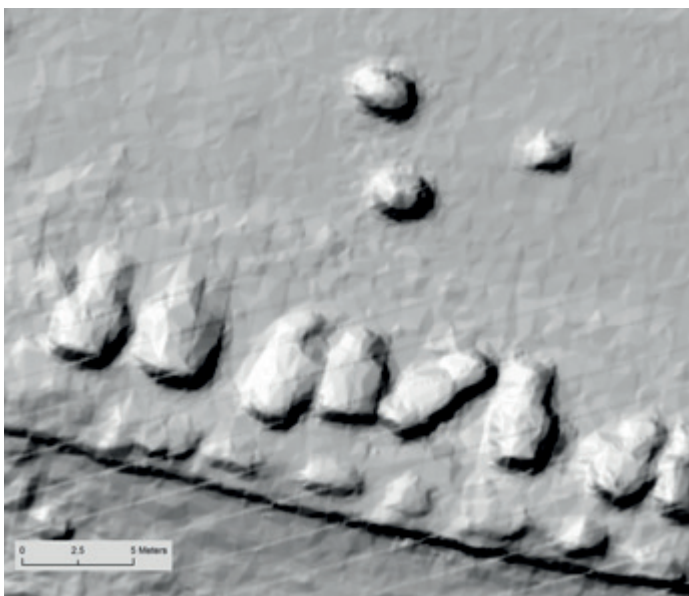
To obtain higher quality data, the researchers turned to a commercial unmanned aircraft vehicles (UAV) designed to capture the systematic, georeferenced imagery needed to create accurate, high-quality maps and terrain models. Lipo, who has years of experience using UAVs for archaeology, was confident that off-the-shelf solutions could obtain data suitable for scientific work.

To prove the effectiveness of UAVs, the team conducted a project along the southern coast of Rapa Nui in January this year. With fund-

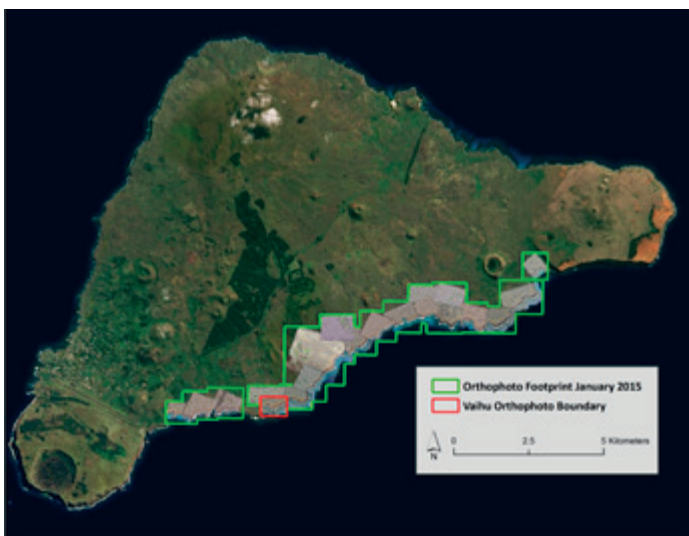




Compared to images captured using a kite-mounted camera (top), the coverage by the UAV (bottom) produced systematic coverage needed for photogrammetry and qualitative analyses (© Suzanne Wechsler, CSULB)



Orthoimage (top) and DEM of moai at 1:125 scale. Consistent data enabled scientists to integrate images taken on different days or with other sensors and datasets (© Suzanne Wechsler, CSULB)



A satellite view of Rapa Nui shows the orthophotos produced by the CSULB team. The team needed only nine days to collect high-resolution georeferenced imagery on more than 10% of the island's surface (© Suzanne Wechsler, CSULB)

ing from the US National Science Foundation, its objectives were to evaluate the performance of the UAV in capturing aerial imagery and to integrate the resulting orthophotos with existing datasets. The team selected a Trimble UX5 UAV to collect imagery along the southern coast.

"In nine days, we flew more than 26 missions covering an area of approximately 18.5sq km," Lipo says. "The UAV captured more than 20,000 individual images, which were processed to produce 26 orthophotos." Flying at a height of approximately 100m above the ground with 80% overlap, the images produced a ground sample distance of 2-3cm.

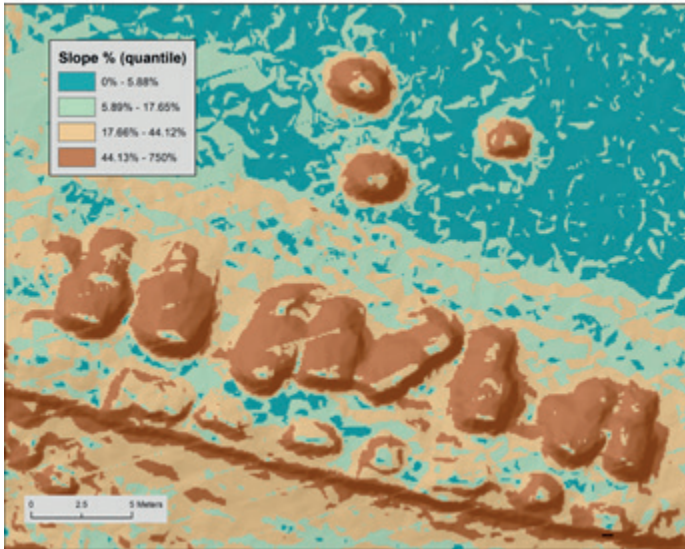
As part of its planning, the team identified a minimum of five ground control points (GCP) for each flight. The stations were measured with Trimble GeoExplorer 6000 GNSS handheld computers and post-processed to decimetre accuracy using data from a GPS reference station originally established for the US space agency NASA (in the 1980s, Rapa Nui's airport runway was expanded to serve as an emergency landing site for NASA's space shuttle).

Lipo says that the CSULB team also operated its own GNSS base as a backup. The GNSS stations provided a consistent reference frame for positioning of features and GCPs. There are a number of geodetic reference points on Rapa Nui and by tying into them, the scientists could develop absolute locations for the archaeological and hydrology features.

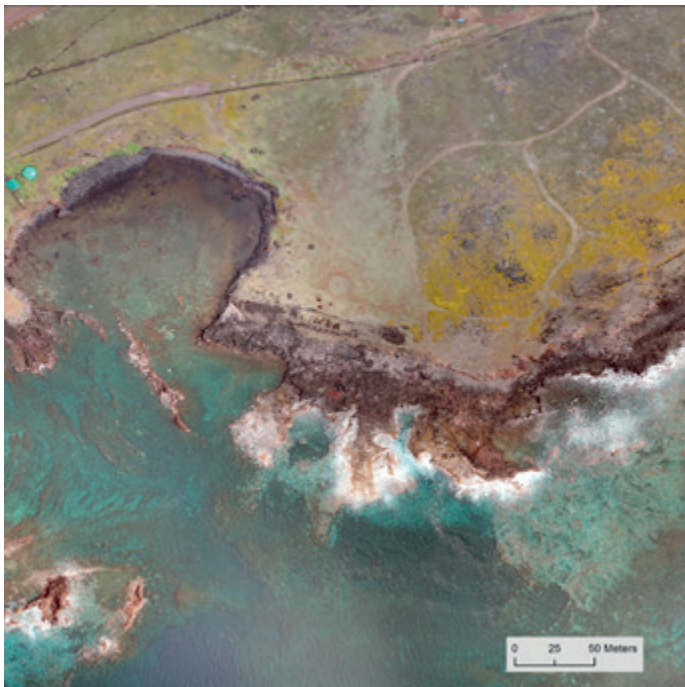
Working with his CSULB colleague, Professor Christopher Lee, Lipo operated the UAV and completed three or four flights each day. They used the Trimble Access Aerial Imaging application to define polygonal coverage areas for each flight. The polygons allowed them to optimise the flights to cover the near-shore areas and collect some inland data as well.

The researchers said the planning was very helpful in getting the best coverage in the face of constant winds, irregular coastline and rocky terrain that limited the selection of landing sites. In several cases, they launched multiple missions from the same location, with the aircraft flying a kilometre or more to the target area before beginning photo passes.





Orthophoto of moai at Vaihu at 1:125. The images confirmed that previously gathered locations in the researchers' database were within specified tolerances



A 1:2000 orthophoto of the Vaihu area of the south coast of Rapa Nui produced from UX5 images. Flight planning software enabled efficient coverage over irregular-shaped areas (Images © Suzanne Wechsler, CSULB)

Between flights, the team downloaded images and installed a fresh battery into the aircraft. In some cases, they switched cameras, replacing the high-resolution colour camera with a near-infrared sensor.

"It's a fast change," Lipo says, "and you can reuse the previous flight plan. So you can easily match the two flights for lighting and weather."

Working to manage the large datasets – the system produced 60GB of imagery – they produced orthophotos from which they derived DEMs for topographic analysis. They then used Trimble's eCognition software's object-based analysis to identify the remains of houses, stone platforms and circular structures for gardens.

### An Island of Information

The performance of the UAV – both in the air and the information it produced – convinced the CSULB team of the value of using commercial solutions to extend the aerial imaging over the entire island. The team is planning new projects that will use the system to blanket all of Rapa Nui with high-resolution imagery.



In addition to archaeology, aerial images are supporting other activities on the island, such as helping the island's Ministry of Public Works to document modern infrastructure and plan and develop the island's growing eco-tourism business. The ministry is planning bike paths around the island and it can use the detailed aerial data to design paths to access historic features without damaging the archaeological record. Because the imagery can be reacquired at low cost, researchers and government officials can see changes in the features and topography over time to gauge the impact of visitors and development.

For Lipo, the payoff lies in the science. By combining topographic information with hydrological data, he has gained new insights into Rapa Nui's history. To illustrate, he points out that the sites of the moai and ahu were apparently based on the location of water rather than for visibility as previously believed.

"The data are astounding," Lipo says. "You see things that you could never see before, even though the island has been studied for hundreds of years. The UAV provides a complete record of what is on the ground. It's the way archaeology should be done."

### IT'S THE WAY ARCHAEOLOGY SHOULD BE DONE

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