

Rapa Nui

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My Magellan handheld GPS says Latitude 27°09'00" South, Longitude 109°20'20" West. Yes that's right, South. In the middle of the South Pacific is an island approximately 2200 miles west of Chile, 2300 miles east of Tahiti, and 4993 miles as the crow flies from the D. Wellman Surveying office in Eugene, Oregon, U.S.A. The place is Easter Island. It's a rather long way from home to do a laser-scanning survey, but the circumstances merited the expedition to the Polynesian island of Rapa Nui, or in Spanish, *Isla de Pascua*.

Rapa Nui is not a place that one gets to easily. If you don't want to go by boat, there is only one commercial option by air, and that's with the very accommodating LanChile airlines and their luxurious Boeing 767. You can depart from Santiago,



Cyrax 2500 as it scans petroglyphs at the ceremonial village of Orongo. Island of Motu Nui in distance.





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Chile, or from Papeete, Tahiti. Flights run twice a week. This type of schedule does not conform to the conventional Monday-through-Friday business week, but the thought of a layover in Tahiti while waiting for the next flight out added an exotic flair to the work assignment. The round-trip ordeal of transporting a mountain of high-tech equipment (with the word “laser” on the packing label), computers, survey gear, and crew members through three major airports in three different countries, while fumbling with different languages, currencies, customs officials, freight offices, baggage clerks, bellhops, hotel rooms and taxis, is not for the faint of heart. That is a whole story in itself. Yet, let us suffice it to say, we made it!

Rapa Nui History

Present theory and legend suggest that indigenous Polynesian settlers arrived as early as 400 to 800 A.D. Legend suggests that King Hotu Matu’a brought 300 settlers from the West, somewhere in eastern Polynesia. Scholars’ research and the isolation of the island, indicates that the inhabitants developed a culture free from outside intervention until Europeans showed up on the scene. The most intriguing aspect of the culture, and certainly the interest of many present-day tourists, are the ever present stone statues, called *moai*, found throughout the island. The first written record was by the Dutch explorer Jacob Roggeveen, who “discovered” the island on Easter Sunday, 1722, and mentioned the moai and the inhabitants. He wondered then how the statues could have been erected without the timbers and strong ropes that were used in his modern world. My favorite Pacific Ocean explorer, Captain James Cook, went in search of the island in 1774 for a place to “rest his men” after searching for Antarctica. Cook found that some of the moai had been “toppled from their platforms.” Visits by other explorers, as early as 1825, recount that all the moai had been toppled.

Starting in 1805 and continuing through the mid 1860’s, slave traders raided the islands to supply workers for the Peruvian guano mines. The native population was decimated by slavery as well as the introduction of smallpox and tuberculosis. Less than one hundred direct de-



Dave and Karen Wellman at Rano Raraku crater. Most moai statues extend well below the ground surface.

scendants of the original population remained on Rapa Nui. Thus, a validated oral history of the islands was also lost. Rapa Nui was one of the first Polynesian cultures to have a written language, and is evidenced as such by the discovery of the *rongo*. These scribed tablets display specialized characters, yet those who could read them were lost with the rest. With no understandable written language, and the break in the chain of oral history, much of Rapa Nui and its incredible past remains a mystery. Why these colossal stone heads and temples? How were they moved and erected? Why were they toppled? What caused “the birdman cult” to become predominant?

Rapa Nui Today

Fifteen miles long and 7.2 miles wide, Rapa Nui has one main town—Hanga Roa. Mataveru Airport was ex-

panded by the U.S. Air Force in 1966, and by NASA in 1986 to provide an emergency landing place for the space shuttle. A bustling combination of Chilean and Rapa Nui residents number about 2500. A fascinating mix of Polynesian and Spanish cultures is seen daily in the small shops, modest homes, and quaint hotels. Dogs and horses can be seen on the cobblestone streets, and there are lively soccer games in the park overlooking the town beach on Sundays. Ever present are the silent, stone carvings. The languages are Rapa Nui and Spanish, the money is the Chilean *peso*, and the government is that of a Chilean colony.

Since 1935 a large part of the island has been designated as a Chilean National Park. *Parque Nacional Rapa Nui* nearly encompasses the island and includes



Knife-edged ridge between crater lake of Rano Kau and Pacific Ocean, near ceremonial village of Orongo.



many of the special features along coastal and inland areas. It is open at all times for a modest fee to the tourist and visitor. It is possible to tour on your own, but to enjoy the treasures to the fullest, a guide is recommended.

We were lucky. Our guides were our clients, the accomplished archeologist Dr. Terry Hunt, and his students from the University of Hawaii Department of Anthropology. A local Rapa Nui committee

presentation of 3D digital models of moai. Up until this time standard procedures such as photogrammetry, calipers, and tape measures were used to provide measurements for the study of the statues, *abu* (ancient temples), and related artifacts. 3D scanning technology, such as Cyra Technologies' Cyrax 2500 can provide the required

field of cultural resources data collection.

Upon our arrival our client took us to the largest and most complex ruin in his permitted area. Before us lay an intricate mosaic of rocks, upturned moai, toppled moai topknot hats, and remnants of the *abu* upon which the moai stood—some parts in good shape, some parts in disarray. The crew made a quick huddle, came up with a plan, and proceeded to scan away for the rest of the day. The sun was shining, and while computers and scanners processed the data, we seized the opportunity to take in the fantastic scenery of Rapa Nui at our job site by the sea. It was a sight we never tired of during our time on Rapa Nui.

While scanning, one crew established a control survey around the perimeter of the site with a key point at the top of the ruins. The non-invasive scanning technology helped maintain respect for the ahu, which hold religious meaning to the Rapa Nui people. Our control survey was to be used by the scientists at a later date to coordinate their aerial survey work with our scanning control, as well as with surrounding project sites. Without having done their GPS survey control prior to our arrival, we assigned temporary local project coordinates to our points.

The complexity of the project required that we use multiple scans registered together to form one cohesive 3D model. This would allow the 3D model to have a complete scan from many angles, thus covering as many surfaces of the site as possible. As the scanning progressed across the project, high resolution targets were set out to tie our earlier scans to the work in progress. These precise, and highly reflective targets allow each of the multiple scans to be registered together, much like overlapping aerial photography uses control points.

We used a combination of methods for the registration on this project. Within the Cyra Cyclone software is a target scanning and registration routine. Precise real world, or project coordinates of the targets, do not need to be known for the scans to be registered to each other. The arbitrary coordinate system created by the



Moai at Museo Antropologico Sebastian Englert with Cyrax targets in place for registration of multiple scanning angles. (Inset: Finished scan showing a "meshed" 3D point cloud. Colors represent intensity values of the laser reflecting off surface.)

called the *Consejo de Monumentos Rapa Nui* is charged with the protection and oversight of the cultural resources on the island. The *consejo* issues permits to scientists such as Dr. Hunt after approval of proposals for research and study. Dr. Hunt's permitted study area was along the south central coast and therefore was our permitted area for this project. However, with other proper approvals gained by Dr. Hunt, we could expand our project to include some other interesting cultural features. Of course the moai are the main attraction to tourists and researchers alike, but an incredible amount of interest on an international scale takes place in many different scientific disciplines. The success of this project could have profound effects in the scientific and academic worlds.

The request for our services as surveyors was based on the University of Hawaii Department of Anthropology's need to evaluate the collection and

accuracy and completeness of data collection of cultural resource treasures such as the moai. A benefit of the technology is the ability to obtain data without touching the artifact. This fact alone is important in gathering dimensional data information on priceless cultural resources and artifacts.

An Intricate Mosaic of Rocks

Being one of only a few companies in the Pacific Northwest that were using 3D survey grade scanning technology at the time, we proposed a joint effort for this pilot project. We teamed up and pooled resources with the Honolulu office of Geo-InSight International Inc. to scan the statues on Rapa Nui. The project objective was to provide an assortment of 3D scanned "point clouds" for our client to evaluate. Our mission was to provide scanning services and generate enough detailed information to demonstrate the advantages of scanning technology in the



scanner becomes the coordinate system for the model. The software automatically registers multiple scans together by matching the naming convention applied to each target by the scanner operator. However, we elected to tie as many of the targets as possible with our reflectless total station, a Leica TCR703, calculating and noting our project coordinates of each target. This methodology essentially tells the scanner the coordinates of specified targets, restrains the registration reduction to those coordinates, then allows for a redundant analysis in Cyra's least squares registration routine.

Infectious Enthusiasm

The project covered two days of scanning. Each days' target coordinates were entered into a separate registration routine and designated as the "home scan." An analysis of the residuals of the registration process allows the operator to cast out redundant outlier target registration combinations which degrade the validity of the solution. Once the registration is completed, each point generated by the scanner has an assigned project coordinate. The entire 3D model is then ready for inspection, surface modeling, detailed measurements, or export to third party software uses for any number of different applications.

Product specifications of the Cyra system are published as 1 sigma single point position accuracy of $\pm 6\text{mm}$ within the 1.5 meter to 50 meter range. Previous experience with the scanner suggests accuracies better than this at nearly twice

the distance. We have found that high angles of incidence and shiny surfaces affect accuracy the most dramatically. Our subject survey error budgets were well within this range. There would be no viable way of checking our accuracy resolution due to the nature of the rock, erosion and degradation of the stone, and varied shapes of the objects. We felt that the truest representation would best be generated by dense overlapping scans. In this manner multiple points could then be statistically modeled into a more true-to-form shape of the subject piece by using third party surfacing software. Scans for this trial were at a nominal 6 x 6 mm spacing. The amount of data collected, and the representation of the point cloud exceeded the client's expectations. The ability to collect such a comprehensive data set far exceeded the archaeologist's efforts to date.

That evening, and most evenings after that, some students headed to the disco to enjoy the night life, while others would gather around and watch as we registered the scans together and showed off our day's work. They

ect for us.

Scanning enthusiasm became infectious, not only within our group, but with other professionals on the island as well. Application ideas were growing in number. The value of the completeness of the "point cloud" data was being realized. The wish list of projects increased; ours included some scans of moai that were standing up.

Our wish was granted on Sunday by Francisco Torres, Acting Director of the local museum, *Museo Antropologico Sebastian Englert*. A moai stands in front of the museum. Torres had been watching our scanning process all week and felt it would be a great opportunity to get a scan of the moai for the museum.



Ahu Nau Nau at Anekena Beach is believed to be where the first settlers landed.

asked questions about services we could provide, data accuracy, technology applications, and applicability of 3D scanning to other projects they were working on. These sessions proved to be a rewarding and challenging aspect of the proj-

The deal was made and we were scanning by noon.

Another valued scan for the scientists to evaluate was that of the impressive petroglyphs at Orango. The petroglyphs are carved on a rock outcrop located at the terminus of a precarious, knife-edged ridge—1,000 feet high—that separates the caldera of an ancient volcano from the Pacific Ocean. The objective of this portion of the project was to evaluate the use of scanning to "digitally preserve" the petroglyphs. The Consejo de Monumentos, also in charge of preserving Rapa Nui





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treasures, is concerned about the degradation of the petroglyphs in such an exposed location, as well as the eminent destruction if the ridge tumbles into the ocean.

A day off was highly encouraged in order to tour the rest of the island and gain an appreciation of all there was to offer. Scattered throughout the island are the ruins of hundreds of ahu, remains of houses, petroglyphs, caves, standing moai, fallen moai, and more. Perhaps the most impressive sight is that of Rano Raraku—the quarry. It is here that hundreds of statues, in all stages of completion, dot the sides of another giant extinct volcano. Most moai are 20 feet tall or larger and weigh up to 80 tons. The largest is 69 feet long, and would have been taller, but was never finished. How many people must have worked here and for how long? How were the moai moved off the side of this mountain and transported up to 10 miles away? The scene is both eerie and fantastic as one walks amongst the colossal heads. It seems as if one Friday afternoon the foreman blew the whistle and told everyone not to come back on Monday.

The Best of Professions

Another interesting stop was that of Anakena Beach. It is in fact one of the few beaches on this rugged volcanic island. This is the spot where it was believed King Hotu Matu'a first landed his canoes of settlers. Nearby is the temple Ahu Nau Nau. This restored ahu and well preserved moai was covered with sand until the 1978 reconstruction. The sand beach, ahu,

moai, and planted palm forest presents another classic Easter Island scene.

On our last evening Dr. Hunt reminded us all of how very few professionals get an opportunity to work on Rapa Nui and its mysteries. To be allowed such an opportunity was both a professional and personal honor. I can think of few other careers that provide as much enjoyment and allow us, as professional surveyors, to use our skills and equipment to assist other professionals with their efforts. Add in a little flavorful travel, some new and unique environments, intriguing clients, and a few

technical hurdles, and you end up with a rewarding surveying career. This project certainly was one to be remembered, but I hope not the last of an anticipated long list of adventures to come. ▼

DAVE WELLMAN is licensed as a surveyor and engineer in Oregon, Washington, and Maine, and has been practicing since 1985. Located in Eugene, Oregon, Wellman's firm offers cadastral and telecommunications lease site surveys, long and short range 3D scanning, and aerial photography.



Unfinished moai at the quarry site on Rano Raraku.

A moai lies in place on the inside rim of Rano Raraku crater, where it would have been broken loose and transported down the mountain.



Petroglyphs of the "Birdmen" at the ceremonial village of Orongo.

