ARCHAEOLOGY ON EASTER ISLAND: REMOTE SENSING FOR LOW-IMPACT ARCHAEOLOGICAL STUDY OF RAPA NUI'S (EASTER ISLAND) MONUMENTAL STONE ARCHITECTURE

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ABSTRACT

This study uses remote sensing techniques to study *ahu* (monumental ceremonial platforms) on the island of Rapa Nui (Easter Island). The first phase of the project used commercial satellite images to locate *ahu* and create a comprehensive GIS database to be corroborated during future ground survey. To supplement the satellite images, a second phase of the study evaluated kite photography - a low-cost, non-destructive, low-impact and culturally sensitive way to supplement the resolution of the satellite images. Kite photography was used to photograph *ahu* and ground targets were used to mosaic photographs together. From the resulting image, traditional archaeological plan view maps were made. The micro and macro survey of archaeological features in this study will contribute first towards protecting the famous heritage sites on Rapa Nui for the Rapanui people and for future research. Data will be used in continuing studies that aim to scientifically understand cultural and environmental change on the island.

INTRODUCTION

Rapa Nui is an oft-mentioned place, but what is not widely appreciated is how little basic knowledge actually exists about the island. Though archaeologists have worked there for decades, there are still basic holes in simple locational data. Traditional large area survey requires long hours with intensive human labor, and so the cost of filling those holes remains high. Additionally, many structures, such as *ahu*, are in very poor structural condition. Not only would a detailed survey of an individual structure dramatically expand a survey's time frame, it would also endanger the subject of the study itself. *Ahu*, in particular, are complicated because of their nature – they are traditional familial burial platforms upon which no one is allowed to step. This study attempts to address these problems in two phases – a macro study of the *ahu* location via satellite image and a micro study of a few sample *ahu* with kite photography to document their condition, construction and to provide a vantage point from which to draw traditional archaeological maps. With this project as a precedent, it is hoped that a good, publicly available digital database of *ahu* locations will be refined over time. Additionally, if more *ahu* and other large structures are studied with kite photography (or other aerial means), hopefully the impact on the archaeology itself and the cultures to which archaeologists are responsible will be reduced.

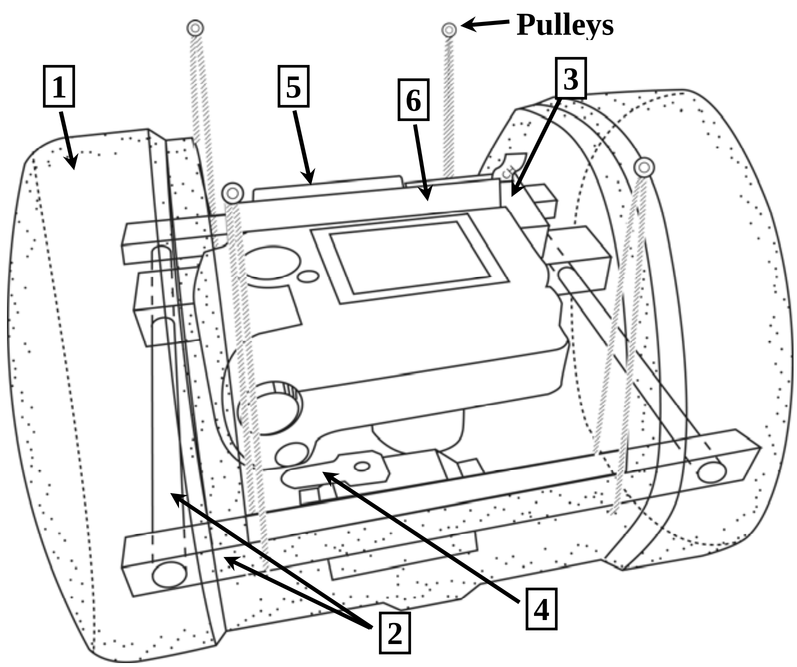
METHODS

For the satellite image survey a total of three commercially available QuickBird images of the island were loaded into ArcGIS. East-west survey lines were created in the computer at intervals of 250 meters and the region between these lines was observed systematically from south to north across the entire island. Potential *ahu* locations were recorded in UTM coordinates in a different file. Potential *ahu* were identified based on specific criteria such as size, shape and tone. Additionally related structures, coastal orientation and locations known to be *ahu* by the author or third party publications were used to help verify that observed phenomena were indeed *ahu* (Martinsson-Wallin 1994, Cristino, et al. 1981).

During the second phase a reliable method for taking good quality photographs from a kite was explored. A riveted aluminum rig constructed for kite photography by a previous student was modified and field-tested to suggest the best design for a new rig for this project. Design goals for the new rig included durability, easy operation, flexibility in application, and consistent photographic results. Durability was the primary consideration in material selection, as the rig is intended to be backpacked into remote locations and used by largely untrained crews of field school students or Rapanui assistants. Ease of operation was also desirable to decrease the learning curve of using the equipment and to speed deployment by experienced operators. The rig was designed to be adjustable to accept different cameras in the event of failure of the primary camera. Finally, consistent results were a mandatory feature of the rig. A four-point "Picavet" suspension system similar to those used by hobby kite photographers was used to minimize twisting and swaying and to self level the rig via pulleys (Haefner 2005).

The resultant rig is a polycarbonate shell (1) enclosing an aluminum and fiberglass frame (2) that holds the radio receiver (3), shutter activating servo (4), radio power supply (5) and a mounting plate for the camera (6). All joints in the rig are either bonded with epoxy resin or are held together with nylon zip ties. The latter are much lighter than other fasteners, allow for flexibility in certain joints and are easy to replace in the field. The rig also has a plastic laminated aluminized Mylar shield that closes the hole in the top of the polycarbonate shell. It provides protection for the camera and radio receiver against the sun and unpredictable light rain showers, but allows easy access to the camera to adjust settings.

FIGURE 1 – Camera Rig



A diagram of the camera rig as described in the text. The pulleys, connected with small line to the rig, create a four-point suspension.

All aerial photographs are subject to several types of distortion, which reduces their usefulness in making accurate measurements. The first type is optical distortion from the camera itself. Most commercial aerial photographs are taken with very large lenses and so optical distortion is minimal. For this application, a light, compact camera was more ideal. A lighter camera allows for a larger range of lift producing wind. Additionally, smaller consumer digital cameras are considerably cheaper, critical for a limited budget project. As a result, the smaller lens incurs more optical distortion. Controlled test photographs found that warping of the images occurred largely at the edges of the photograph. Also, tests with a freely available high quality, open source program called Panorama Tools showed that software correction of the optical distortion produced good results, with only minor residual distortion. This software was used to process all photographs before use (Dersch 2005).

Another type of distortion to which all aerial photographs is subject is tilt in the camera. This problem was primarily addressed in the four-point rig suspension and self-leveling system. Secondarily, a survey grade GPS unit was used to take UTM coordinates of cloth targets pinned to the ground in the target area. Transforming the photographs to fit the GPS coordinates created an image more true to real life. Any photographs that required heavy transformation to fit the coordinates were assumed unacceptably tilted and discarded.

The final type of distortion is that of radial displacement of objects with height outward from the center of the photograph. This displacement increases with distance from the center of the photograph. For a continuous surface such as a beach, the GPS ground targets allow for reasonable transformation when there are ample targets in a photograph. For discrete objects such as palm trees, radial displacement was problematic. As much as possible, photographs were cropped to fifty percent of their original width and sixty-seven percent of their original height to remove the areas with the heaviest radial displacement. However, because objects like palm trees are not the subject of study, considerably higher error in alignment was tolerated than for archaeological structures. Given a good method for recording the altitude of the camera at the time each photograph is taken and a good digital elevation model of a target location, this most elusive form of distortion can be largely eliminated with the creation of an orthophotograph using specialized software (Wingert 2005). This, however, was outside of the scope of this project, though it would be advisable to explore this technique in a future project.

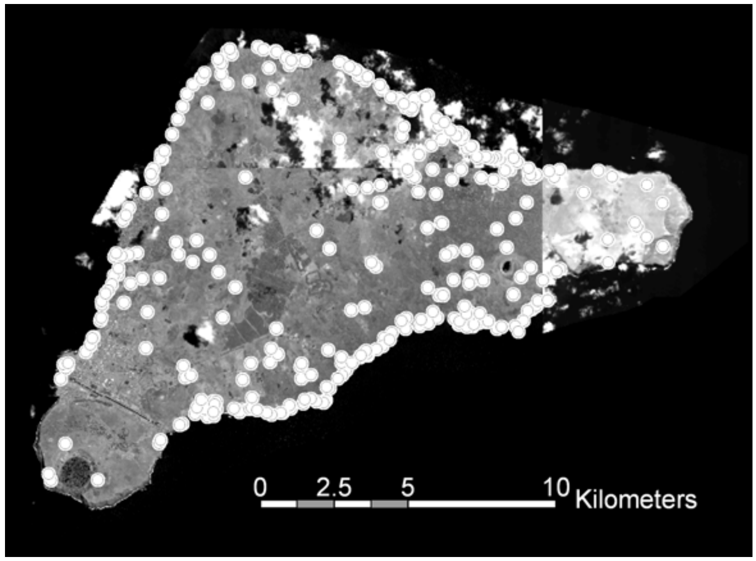
Photographs that showed good exposure, composition and low distortion were used in the final stage of this project. These photos were imported into ArcGIS and georeferenced using the GPS coordinates. They were layered into a mosaic to give a continuous image of an area under study.

RESULTS

The satellite survey resulted in the identification of 331 *ahu* locations. Figure 2 shows the distribution of these locations around the island. These locations are, of course, based only on generalized identification criteria. Some of these points may turn out to be modern structures and other *ahu*, especially small ones, may remain hidden. This survey is, however, an important first stage to creating a comprehensive database. As has been done with previous satellite image surveys of roads and agricultural features on Rapa Nui by Dr. Terry Hunt, Dr. Carl Lipo and their respective students, this *ahu* survey will be subjected to ground-truthing during upcoming field seasons (Lipo and Hunt 2005; Bradford, et al. 2005). At a minimum, a random sample of the identified points will be located to estimate the success rate of identification. However, because *ahu* are large structures and are prominent in ancient and modern Rapanui culture, over time it should be possible to verify all *ahu* points with the help of hand-held GPS units either as a stand alone survey, or in conjunction with other survey.

During the summer of 2005, a research trip to Rapa Nui was taken to photograph three different locations of archaeological interest. The most extensive photography was undertaken at Anakena beach on the north shore of the island. The resulting photo mosaic can be seen in Figure 3 on the following page. Aerial photography was also conducted at an *ahu* on the north coast and one on the south coast. These mosaics were considerably smaller, consisting of only a few photographs.

FIGURE 2 - Ahu Locations



Distribution of identified *ahu* locations across the island.

For *ahu* of particular interest, close-ups of the photo mosaic were traced to produce a planimetric map of the structure in a traditional archaeological style in a simple representation of its construction and condition. Large boulders and cut stone down to cobbles approximately 20 cm in diameter were depicted separately. Smaller stones were not distinguishable from each other at the resolution provided by the kite photographs. Instead an area showing a pattern suggesting scatterings of small stones was represented with a generic pattern on the map, as is common in archaeology.

In some cases, there were limitations to what data the aerial photographs could provide. For example, whether large stones were uprights or not was not always clear. Also, type of stone was sometimes not apparent. This caused some problems in identifying which stones were structural, which were fallen remnants of *moai* (statues often topping an *ahu*), or *pukao* (stones set on the heads of the *moai*), all of which are composed of different local stones. However, were greater detail desired in the maps, a quick ground reconnaissance would easily reveal such details. As with all remote surveys, the final product could be improved with confirmation from the ground.

The Anakena mosaic will be used to study the state of the archaeology at Anakena beach, and with repeated photography in future seasons, changing geological conditions and the state of archaeological structures can be studied. Similar information will also be gathered from the other *ahu* photographed. The *ahu* on the northwest coast was previously unmapped because of its large size and poor condition, but kite photography has allowed for a detailed record to be made. Finally, the photographs and mosaics will be sent back to the Museo Antropológico P. Sebastián Englert in Rapa Nui to be made available to the Rapanui people for education and preservation.

FIGURE 3 – Kite Photograph Mosaic

A section of the mosaic of Anakena beach. The rectangular structure adjoining a thin circular wall is an *ahu*, as is the smaller structure in the upper right corner. The black rectangles on the sand are fences protecting field school excavation units during the summer of 2005.

CONCLUSION

Satellite image survey and kite aerial photography have proven to be extremely low impact and labor efficient ways to supplement traditional archaeological survey. Satellite imagery allows for quick work over a large area and kite aerial photography is a highly portable and robust means with which to collect more detailed data, especially for fragile structures in remote areas. A visual survey of satellite images of the island will provide the basis for a comprehensive database following ground-truthing in upcoming field seasons. Kite photography has provided detailed images of structures for further study, education and preservation.

Future work on similar projects would do well to expand upon the scope of the project considerably. As mentioned earlier, the creation of orthophotographs would increase the usefulness of the images for making measurements. Experimentation with other methods of imaging would also be advisable. Given the high sensitivity of digital sensors to near infrared (NIR), digital photographs taken with NIR filters may reveal details that would otherwise be hidden. For even tighter ground control work, a total station could be used to measure ground target locations, instead of a GPS unit. Continuous revisions to the rig design itself are also advisable as lighter or stronger materials become more readily available or as field experience suggests revisions to the design. Given a larger budget, it would also be helpful to use a higher resolution camera, preferably with a larger, higher quality lens. All of these improvements will take considerable experimentation to implement, but it is the author's hope that with continued work with kite photography it will grow in its usefulness as a counterpart to satellite images in low impact survey work.

ACKNOWLEDGMENTS

The author would like to especially thank the Hawai'i Space Grant Consortium for an opportunity to conduct research as an undergraduate and for their continuous moral and financial support, as well as NASA for it's continuing investment in education that has been the root of this project. Mentor Dr. Terry Hunt has been very supportive and has provided the author with innumerable opportunities over the last few years. California State Long Beach's Dr. Carl Lipo has made essential contributions to this project including satellite images, survey GPS units and considerable technical input. The financial support of the Manoa Arts and Sciences Advisory Council and the Department of Anthropology Carol Eastman Fund were instrumental in allowing photography of the *ahu* during the summer of 2005. A special thanks goes out to Alex Morrison, who has been an invaluable resource for ArcGIS and Dr. Everett Wingert whose expertise on aerial photography has been most helpful. Kelley Esh has been great moral support and her interest in this project has been a consistent motivator along the way.

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