THALES PROMARK 2 GPS ON EASTER ISLAND

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ABSTRACT

The Easter Island Statue Project (EISP) directed by Dr. Jo Anne Van Tilburg, began in 1982 as component of archaeological survey to collect metric and descriptive data for all the statues. The EISP is on-going and in the summer of 2002 Dr. Peter Boniface joined the EISP and undertook the GPS mapping of the quarries and statues in the Rano Raraku volcanic crater using Thales Locus GPS receivers. Dr Boniface returned in the summer of 2003 and completed the mapping using Thales Promark 2 receivers. This paper describes the success a low-cost single frequency system in rapid data collection using the stop-go method averaging 10-15 seconds per point. The data was downloaded to a laptop and imported into a Microstation CADD environment for map compilation and editing. The mapping will be subject to a field check in the near future. It is planned to incorporate the art-work of Cristian Arevalo Pakarati of Easter Island (Rapa Nui) who is a co-investigator with Dr.Van Tilburg on the EISP. Cristian Pakarati accompanied Dr Boniface during the mapping, drawing field sketches of all the quarries and statues. These sketches will be merged with the GPS point outlines to form a final presentation of the Rano Raraku quarries.

INTRODUCTION

Lying isolated in the East Pacific, in an extreme windward position, Rapa Nui is the easternmost Polynesian island. It is in the Southern Hemisphere at 27° 9’ S latitude, 109° 26’ W longitude. Situated on the Nazca Plate at a volcanic and tectonic “hot spot,” it is 3703 km west of South America and 1819 km east of Pitcairn island. It was formed by three submarine eruptive cycles, between three and four million years ago creating three principal volcanoes, Poike (352 m), RanpKau (324 m) and Maunga Terevaka (525 m). There are about 104 secondary volcanic cones, all currently inactive.

Fig 1 Dr. Jo Anne Van Tilburg with Locus GPS receiver

Rano Raraku, the site of the GPS mapping, is a satellite cone of Maunga Terevaka. Formed of consolidated lapili tuff , the crater is awkwardly shaped, with steeply rising cliffs on its southeast side and much lower, softer, eroded slopes on the northwestern side. The crater is divided into five discrete survey zones. The specific goal of the Rano Raraku interior survey was to map every statue or possible statue and each quarry found within the boundary of Section C & D; to map the orientations and tilt of all prone, supine, or lateral statues in relationship to Section C; to map every standing statue in the interior, and to compile a contour map of the area showing the main topographical and archaeological features.

During the GPS survey of Section C and D, additional color slides of each statue on the interior slopes, as well as details of rock art superimposed on statues and quarries were added to the existing collection of standard, black and white photographic documentation from 1980s. These images are being digitized, along with historical photographs, excavation records, measurements and other details for inclusion in a comprehensive digital database that will organize all information about the statues from various field seasons and sources. The creation of a centralized information system will help to co-ordinate all archaeological, conservation, and cultural heritage management projects on the island.

THALES LOCUS MAPPING - SUMMER 2002

Project GPS Network

In the summer of 2002, Thales Navigation kindly loaned the EISP a complete mapping system based on two Locus receivers. Thales thought the Stop/Go procedure would be ideal for the Island conditions of open skies and no trees, and this proved to be the case. The Stop/Go method required an initialization of both base station and rover for a period of 5 minutes, Then the rover is set on a range pole, and must stay locked on to the satellites during subsequent point data collection. The epoch was set to 5 seconds and each point required 15 seconds observation time.

The first visit to the Rano Raraku site revealed grassy slopes of up to 28 degrees - no trees, but some areas of shrubs about 6 - 8 ft in height. The sloping ground meant that some satellites would not be visible, however, this did not affect the mapping. Most of the time a minimum of 6 satellites were visible. The grass was waist high in places and carrying the rover up the grassy slopes took some effort.

The GPS survey was based on a geodetic station "Easter Island Laser Station - JPL 4008-S" established by JPL in 1992. Figure 3 shows the site and the protective cover over the monument. The Locus receiver was set up over a point estimated to be the central point on the dome.

Rano Raraku quarries were 10 km from the base station and a small network was established in the crater using the Fast Static method. Observation times at each point were approximately 40 minutes. The resulting accuracy of the network points was in the order of 0.07 ft. Whilst this may be considered inadequate by some - it was felt that it was more than adequate for the quarry mapping.

Fig 2 Locus Bar Initialization

Figure 3 : Base Station

Figure 4 : Peter Boniface On the highest point

Stop/Go Measurement

The Locus receiver is a single-frequency system that communicates with the operator by means of a series of flashing lights. These lights indicate the battery status, the number of satellites in communication with the receiver and when to terminate the session for different baseline lengths. This is sufficient for **fast static** measurements. For Stop/Go, however, one needs to communicate with the receiver by means of a PDA. The PDA is held in front of the receiver and contact is established via an infra-red port. The PDA and receiver are synchronized and from then on the PDA can be used as timing device, quite independently of the receiver. The PDA can be placed in a pocket and started when the surveyor has the rod vertically over a point. A beep indicates the end of the observation.

The **Stop/Go** procedure requires a 5 minute initialization using a 0.5 m bar (Fig 2). Once completed, the rover is transferred to a standard range pole and the surveyor can then move from point to point. If the rover loses lock on the satellites, a warning beep is heard and the rover must be held on a known point for 15 seconds - point measurement can then resume. On most of the quarries lock was rarely lost. However when the rover was held against vertical quarry faces, the antennae had to be raised in order to keep lock. A network of control points was established over the mapping area to serve as known points which could be used in the event of loss of lock.

Mapping the Quarries

Dr Boniface operated the rover while Cristian Arevalo, the Rapa Nui artist indicated the location of points to be measured. Arevalo had previously prepared careful drawings of the quarry outlines which included several partially carved statues which were still part of the base rock. Point numbers were then marked on the quarry drawings.. Some of the rock surfaces were extremely steep and often measurement proceeded rather slowly. Nevertheless, on days where there were no interruptions, in excess of 300 points could be measured.

Mapping the Stautes

There were a number of standing statues and many of these were leaning at various angles from the vertical. Points were measured equidistant in front and behind the statue giving the direction the statue was facing as well as it's XYZ location. The angle of lean was measured using an abney level, a small sighting device with a level bubble and a 180 degree protractor.

Downloading and Processing

Data is downloaded to a laptop via an infrared connection. The receiver is simply placed in front of an infrared port connected to the laptop via a cable, and the day's data is transferred in about 10 - 15 minutes. The Thales Ashtec software proved to be very easy to use and an example of the software GUI is shown in figure 5.

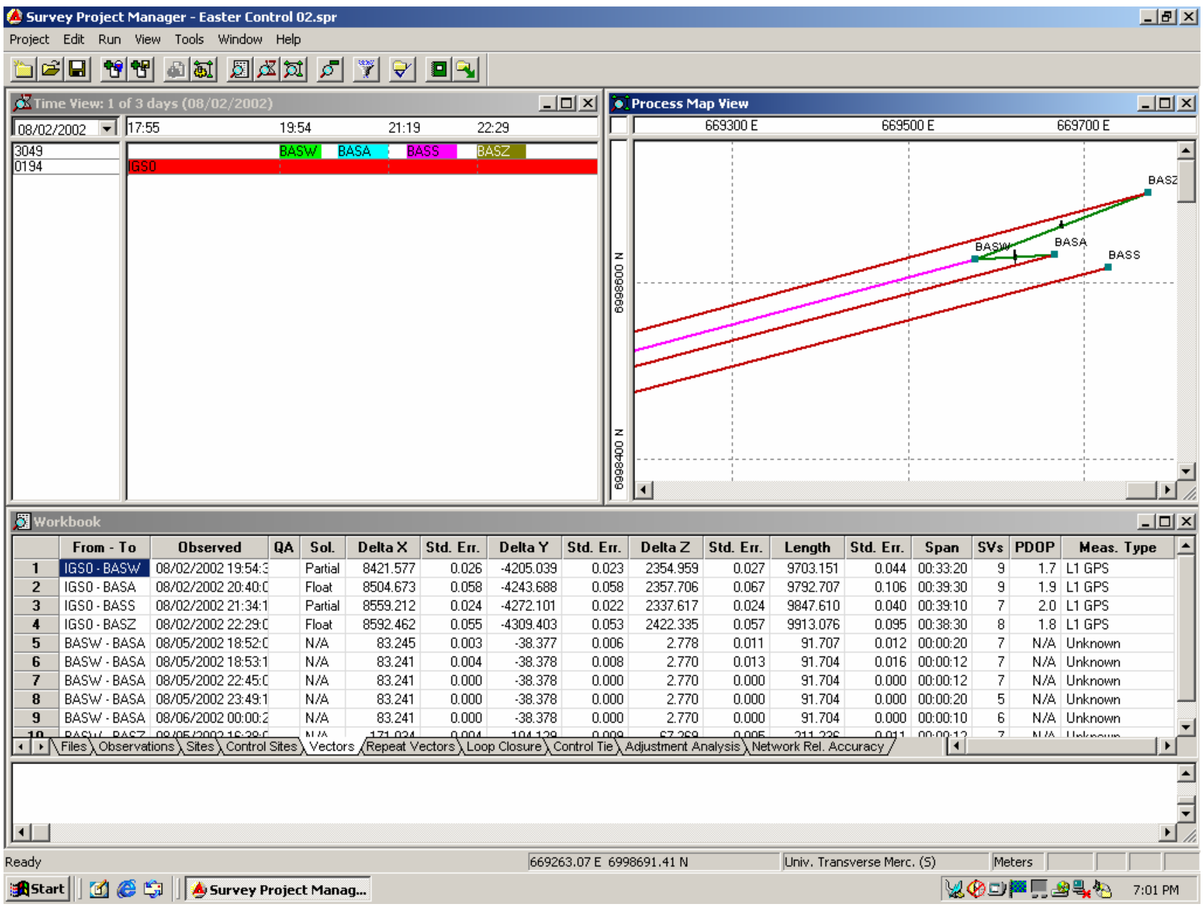

Figure 5 : Thales Ashtec Solutions - Survey Project Manager - Vector data display

Although the software is easy to use it is quite comprehensive and satellite observation data can be graphically displayed and rogue observations can be deleted in order to improve the results.

CADD Processing

GPS points were imported to a Microstation design file and it remained to "join the dots" and add some annotation to complete the mapping. Most of this was completed after returning to California. It is planned to integrate Cristian Arevalo's field drawings with the design file by using Photoshop to rubber-sheet the drawing outlines to the GPS points.

THALES PROMARK 2 MAPPING - SUMMER 2003

Promark 2 vs Locus

The Promark 2 represents a significant advance in single-frequency receiver design. It has several major improvements over the Locus - not the least being price! It is quite small and light and therefore very easy to transport. It's major improvement is in the in-built screen which allows the user to communicate more efficiently with the rover. One can also display a keyboard for the input of point ID and point descriptions. A list of control points is available when lock is lost. Also, the PDOP and other DOP values can be read. All in all the Promark 2, in Stop/Go mode, represents a low-cost, high-speed data collection device which appears to be extremely efficient and user-friendly.

Fieldwork

The quarry mapping continued in the summer of 2003 and a new area named Area D was mapped. This area was significantly larger than the 2002 Area C, and was more complicated in that it involved some very steep quarry sites and rock formations difficult to traverse. Only three of the control points set in 2002 were recovered and the missing points had been removed. Even with ties, the missing points could not be recovered. A new set of control points was established using the 3 recovered points as base stations. The Promark 2 proved to be extremely reliable and except for a brief session on one day, operated flawlessly throughout the weeks of mapping. The PDOP wastoo high for one hour before fieldwork commenced each day so there were very few interruptions due to poor geometry.

Figure 6: Peter Boniface and Cristian Arevalo working with the Promark 2 on Area D

Figure 7: The Promark 2 receiver

CADD Mapping - Satellite Imagery

The compilation of the final map continues and filed checking is planned in the future. A field check for 2002 Area C was performed later that year. Due to the remoteness of Easter Island it is not possible to use photogrammetry for the contouring. The Rano Raraku crater was covered by the Digital Globe 0.6 m pixel imagery and a virtually cloud-free image was available. Digital Globe kindly donated a license for the image to the EISP. The image is too large to display in this paper however future imagery might be used to contour the slopes of Rano Raraku.

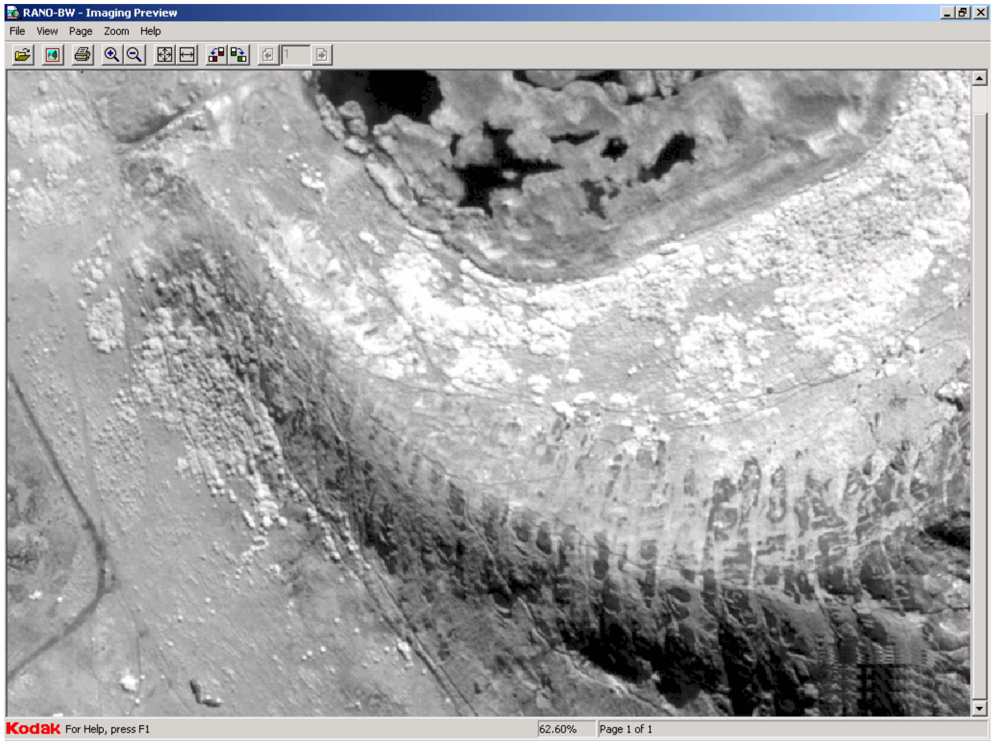

Figure 8 : Digital Globe 0.6m imagery of Rano Raraku crater - Statues are visible as small black dots

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