

Stereo-Photogrammetric Documentation of the Adivino Pyramid at Uxmal, Yucatan

March 12-24, 1999

by

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Adivino Pyramid, Uxmal, Yucatan. Pic: Roberto Centeno Lara. 1999.

Background

The Adivino Pyramid is located at the Maya archaeological site of Uxmal in Yucatan, Mexico, and is about 60 meters at base and 30 meters high with stairways on the west and east sides leading to two temples built on the top. At the request of the Mexican government UNESCO has registered the site of Uxmal as a World Heritage Site, and the pyramid is considered by both historians of architecture and archaeologists as a world class monument, and one of the finest examples of Maya architecture.

Through the 1960s the pyramid was regularly repaired and maintained, and in the early 1970s a major conservation project was undertaken by National Institute of Anthropology and History (INAH) archaeologists to consolidate the sides and flat terraces, and to improve the structural integrity of the temples.

Periodic inspections of the pyramid after consolidation noted no structural problems, but late in 1988 Hurricane

Gilbert swept across the Yucatan Peninsula with very high winds, and great rain fall which caused extensive damage to crops and forests, and to both modern and ancient architecture. A short time after the hurricane archaeologists noted that cracks had developed in the walls of the south side, on both sides of the west stairway, and that the stairway itself showed signs of instability. The vertical walls at the base of the pyramid on the west side were noted to be out of plumb in the direction of the plaza, and downward movement of the pyramid interior and facing stones on the south side of the stairway caused the lintel of the doorway on the south side of the stairway to shear the top of the stone door jamb.



Adivino Pyramid south facade. Cracks are filled with light colored concrete. Exploration hole was dug by archaeologists to research structural instability, and develop a strategy to prevent further damage. Pic:Roberto Centeno Lara. 1999.

Archaeologists and conservators with INAH immediately began the process of developing a strategy for conservation and stabilization. The first step was to strengthen the west façade, monitor any structural changes, and institute emergency measures where needed. The void under the base of the stairway was filled with stonework mortared with concrete, and plaster movement monitors were placed at critical locations.

Early in 1989, the director of Centro INAH Yucatan, archaeologist Ruben Maldonado, requested that a stereo photogrammetric record be made of the west façade of the pyramid. The west façade was documented at ground level using a calibrated photogrammetric camera, and surveyed with a transit (Desmond 1991 and 1994).

A second photogrammetric survey of the west façade was made in 1990 using a total station theodolite, the entire west façade was photographed from ground level, and a hydrogen balloon was used to lift a camera high enough to photograph the temples on the upper part of the pyramid, (Desmond 1991 and 1994).

The photogrammetric record of the pyramid generated by these two projects would have provided useful scaled drawings and measurable photographs for rebuilding should the west façade have collapsed. But, the scale of drawings that can be produced from these data is not sufficient for engineering analysis.

The immediate measures taken to stabilize the pyramid had prevented a catastrophic collapse, but late in 1997 archaeologists noted additional small cracks had developed in the walls of the pyramid.

Adivino Pyramid Conservation Project planning

Early in 1998, the Autonomous University of Yucatan (UADY) Adivino Pyramid Conservation Project was initiated, and placed under the direction of Engineer Roberto Centeno Lara. The project collaborates with the INAH Uxmal Project coordinator, Jose Huchim Herrera, and the University Center for Preservation of the Cultural Heritage of Yucatan (CUPPCY) at UADY directed by anthropologist James M. Callaghan.

As a first step in an engineering analysis of the pyramid it was decided to carry out a large-scale stereo photogrammetric documentation of the entire structure. In addition to the field documentation project, a seminar on the use of close-range photogrammetry for heritage preservation was planned. The field project and seminar were scheduled for March 12 to 24, 1999.

Lawrence Desmond, Senior Research Fellow with the Mesoamerican Archive and Research Project at Princeton University, was asked to coordinate the photogrammetric documentation of the pyramid, by enlisting the assistance of qualified photogrammetry personnel, and to collaborate in the organization of the seminar. While there are highly trained photogrammetrists in Mexico who work on cartographic projects, there were none who were trained in the very specialized technique of close-range architectural photogrammetry.

Photogrammetric consultants

Photogrammetrists Paul Bryan and Michael Clowes from England were contacted to carry out the photogrammetric recording because of their international reputation as professional photogrammetrists and surveyors, and their dedication to architectural photogrammetry. They agreed to take time out from their work with English Heritage's

Survey Team to volunteer during their vacation to carry out the documentation of the pyramid, and to teach a portion of the classroom and field seminar on photogrammetry for heritage preservation that had been organized by UADY.

Seminar on photogrammetry for heritage preservation

Before the fieldwork began, a seminar on the use of photogrammetry for architectural documentation and heritage preservation was held at the Department of Engineering at UADY in Merida. The purpose of the seminar was to provide archaeologists, architects, and architectural conservators with a basic knowledge of close-range photogrammetry, and how it is applied to preservation of the cultural heritage.



Seminar on close range photogrammetry at the School of Engineering of the University of Yucatan. Archaeologist James Callaghan, CUPPCY Director, leading a discussion about University Center for Preservation of the Cultural Heritage of Yucatan (CUPPCY). The Center was one of the co-organizers of the photogrammetric study of the Adivino Pyramid, and is working with Mexico's National Institute of Anthropology and History to plan additional photogrammetric documentation projects. Note Rollei 6006 camera and stereo viewing glasses on the table in the foreground. Pic: Paul Bryan. 1999.

The seminar was led by Paul Bryan and Mick Clowes who discussed the use of photogrammetry as a part of the conservation process, and field and laboratory procedures. An additional presentation was made by Lawrence Desmond who provided a historical perspective on the use of photogrammetry for heritage preservation, including previous photogrammetric studies of the Adivino Pyramid; by James Callaghan who reported on CUPPCY and its preservation projects; and by archaeologist Tomas Gallareta who presented an overview of the archaeology of the Puuc region within the context of current conservation projects and future plans.

The seminar was continued during fieldwork where theoretical training was integrated with the actual process of photogrammetric recording of the pyramid. In this way participants gained a first hand experience in the taking of 3-D photographs, the placement of control targets on the pyramid, and in survey methods using a total station.

Equipment

A Nikon total station Model DTM 310 accurate to 5 seconds of arc was made available by engineer Francisco Mendoza d'Argence, a professional land surveyor in Merida, and it was used to survey control targets on the pyramid. Mendoza worked closely with Bryan and Clowes to learn the technique of surveying control targets, placement of



Nikon total station used for acquiring the 3-D coordinates of survey control targets on the pyramid.
Engineer Francisco Mendoza d'Argence surveying. Pic: Roberto Centeno Lara. 1999.



Mick Clowes photographing with the Rolleiflex 6006 calibrated photogrammetric camera in the Plaza
of the Birds (west plaza of the Adivino Pyramid). Left to right: Lawrence Desmond, Paul
Bryan, and Mick Clowes. (Date stamp is incorrect) Pic: Roberto Centeno Lara. 1999.



West facade of Adivino Pyramid at Uxmal. Scaffolding with Paul Bryan and Mick Clowes making 3-D stereo photographs for close-range photogrammetry documentation. Pic: Roberto Centeno Lara. 1999.



Hydraulic lift with Paul Bryan and Mick Clowes taking photos of the southeast corner of the Adivino Pyramid. Pic: Roberto Centeno Lara. 1999.



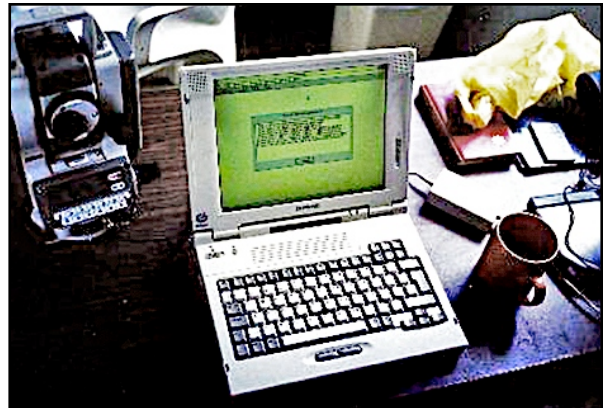
Photos of the west facade were taken in stereo 3-D by moving the camera in the horizontal plane along the scaffold. Photos are being taken from the first platform 7 meters above the ground with a Rolleiflex 6006 camera by Mick Clowes and Paul Bryan. Pic: Roberto Centeno Lara. 1999.



Archaeologist Pepe Huchim, chief of archaeology at Uxmal, directs the attachment of survey control targets on the pyramid. Pic: Roberto Centeno Lara. 1999.



Paul Bryan and Mick Clowes downloading survey data from the total station surveying instrument to a laptop computer in the archaeology laboratory at Uxmal. Pic: L. G. Desmond. 1999.



Laptop computer and total station surveying instrument linked for download. Survey data of control targets used to determine 3-D coordinates for measurements of photographs of the pyramid was downloaded daily to the laptop computer. The data was then analyzed for accuracy, and the detection of surveying blunders. Pic: L. G. Desmond. 1999.



Chenes Temple, west facade, Adivino Pyramid, Uxmal, orthophoto. This image was made using the Leica Helava all digital 3-D photogrammetric system. The two images used to make this measurable photograph were corrected in 3 dimensions by the Helava system so that scaled drawings can be made. On close inspection of the image black-and-white survey control targets can be seen, and the cross on the doorway lintel is one of fifteen used to control for film expansion or contraction. Photo was taken by Paul Bryan using a Rollei 6006 medium format calibrated photogrammetric camera. ((C) Copyright 1999 Paul Bryan & Roberto Centeno L.)

secondary survey monuments, and the setting of a primary survey grid around the pyramid.

A Rollei 6006 (6x6 cm format) calibrated photogrammetric camera with a 50 mm, F4 lens was used for all photography. The films used were color Kodak Professional Ektachrome E100SW, ASA 100, and black-and-white Kodak Verichrome Pan (VP), ASA 125.

Photogrammetry fieldwork

Because the west façade was inaccessible to a hydraulic lift, a scaffold 14 meters in height was built in front of the west facade of the pyramid in order that vertical and horizontal overlapping stereo 3-D photos of the façade could be taken. The scaffold

had two photo platforms: the first platform was approximately 7 meters above ground, and the second 14 meters.

For the north, south and east sides, a rented hydraulic lift mounted on a truck was used to lift the camera, a tripod, and a crew of two to carry out photography. As no lift controls were provided in the bucket itself, directions from the crew members to the equipment operator were made by radio so that the lift bucket could be placed exactly where needed for stereo photography.

After control targets were affixed to all sides of the pyramid using a removable clear silicon based adhesive, their 3-D locations were determined using the total station, and the photographic documentation was then carried out. 245 targets were surveyed, and 700 3-D stereo photographs were taken in both black-and-white and color transparency film. The survey data was downloaded to a laptop computer daily for immediate analysis of accuracy and detection of possible surveying blunders prior to post processing using the 'Landscape' software package.

Current status of the project and future plans

After processing, the original negatives and transparencies were scanned onto Kodak's Photo-CD Rom to enable their potential use by all digital photogrammetric systems, such as the Leica Helava. All of the original photographic negatives, prints and transparencies are now stored at the UADY photographic archive in Merida.

As a first step in analysis, the façade of the Chenes Temple on the west facade of the pyramid was processed to create a measurable orthophotograph. Engineers and archaeologist with UADY and INAH are currently working with this and other analytical images and drawings. However, with the total coverage provided by this survey, CAD drawings of any part of the pyramid can be generated by photogrammetric lab equipment as and when required.

The engineering department of UADY is currently working to secure funding to purchase digital photogrammetric laboratory equipment in order to have an analytical photogrammetric capability for heritage preservation at UADY in Merida. This will be the first close-range photogrammetric laboratory in Mesoamerica to work directly in support of the conservation of historic and pre-Columbian monuments.

Project Team Photos



Adivino Pyramid Photogrammetry Project scaffold construction team. Pic: Roberto Centeno L. 1999



Archaeologist Pepe Huchim (next to yellow box), Engineer Francisco Duarte, and Engineer Leopoldo Espinosa. Pic: Roberto Centeno Lara. 1999.



Mick Clowes (photogrammetrist), James Callaghan (archaeologist and director of CUPPCY), Kevin Havener (video), Paul Bryan (photogrammetrist), Francisco Mendoza d'Argence (surveyor), Pepe Huchim (chief of archaeology at Uxmal), Lawrence Desmond (archaeologist and photogrammetry project coordinator). Roberto Centeno Lara, professor of engineering and director of the Adivino Documentation Project is not in the photo-- he took it! 1999.

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Project Personnel

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Note:

A 35 minute educational video about the photogrammetric documentation of the pyramid was made by videographer Kevin Havener. For information about the video email Kevin Havener at Khave01-at-Hotmail.com.