# **REVRITING THE HISTORY OF THE KHMER EMPIRE**

Exploring for Ancient Temples in the Jungles of Cambodia

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Exploring for Ancient Temples in the Jungles of Cambodia SUBMITTED BY MCELHANNEY CONSULTING SERVICES LTD.

## INTRODUCTION

In April 2012, McElhanney completed an extensive LiDAR and digital aerial photography acquisition and dataprocessing project in the provinces of Siem Reap and Preah Vihear, Cambodia (see map). Additionally, McElhanney played a pivotal role in inspiring, conceiving, and scoping the project. The resulting data has provided unprecedented insight into the former Khmer Empire, the major power in Southeast Asia between the 9th and 15th centuries. The spectacular remains of the Khmer's ancient capitals and hundreds of



temples are centered in Angkor, which was designated a UNESCO World Heritage Site in 1992. Angkor Wat, the largest and most famous temple, is depicted on the Cambodian flag. Angkor is now a major international destination, visited by 2 million tourists each year. Believed to have been the largest pre-industrial urban complex in the world, Angkor was estimated to have supported a population of 1 million at its peak. This estimate is now being revised upward due to McElhanney's work.





Many of Angkor's temples are surrounded by heavy forest, and much of the exploration and research undertaken over the past 150 years has been carried out by ground survey. More recently, aerial photography and radar surveys added to the information available. However, the dense forest cover, decades of civil unrest, and the resulting presence of landmines and unexploded ordnance have combined to severely limit the ability of archaeologists to fully explore the true extent of the Khmer Empire's urban and agricultural development.

Unlike other mapping techniques, airborne LiDAR technology uses time-lapse measurement of light pulse emissions reflected by the ground to create accurate elevation mapping. McElhanney has pioneered the use of LiDAR since its inception in the 1980s, but only in recent years has this technology has become sufficiently sophisticated to generate millions of ground elevation points per square kilometer, even through heavy vegetation.



McElhanney has been involved in projects in Cambodia since 2002 and recently became aware of the lack of reliable mapping information available to archaeological teams working in and around Angkor. At the same time, McElhanney became inspired by the experimental use of LiDAR for archaeological research at the Stonehenge World Heritage Site in England and the ancient Maya city of Caracol, Belize.

McElhanney sought out Dr. Damian Evans, Director of the Robert Christie Research Centre, Deputy Director of the Greater Angkor Project, and a true modern-day Indiana Jones. A meeting was organized in Siem Reap to present McElhanney's proposal to the archaeological team for a LiDAR mapping project. Initially, Dr. Evans and his team were dubious of the prospects for success due to the differing landscapes of Angkor and Caracol. Whereas Caracol lies beneath undisturbed forest, much of Siem Reap comprises secondary forests, agricultural land, and urban developments. Also, with the exception of the temples, Khmer construction consisted only of earthworks and perishable wood. However, McElhanney was able to persuade Dr. Evans that the precision of modern LiDAR would enable the remains of roadways, canals, reservoirs, and similar features to be identified, should they still exist, even after almost 1,000 years of degradation.

With McElhanney playing a central coordinating role, eight archaeological research organizations from around the world formed the Khmer Archaeology LiDAR Consortium, headed by Dr. Evans, to raise the necessary funds for the project and share the resulting data.



#### COMPLEXITY

Traces of Angkor's civilization usually consist of subtle ground undulations, in linear and rectilinear patterns, invisible from the ground and aerial photography, and obscured by dense vegetation or centuries of agricultural activity. To address this, McElhanney designed a gridded flight plan, carefully customized to the site, to produce an unusually high density and accuracy of ground elevations. This required careful terrain reconnaissance (often on foot or by motorbike) and detailed consultation with the archaeologists to precisely understand their expectations.







The logistics of working in Cambodia are a significant challenge. After decades of genocide, civil war, and border conflicts, many resources and services taken for granted elsewhere are simply not available. Many of the archaeological sites are in remote areas, difficult to access by road. Furthermore, northwestern Cambodia is obscured by cloud in the rainy season and smoke from rice stubble burning in the dry season, limiting flying opportunities.

Normally, airborne LiDAR data collection is carried out by mounting the scanner over an opening in the floor of a small plane. However, the point density requirements and weather dictated using a helicopter to achieve optimal flying speed and elevation. To facilitate this, McElhanney designed a custom pod to house the LiDAR system, mounted on the port skid

of the only suitable helicopter available locally, a Eurocopter AS350B3+.

To further complicate matters, special permits were required to import the pod and to enter the nofly zone over Angkor. McElhanney was able to overcome these challenges thanks to their prior experience in Cambodia.





DURING THE ACQUISITION, PREVIEW IMAGES WERE GENERATED TO CHECK FOR COVERAGE AND PRELIMINARY QUALITY



## SOCIAL AND ECONOMIC BENEFITS

LiDAR technology enabled a volume of data to be collected that would have been unimaginable using manual ground-based methods, and would have endangered the lives of surveyors due to the high density of landmines still existing in this area. For example, Beng Mealea was largely unexplored due to the presence of landmines. Originally thought to consist of only a temple and sporadic settlements, it has now been revealed as a beautifully planned city.





The data collected will take many years to analyze and to fully appreciate its impact on the scientific understanding of the history of the Khmer Empire. However, the data has already revealed the existence of seven previously unknown temple sites, as well as evidence of inhabitation and agriculture extending far beyond previous estimates. In the short term, the new discoveries will undoubtedly attract additional tourism and scientific exploration, thus economically benefitting the people of Cambodia.

In the longer term, the new discoveries will aid in understanding the rise and fall of the Khmer Empire. It is known that the prosperity of the Khmers that led to their military, cultural, religious, and architectural achievements was derived from their ability to manage water, thereby sustaining multiple rice crops each year. The detailed three-dimensional ground model provided by McElhanney's LiDAR survey will improve modern society's understanding of how water was managed by the Khmers, and why their Empire declined. This in turn will add to the body of knowledge about the impacts of deforestation and agriculture on local climatic conditions.



LARGE RESERVOIRS WERE CRUCIAL TO THE KHMER EMPIRE'S ABILITY TO MANAGE ITS WATER RESOURCES



#### ENVIRONMENTAL IMPACT

The results of the data collection were even better than predicted, yielding billions of data points at an average density of 12-14 points per square meter, complemented by approximately 5,000



digital aerial photographs. LiDAR technology is also completely non-invasive. To achieve the same density of ground elevation points in forested areas using groundbased methods would have required the destruction of much of the forest. For example, in the words of the chief archaeologist, Dr. Evans, the mapping of "the forested enclosure of Ta Prohm revealed an entire ancient city beneath the forest, with a precisely laid out grid of streets, canals, ponds and occupation mounds, which no one had ever noticed in spite of 150 years of research and 2 million tourists per year."

As well as identifying areas requiring immediate protection, the new information has provided evidence of illegal activities such as excavation, looting, and logging, enabling the Cambodian authorities to take appropriate action to protect the country's heritage and environment.

The full impact of this project will likely be appreciated in the years to come. Having proven the effectiveness of LiDAR technology for this purpose, future projects will be able to collect even more extensive archaeological data without disturbing the environment. This success will also serve to demonstrate to the Cambodian authorities that mapping projects serving other purposes, such as highway, irrigation, forest management, and biomass mapping, can be carried out with no negative environmental impacts.



#### MEETING CLIENT'S NEEDS

Thanks to this project, the formation of the Khmer Archaeology LiDAR Consortium resulted in the collaboration of the following organizations:

- 1. Authority for the Protection and Management of Angkor and the Region of Siem Reap (APSARA) [Cambodia]
- 2. École Française d'Extrême Orient (EFEO), Siem Reap Centre [France]
- 3. University of Sydney (USYD), Robert Christie Research Centre [Australia]
- 4. Société Concessionnaire des Aéroports (SCA) [France and Cambodia]
- 5. Hungarian Indochina Company (HUNINCO) [Hungary]
- 6. Archaeology & Development Foundation (ADF), Phnom Kulen Program [France]
- 7. Japan-APSARA Safeguarding Angkor (JASA) [Japan]
- 8. World Monuments Fund (WMF) [USA].





Covering 270 square kilometers, this is the largest archeological mapping project ever undertaken. The archaeologists say that McElhanney has produced "a lifetime of data," enabling them to "rewrite the history of the Khmer Empire," and they consider their involvement as "career defining."

Not only did McElhanney introduce this new technology to the archaeological community in Cambodia, but it was also pivotal in inspiring, scoping, and budgeting the project, which was completed on time and within budget. Following completion of the field work, but prior to the realization of the true value of the data collected, Dr. Evans told McElhanney: "It's a great pleasure to work with people with such a degree of professionalism and commitment to getting things done right—and not only that, but also delivering well above and beyond what the job required."

The archaeological team is still analyzing and processing the data; the scientific papers that will announce their conclusions to the world are still being written.

