

Outcome of the 2012 LiDAR Remote Sensing Programme over Angkor, Phnom Kulen and Koh Ker

Philippe Delanghe

UNESCO Phnom Penh Office, Cambodia



Abstract

In mid-April 2012 full coverage was obtained over the three main acquisition blocks of Angkor, Phnom Kulen and Koh Ker.

The four months of planning culminated in various contractors from various countries converging in Siem Reap for seven days of flight operations in mid-April, with all work overseen by staff from the APSARA National Authority, the University of Sydney, and Civil Aviation authorities. The logistical support was provided by various teams.

Flight operations consisted of approximately 20 hours of total flying over the seven day period, with the LiDAR instrument mounted in a specially-designed pod attached to a helicopter, just a standard helicopter of the type usually used to carry out touristic flights over Angkor.

Special permission was granted by the APSARA Authority and the State Secretariat of Civil Aviation for a waiver of the usual flight restrictions over the Angkor Archaeological Park, and with the cooperation of air traffic control, all flight

patterns were controlled to guarantee minimal disturbance to regular aircraft movements at Siem Reap international Airport.

In addition to the air crew, several ground crews manned GPS base stations during flight operations, at various locations in Siem Reap and Preah Vihear provinces. Incidentally, networks of new, permanent survey-grade benchmarks were established as part of this process, including at sites like Koh Ker, where no accurate benchmarks previously existed.

Thanks to excellent cooperation among all international teams, private contractors and the various government agencies involved, not to mention an excellent run of clear weather and blue skies, flight operations finally came to an end on 22 April, and the LiDAR instrument and technical team was demobilised back overseas. The Canadian company responsible for the acquisition has been working on calibrating and post-processing the enormous amount of data collected during these flight operations.

Our three acquisition blocks were widely separated, and involved extensive ferrying of the helicopter to and from the different sites, as well as to and from Phnom Penh at the start and end of flight operations. While the helicopter was in transit between the blocks, the LiDAR instrument remained on, collecting data. Although our initial contract with the LiDAR provider was for 270 square kilometres of data, they have offered to process several additional blocks of data that were acquired incidentally. Notably, those additional blocks include the Roluos and Beng Mealea temple groups.

This brings our total coverage to approximately 300 square kilometres overall. Something like four billion individual laser measurements were taken during the course of the project, which is the first of its kind in Asia and the largest of its kind ever achieved anywhere in the world.

LiDAR 2012

Outcomes of the Program over Angkor, Phnom Kulen and Koh Ker

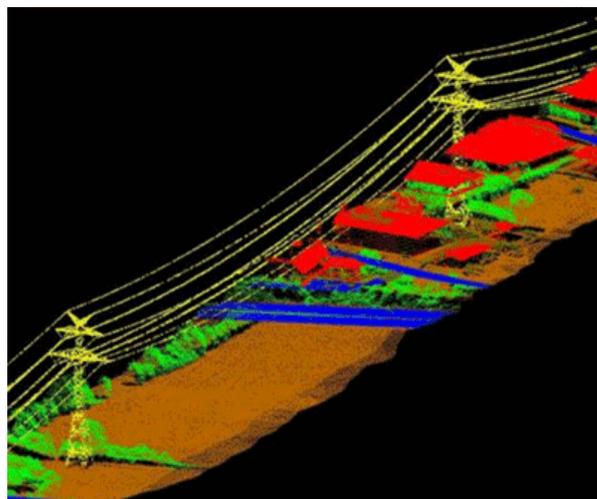
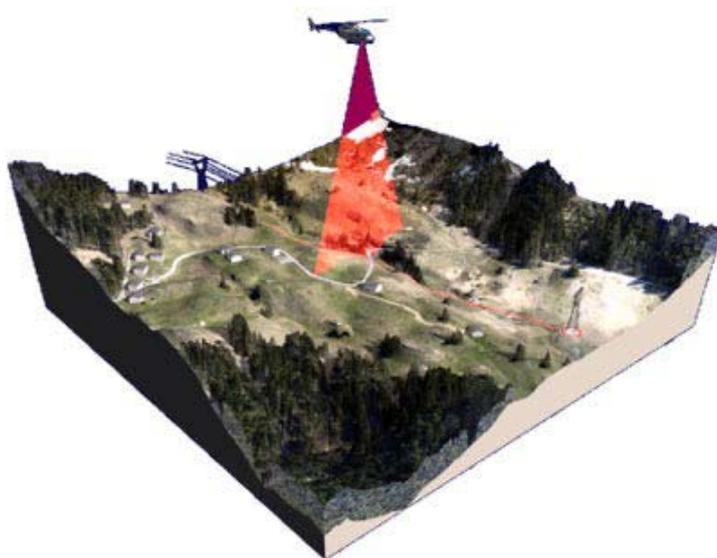


Dr. Damian Evans | Department of Archaeology
University of Sydney | damian.evans@sydney.edu.au

LiDAR 2012



High-Precision, Helicopter Mounted System





APSARA National Authority • JASA • EFEO
University of Sydney • HUNINCOR • ADF Kulen
World Monuments Fund • SCA/INRAP (Airport)

Khmer Archaeology LiDAR Consortium (KALC)

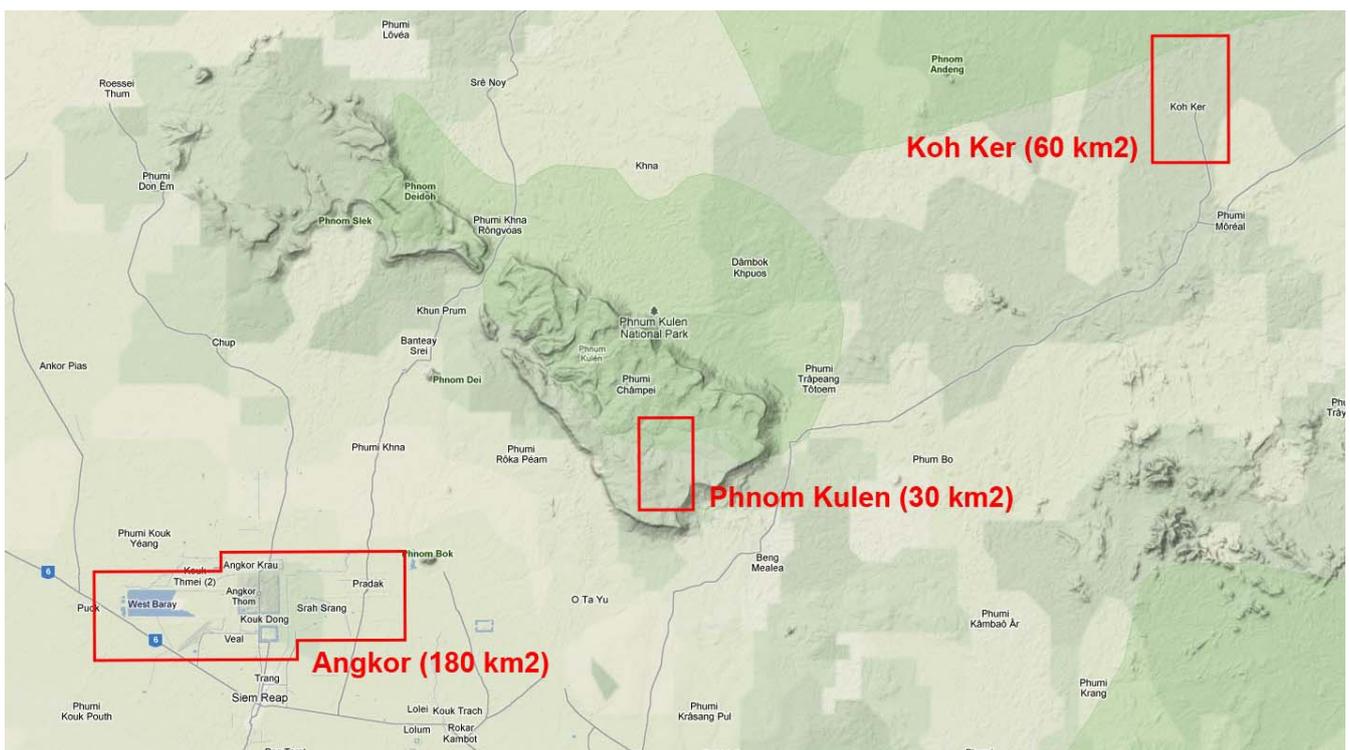




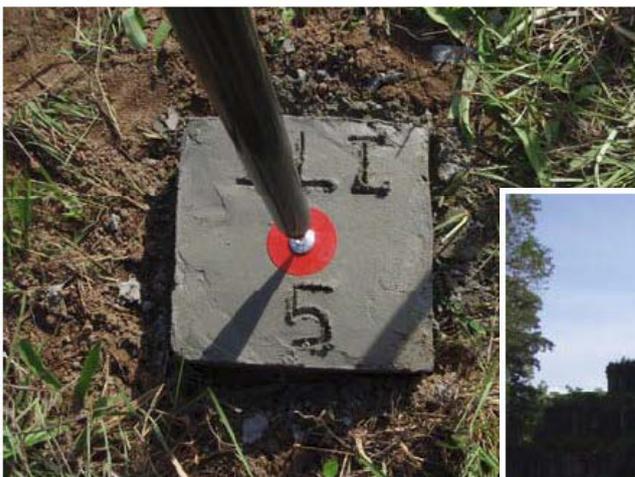
Photo: Im Sokrithy



Photo: Francisco Goncalves

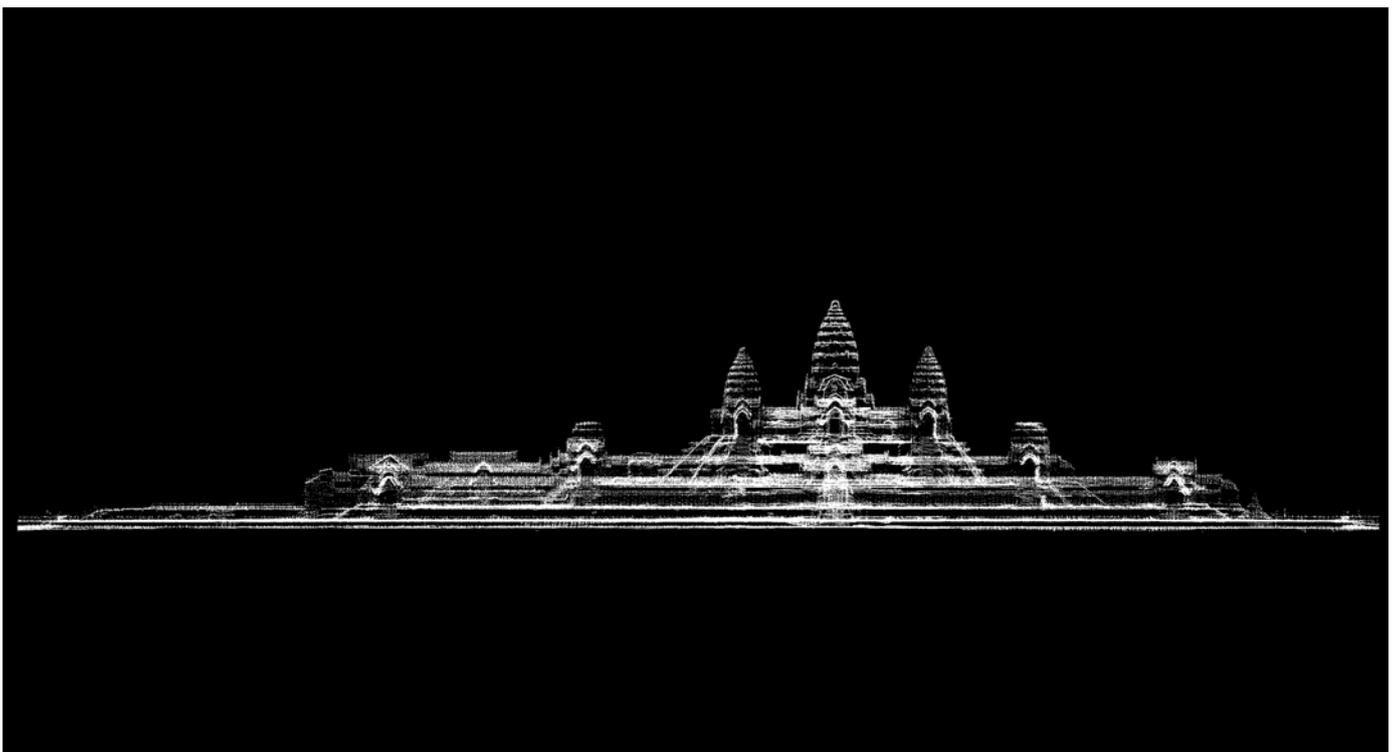


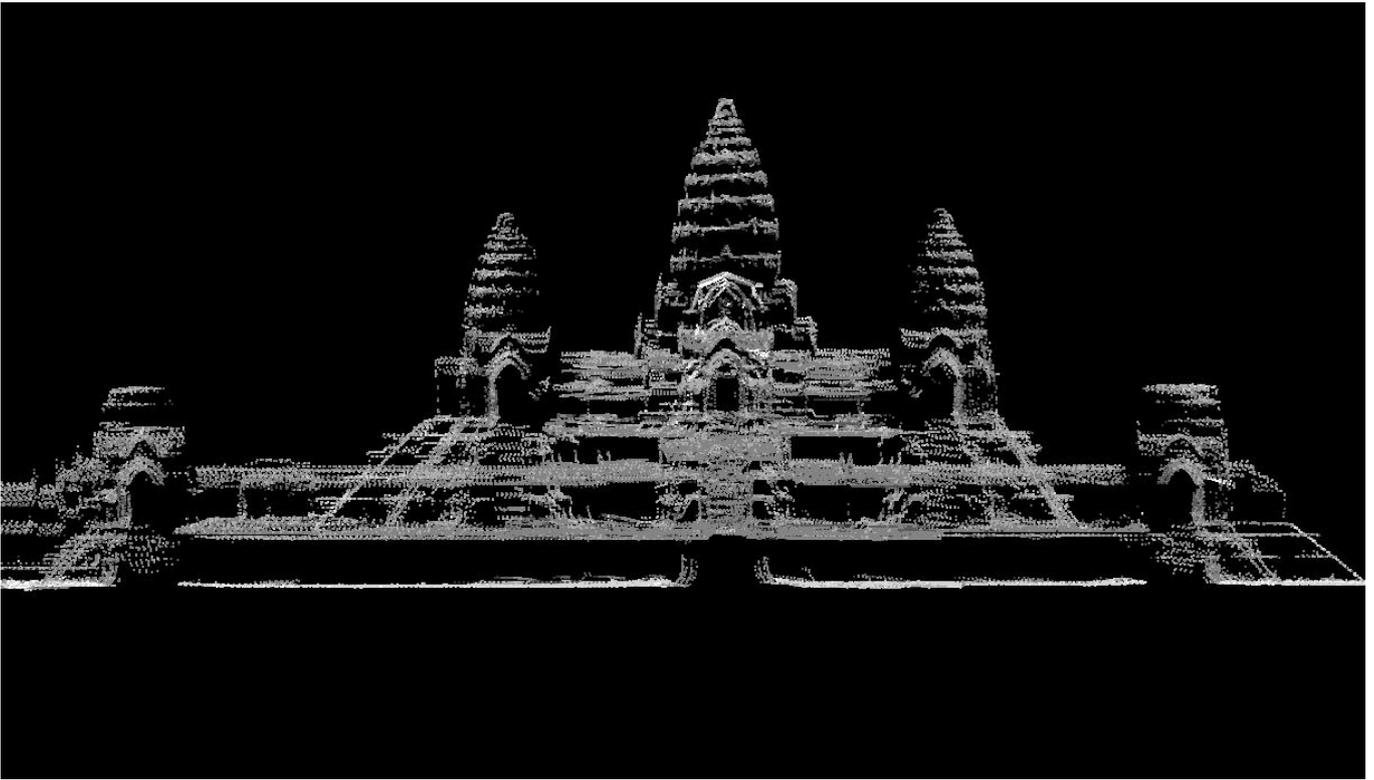
Photo: Francisco Goncalves



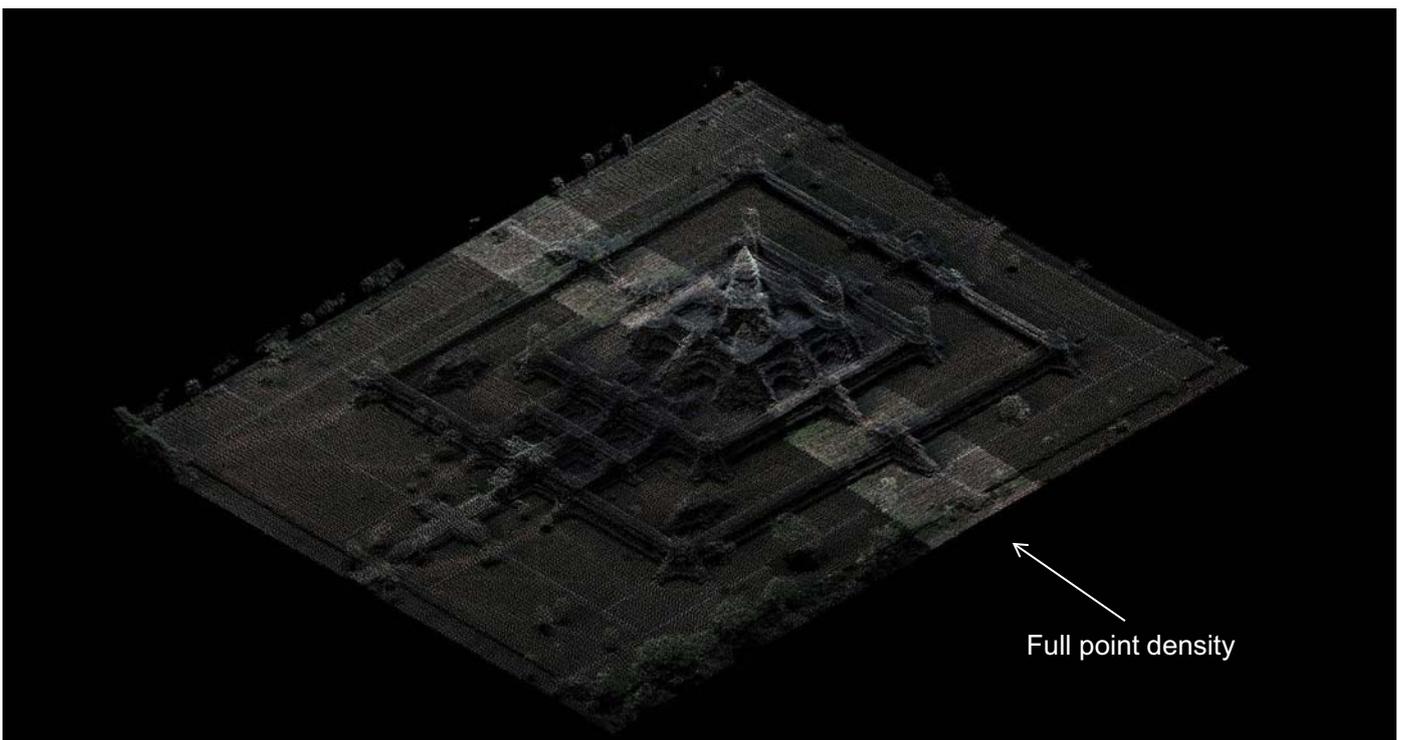
- Duration of flight operations: April 16 to 22
- Total coverage area: ~300 km²
- Total flight hours: 20
- Total flight length: 1165 linear km
- Average flight height: 800 m above ground
- Largest helicopter-based archaeological survey ever undertaken, anywhere.

9

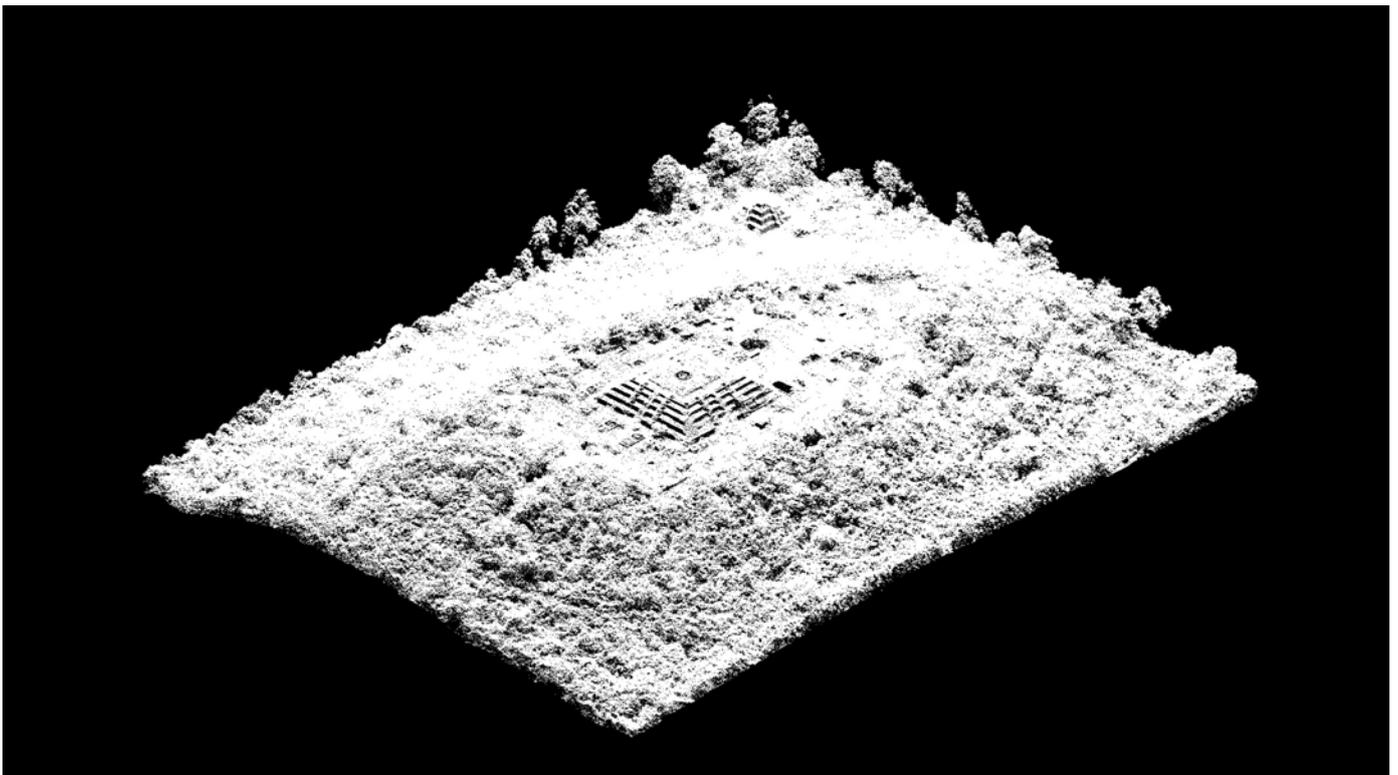




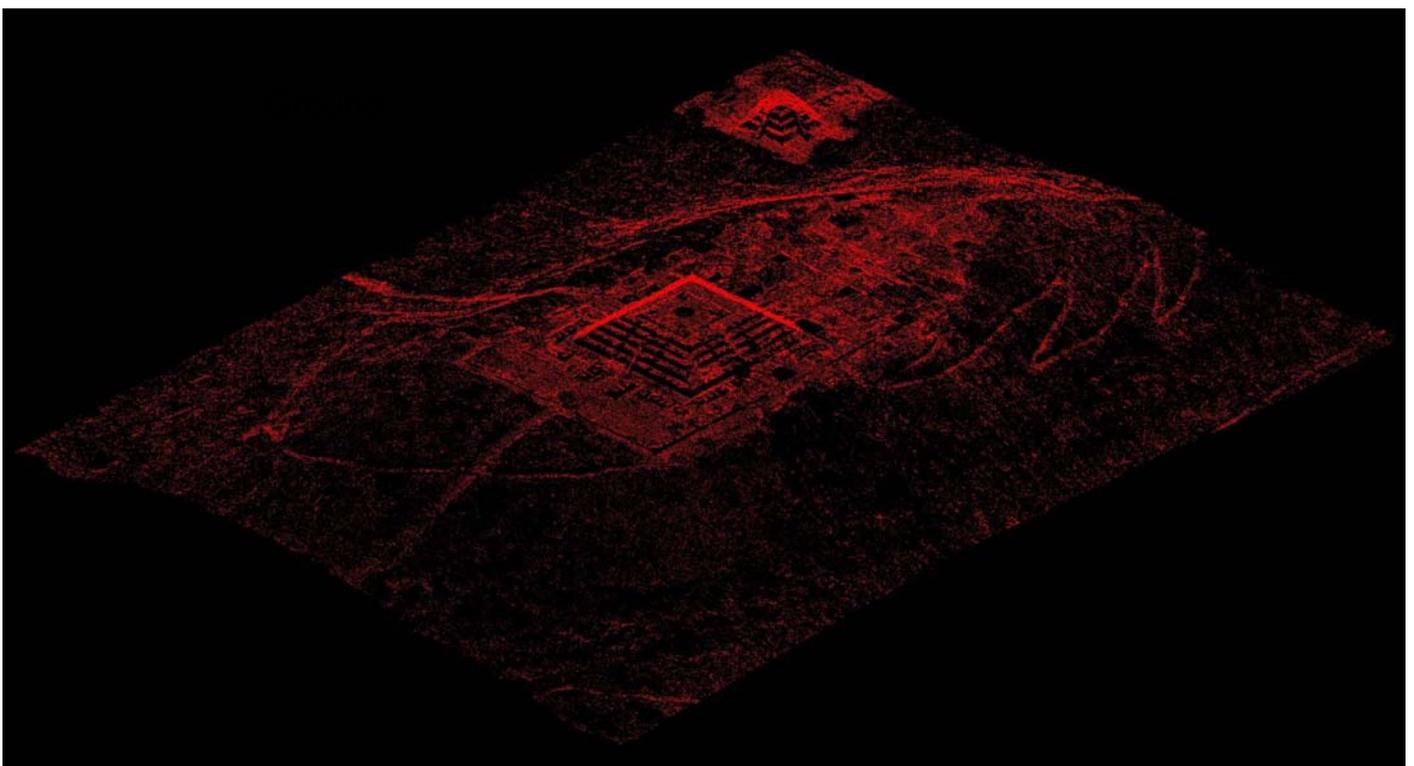
Angkor Wat



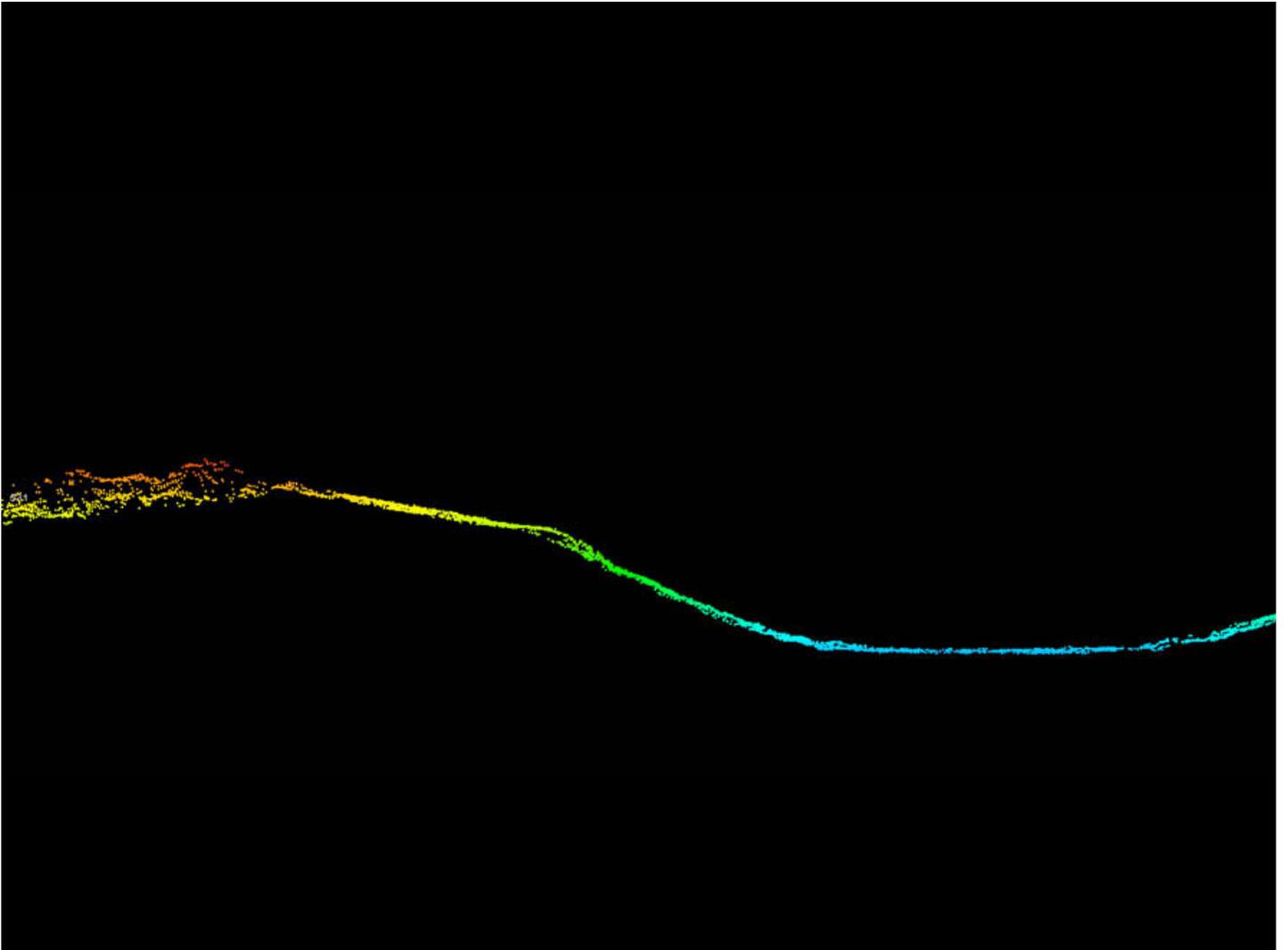
Angkor Wat



Phnom Bakheng



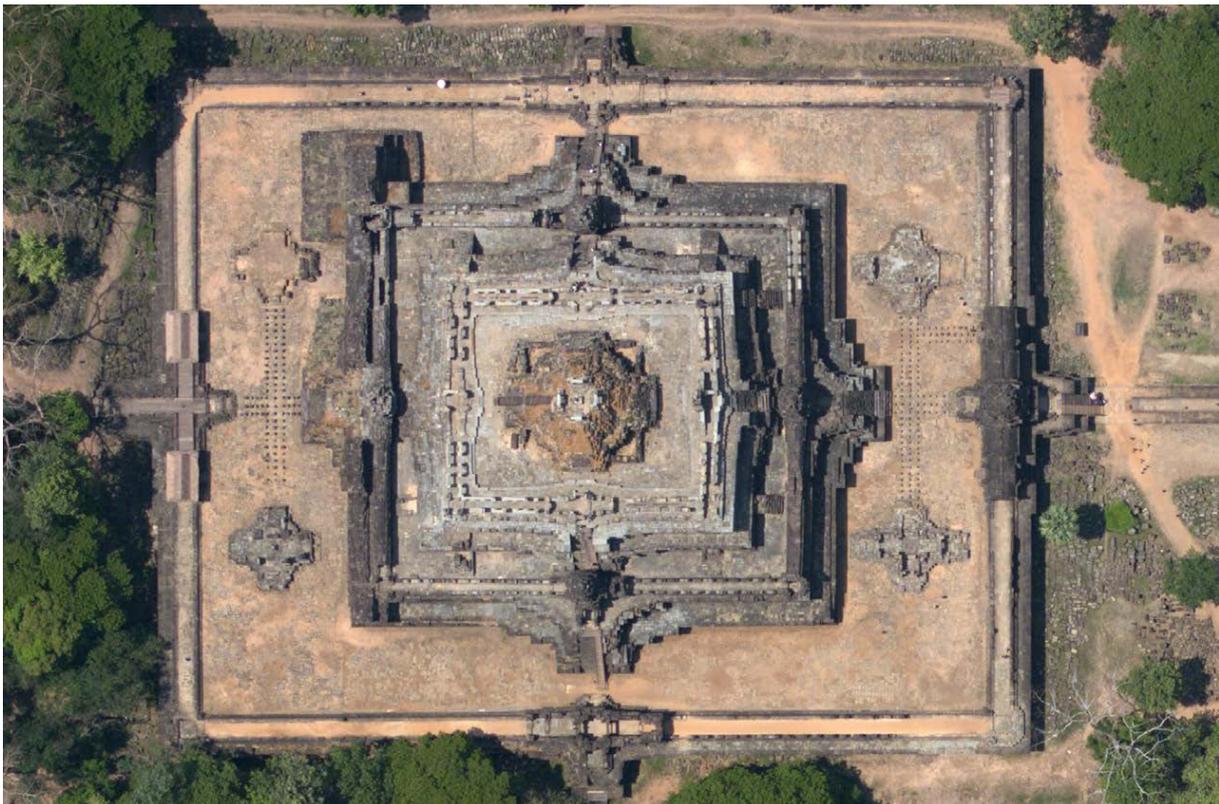
Phnom Bakheng



LiDAR 2012



Conventional Aerial Photography



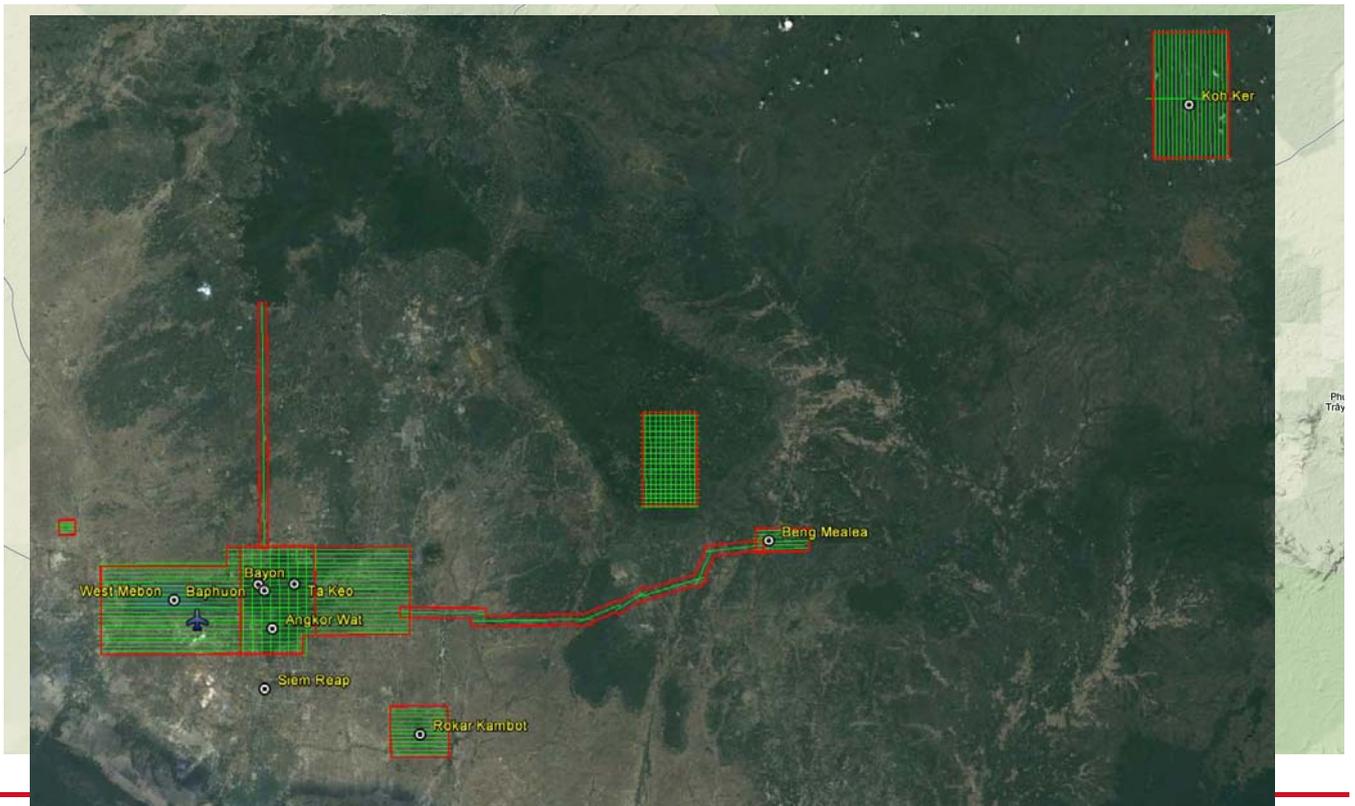


LiDAR 2012



Data Fusion: Aerial Photography and Point Clouds





- Total number of points: ~4 billion
- Average measurements per m²: 10-15
- Accuracy: >15 cm horizontal + vertical
- Number of air photos: ~5000
- Spatial resolution of air photos: ~10 cm
- Most extensive archaeological LiDAR survey ever achieved, anywhere.

**Royal Govt of Cambodia**

HE Dr Sok An
 HE Keat Chhon
 HE Dr Sok Siphana
 HE Mme Chau Sun Kérya

Société Concessionnaire d'Aéroport

Mr Emmanuel Menanteau
 Mr Bruno Desveaux
 Mr Feliciano Enriquez

Archaeology and Development Foundation

Dr Jean-Baptiste Chevance
 Mr Seu Pich
 Mr Sakada Sakhoeun
 Mr Stéphane De Greef

PT McElhanney

Mr Francisco Goncalves
 Mr Chris Cromarty
 Mr Oliver Swaffield
 Ms Glorie Siahaan
 Mr Imam Hartono

APSARA National Authority

HE Bun Narith
 HE Dr Tan Boun Suy
 HE Khuon Khun-Neay
 HE Soueng Kong
 HE Dr Hang Peou
 HE Ros Borath
 Mr Hok Pengse
 Mr Im Sokrithy
 Dr Ea Darith
 Mr An Sopheap
 Mr Kim Samnang
 Mme Hang Sawathya
 Mr Phin Samnang
 Mr Chea Socheat

Helistar Cambodia

Mr Hin Samnang
 Mr Chan Sopheap
 Mr Phil Butterworth

INRAP

Mr Pierre Bâty

State Secretariat of Civil Aviation

HE Mao Havanall

UNESCO

Ms Anne Lemaistre
 Mr Blaise Killian
 Mr Lim Bun Hok

EFEO

Prof Christophe Pottier
 Dr Dominique Soutif
 Prof Pascal Royère
 Mr Vann Sary
 Mr Chea Socheat

World Monuments Fund

Mr Glenn Boornazian
 Ms Konstanze von zur Muehlen
 Ms Lisa Ackerman
 Ms Bonnie Burnham
 Ms Cheam Phally
 Ms Ginevra Boatto

JASA

Prof Takeshi Nakagawa
 Dr Ichita Shimoda

HUNINCO

Dr Istvan Zelnik
 Mr Robert Kuszinger
 Ms Dóra Egyházi
 Ms Zsuzsanna Renner
 Mr Sam Sambath

ILI Consult

Mr Jerome Suszeck

National Geographic Society

Mr John Francis
 Mr John Bredar

University of Sydney

Prof Roland Fletcher
 Dr Damian Evans
 Ms So Malay
 Dr Martin King