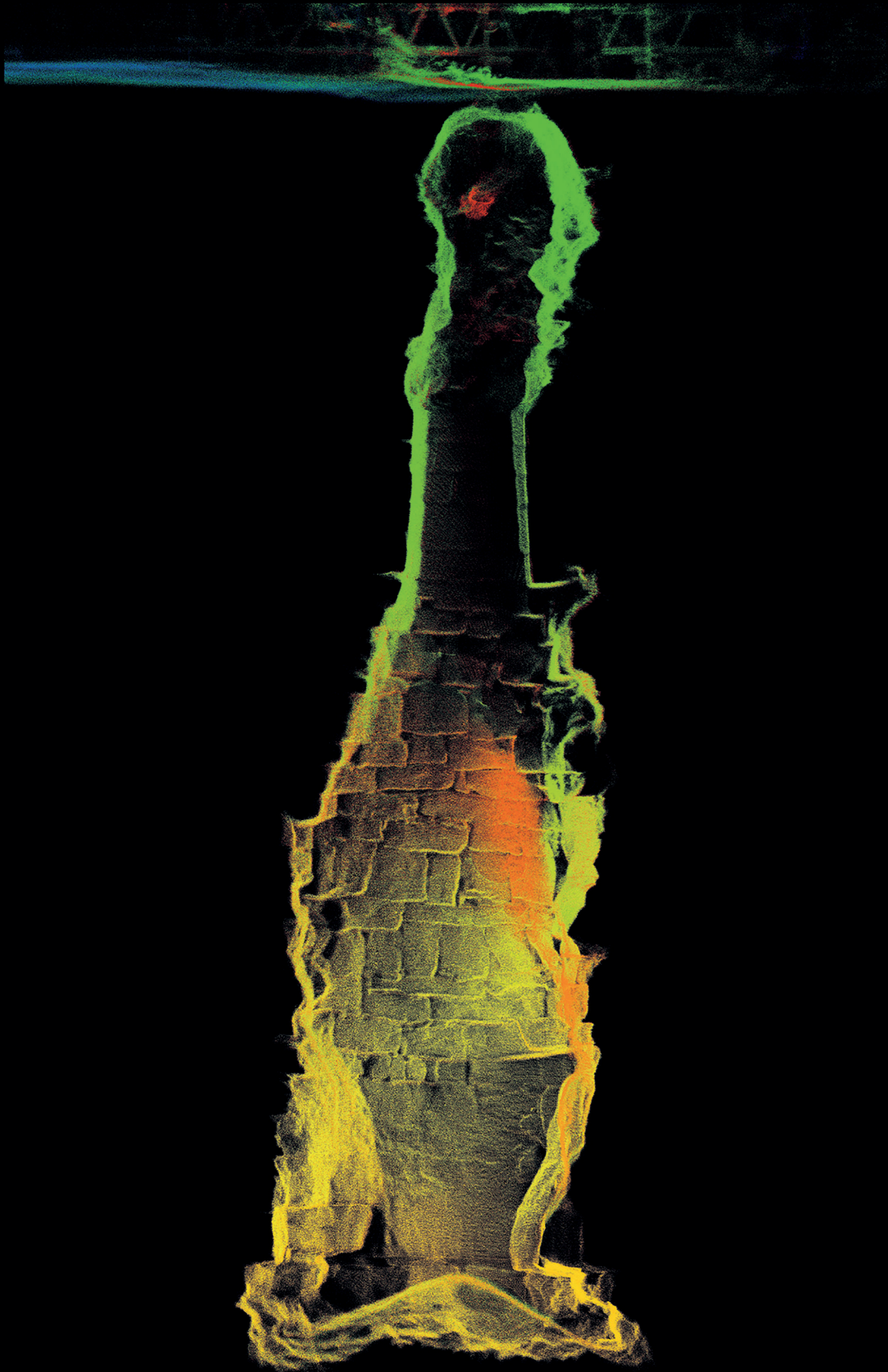


The Journal of the Chartered Institution of Civil Engineering Surveyors

# CIVIL ENGINEERING SURVEYOR



Thai Cave Rescue

mycareerpath

Sinkholes

UAS in Malaysia

December/January 2020

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Cover image: What lies beneath? Lucy Hamilton and Chris Shelley ask on pp32-33. ©Chris Shelley

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Chartered Institution of Civil Engineering Surveyors  
Dominion House, Sibson Road, Sale, Cheshire M33 7PP United Kingdom  
+44 (0)161 972 3100 [www.cices.org](http://www.cices.org)  
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Operations Director and Editor in Chief: Darrell Smart BEng  
[dsmart@cices.org](mailto:dsmart@cices.org) • @darrellsmart  
Managing Editor: Abigail M Tomkins BA(Hons)  
[atomkins@cices.org](mailto:atomkins@cices.org) • @amtomkins  
Media Sales Manager: Alan Lees  
[alees@cices.org](mailto:alees@cices.org) • @alan\_lees  
Administrator and Subscriptions Manager: Joanne Gray  
[jgray@cices.org](mailto:jgray@cices.org) • @joannegray74  
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# 3D modelling the Thai cave rescue

Abigail Tomkins with Sophie Elwin Harris, Director, Drain the Oceans: Thai Cave Rescue

## How laser scanning revealed the secrets behind the major search and rescue operation



The original dive line still in place from the rescue.

**I**T'S a story that you already know the ending to. From 23 June to 10 July 2018, 12 boys from a junior football team and their coach were trapped in a cave system over 2,000ft below Thailand's Doi Nang Non mountain range. You know the ending because for 18 days it dominated news channels throughout the world. From the video clips from the helmets of divers Richard Stanton and John Volanthen showing all 13 as they were discovered for the first time, still alive and in relative good health, to the moment of the final dive rescue, it was the impossible made possible by human strength, courage and ingenuity. It wasn't without its cost, Saman Kunan, a former Thai Navy SEAL who was there as a volunteer, died fixing oxygen tanks along the escape route.

That Saman Kunan was the only loss of life in this rescue is astonishing. At the time of the rescue of the 12 boys aged between 11 and 16, and their 25-year-old coach, the relief was such that no-one

watching from afar could work out quite how it happened. The Tham Luang cave system remained an underground mystery. How did the boys get so far? How did they get out? The international team of divers involved in the rescue relied on 2D maps drawn by other cavers which they followed from memory as they felt their way through the underwater darkness – they offered little in the way of explanations. A new programme from National Geographic due to air in the new year uses 3D visualisation to better understand the rescue. Director Sophie Elwin Harris and cave surveyor Roo Walters went into the Tham Luang system 10 months after the rescue to laser scan it for the first time.

### Laser scanning Tham Luang

Roo Walters and his team spent three weeks laser scanning 1.5 miles of the cave system, from Chamber 9 where the boys were finally found sheltering, through to the main rescue site in Chamber 3. A total



Roo Walters at one of the scan stations.



of 400 scans from a Riegl VZ-400 scanner captured 8.7bn points. While the scanning was taking place underground, above ground a DJI Phantom unmanned aerial system (UAS) was flown over the mountain range to create a 3D terrain model.

### Post processing

The cave scans were collated in RiSCAN Pro and stitched together into one model, while the errors, reflections and people were removed. The point clouds were then processed in Hexagon 3DReshaper, to create meshes at various levels of resolution and to colour the cave from the 7,000 high-resolution photographs taken at each station. Point cloud rendering was done with 422 South's software GDN, with further post processing for the visualisation involving Autodesk Maya, Global Mapper and AfterFX.

The terrain model was created using photogrammetry, and a mixture of DroneDeploy, reality capture, Adobe Photoshop and Commendium's own proprietary software.

### Results

The final model revealed answers to many of the questions that the rescue team had asked, including why the cave system flooded so quickly. When the boys entered the caves, they could not have known that the rainy season would start weeks earlier than anticipated. Over an inch of rain fell in just one hour, causing the dry channels within the cave to quickly fill with water. One area, Sam Yak, was discovered to be the meeting point of two underground rivers. When it is revealed in the model, you see very clearly why the boys had no chance of getting out themselves.

Another revelation is a small narrow corridor that branches off to a dead end from Chamber 9. This tiny tunnel was dug by the boys themselves using rocks they found in the cave in an attempt to dig themselves out. When the laser scan cave data is combined with the surface terrain model, you can see just how far below the surface the boys were, and how futile that attempt was. It is a heartbreaking thing to witness, but is testament to their own tenacity that they even tried.

### Retelling the rescue

With a full 3D model of the cave system, the sheer brilliance of the rescue comes to life. National Geographic features interviews with divers involved in the rescue. You hear first hand about the planning and rehearsals to get the boys out, the decision to sedate them and the implications that had on the diving team. One diver recalls carrying the boys underneath him like a shopping bag, feeling a small hand twitch and the

### Director Sophie Elwin Harris on the challenges of scanning and filming within the Tham Luang cave system

#### How did the cave survey come about?

I was working on the series *Drain the Oceans* for National Geographic – the whole premise of it is to use 3D scanning to virtually 'drain away' water from shipwrecks, underground cities, lakes and so on. We use the scans to create models and graphics for archaeologists and scientists to find out more about them. When the Thai cave rescue unfolded in the news, the executive producer, Crispin Sadler, said we should do an episode on it. Could we actually drain a cave virtually? We knew we'd need amazing scan data to do it. While I loved the idea, I didn't think we would ever get permission. I never let a challenge pass me, so I called some caving contacts and I was introduced to Roo Walters. He put together a cave scan proposal using LiDAR, and then it was down to the Thai authorities.



#### How did the Thai government react to your proposal?

We were planning all this in September 2018, when the caves were still flooded. We knew we'd have to wait until the dry season in February or March 2019 before we'd get a chance. Around Christmas last year, I made some headway with the Thai authorities thanks to Josh Morris, a caver who lived in Thailand. Josh had been involved with the rescue, he knew the right people to speak to and his local knowledge and translation skills proved crucial. The Thai authorities could see the benefit of having a 3D model of the caves. Prior to this they relied on 2D maps updated by local caver Vern Unsworth – who himself played a major part in the rescue. Those maps had been vital to the rescue mission, but the 3D model would really help tell a tale that will become a huge part of the country's history. Thai authorities have been very careful to leave some of the key elements of the rescue in place – almost like a museum – including the dive line that was used in the rescue.

#### Did you enter the caves yourself, or were you directing from the sidelines?

I went in myself. Rob Franklin, my cameraman, took me to the Mendips caving beforehand, so I could experience what it was like. It was a challenging and unpleasant experience. I was squeezing through cracks in rocks, there was water pouring down my face and I experienced claustrophobia. Luckily when I got to Thailand and told one of the cavers I'd been down that particular cave, he said not to worry as Tham Luang isn't as bad as that! He was right. Many stretches were just like fell walking underground, but there was one stretch where there was a 10m crawl. I got in and it was just hideous. How can you go in a hole that you can't see the end of? One of the cave surveyors told me to lie on my belly, recite my favourite nursery rhyme and start crawling! So that's what I did. I went through *Twinkle, Twinkle, Little Star* repeatedly until I got to the end. I'm glad I did it, because I could then reach the area in Chamber 9 where the boys had been rescued from.

#### What was your most memorable experience from the survey?

It was getting to the place where the boys had been waiting. We clambered up to this ledge, and there was all this stuff that had been left there – foil blankets, spoons, torches. They'd even carved little beds with pillows into the clay to make themselves more comfortable, and then we found the tunnel they'd started building themselves. To be in the spot where they'd sat there and waited and been so patient, so stoic, I found that really emotional. It was a shrine to survival.

realisation that he'd have to administer another shot of sedative whilst chest-deep in water in a pitch black cave. Another recalls losing hold of the guide rope and calmly stating that he knew he must not panic. He dived with the boy he was responsible for back to one of the chambers, where he had enough room to familiarise himself with the surroundings and find the rope to start again.

When you watch the programme, and relive those two-and-a-half weeks, even though you know the ending, you find yourself holding your breath. Roo Walters likens it to Apollo 13, another gargantuan effort of brainwork and resilience that saved people's lives. As Sophie Elwin Harris says: "Quite frankly, they were as isolated as those astronauts were in space, that's how difficult it was technically to get them back." But they did get them back. And now, there's a survey-grade 3D model that shows you how. And that, like the rescue itself, is utterly remarkable.

*Abigail Tomkins with Sophie Elwin Harris, Director, Drain the Oceans: Thai Cave Rescue*

With thanks to Roo Walters. *Drain the Oceans: Thai Cave Rescue* airs at 8pm on 6 January 2020 on National Geographic. It is dedicated to Lieutenant Commander Saman Kunan.