



AN EXPLOSIVE MODEL

WHAKAARI IS NEW ZEALAND'S MOST ACTIVE VOLCANO AND WAS A POPULAR TOURIST ATTRACTION BEFORE AN ERUPTION IN 2019. A 3D MODEL IS NOW THE ONLY WAY TO EXPLORE WHAKAARI. **RACHEL RAYNER AND BARBARA HORVATIC** EXPLAIN HOW IT WAS CREATED

Most UAV mapping projects have benefits beyond the finished orthomosaic – even if it is only getting out of the office for an afternoon. The model of the volcano of Whakaari that Wild Atlas and New Zealand Geographic created in early 2019 was intended to help the volcano's owner investigate the repair of an old mining track. But the completed model had benefits to the scientific community and to the New Zealand public as a whole. Some six months after the model was completed, a deadly eruption closed Whakaari to the public – possibly for good. The model is now the only way to explore Whakaari.

Whakaari is New Zealand's most active volcano. Some 50km of rough seas away from the mainland of New Zealand's North Island, the volcano can be approached by water or by helicopter. Whakaari has been uninhabited since the 1930s, when the last sulphur miners decamped. However, the privately-owned island was a popular tourist attraction, with the remains of the mining camp one of the island's attractions, along with the gannet colony and crater lake. That was until an eruption in 2019 claimed 21 lives.

"Whakaari's pretty indescribable – it's almost like you're on a different planet,"

says Arie Spyksma, the founder and flyer of surveying firm Wild Atlas. Wild Atlas' team landed on the volcano to collect virtual reality footage for New Zealand Geographic and perform a preliminary survey for the island's owners. "An old miner's track crosses part of the face of the volcano. The owners were interested in recreating the track for tourists and wanted to locate it on a model, so the engineers could get an understanding of the terrain."

Mapping an active volcano included all the challenges of any UAV survey and more. "The volcanic plume is pretty caustic," says Spyksma. "As we were being shown around the island, we were warned that three or four UAVs had flown into the crater and the smoke had just completely done them over – the plume is really acidic and has been known to 'eat' UAVs!"

Collecting the data

Mindful of the volcanic plume, the team launched their DJI Mavic 2 Pro. The UAV was chosen for its compact size, which can be easily packed in and out of remote areas. "The image quality is pretty exceptional for what it is," says Spyksma. The company's director of photography, Richard Robinson, flew a second UAV, a DJI Matrice carrying

a 360-VR camera, to capture the volcano for NZGeo's virtual reality experience.

The data was collected over the course of three days, all from a boat at sea, in 12 separate flights. The island itself, at approximately 350ha, was small enough that the capture could have been achieved in a single day. However, one portion of the island was constantly obscured by a volcanic plume, which resulted in the team having to move around the island to capture different sections as the plume changed direction with the wind.

"We had to map one area, wait half a day for the wind to change, and move round to the other side of the island," says Spyksma. "There was quite a lot of moving back and forward, just trying to capture every bit while it was visible and avoiding getting smoke on the UAV as much as possible." Imagery was captured with the camera tilt at -75° so that more detail of features such as the steep crater walls could be captured.

Data cleaning

Consequently, as the capture took place over multiple days, the lighting conditions were variable across the entire data set. At the end of each flight – and to ensure the model reconstruction was as sharp as possible – the captured imagery was manually checked for images that were blurry or obscured by low clouds or smoke. These were removed, with the high-quality images added to a separate folder containing all the high-quality shots captured across the three-day period.

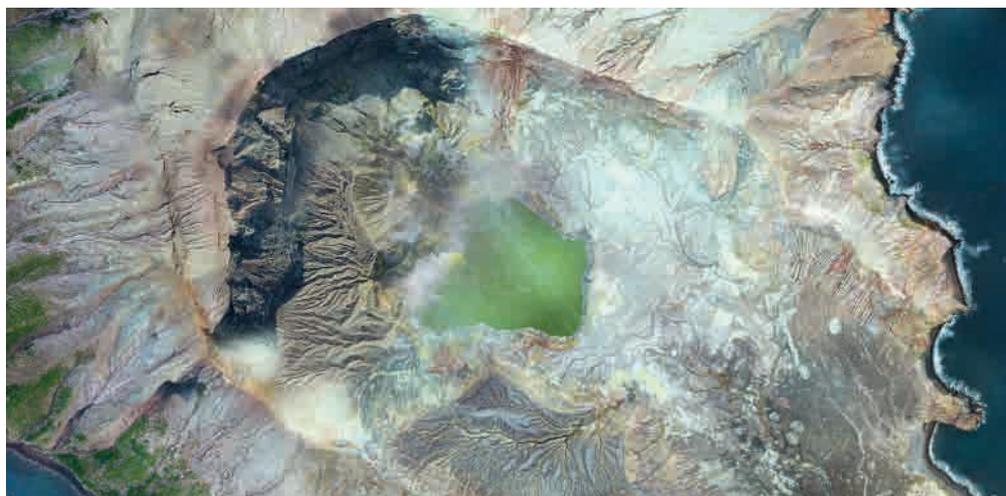
Lighting conditions during the acquisition period varied, so to ensure consistency across the dataset, batch editing was done in Adobe Lightroom. Images were also renamed so that the naming convention was consistent throughout.

To capture the island's elevation, the team flew as high as 400m above sea level. Flexibility, mobility at sea and good flight-planning were required to ensure line of sight and an appropriate height above ground level were maintained throughout. Before take-off each day, the team liaised with local helicopter operators – something necessary under New Zealand's UAV legislation and a requirement of flying around this area famous for tourist flights.

The surveying mission was a last-minute addition to the team's plan to capture a 3D model volcano, but it was a natural extension of the project. Wild Atlas' portfolio includes a mix of ecological projects, including wetland and vegetation mapping with photogrammetry, and the sort of early-surveying work completed on Whakaari.

"My background is science and I really like the idea of getting data from imagery," says Spyksma. "Obviously, photogrammetry is the perfect tool for that."

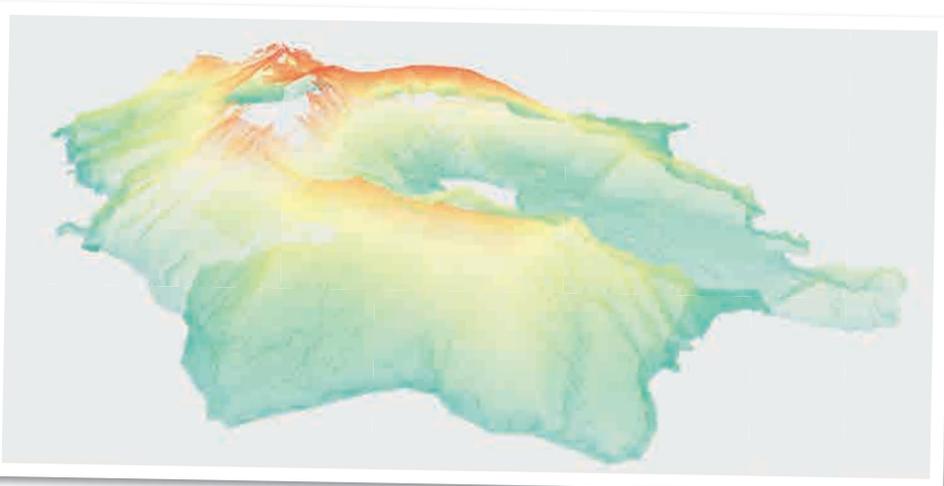
Because the surveying was a mission extension and not a core part of the



Orthomosaic clip from the volcano created in Pix4Dmapper



Pix4Dcloud 3D model of the volcano



Point cloud of the volcano

project, the team did not have the necessary equipment on hand to place ground control points (GCP) throughout the site, nor would it have been safe to do so. Luckily, there were two permanent GCPs already on the island, left after a government survey, that the team could use. This was most beneficial for the vertical datum, bringing it into usable projection relative to a New Zealand specific datum.

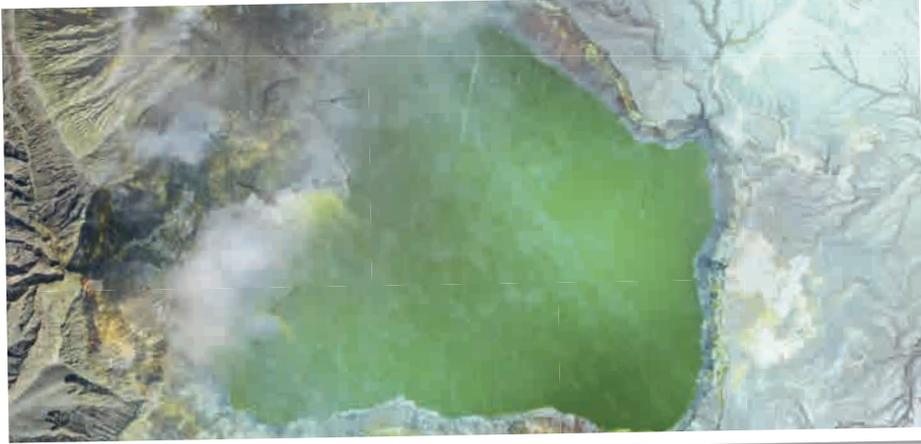
The team found that combined with manual tie points, the two GCPs were sufficient to achieve a great result. "We achieved a ground sampling distance of around 10cm," says Spyksma. "Even though we were flying really high, the model is super high in detail."

One part that was less easy to reconstruct was the crater lake. "It came out a bit lumpy, and the water didn't reconstruct that well -

3D VISUALISATION



Whakaari is now uninhabited



The reconstructed crater lake from the orthomosaic

but better than expected," says Spyksma. "I think it's because we were flying so high, there were relatively few images which were only water." The team smoothed over the results by editing the point cloud to remove any obvious spikes caused by the reconstruction. The repair is barely visible on the finished model.

Modelling the volcano

The client and the engineers that they had engaged were interested in restoring an old miners' track traversing across the southwestern slopes of the crater. For this, they required a point cloud and a high-resolution 3D model to be created.

Because the island was incredibly feature-rich and all flights had a high overlap (80% vertical and 75% horizontal), default initial processing options were selected in Pix4Dmapper – key points image scale set to full and calibration set to standard. The point cloud was then densified using

the multiscale option. The team chose this as the northern slopes of the island had dense forests which they believed would benefit from additional points being created, while areas such as the crater, which had an abundance of easily matched features, could use a smaller image scale.

The 3D textured mesh was not generated at the same time as the point cloud. Instead, once the point cloud was completed, it was carefully inspected for irregularities, which were removed. The points corresponding to the surrounding coastal waters were disabled, as were spikes and troughs in the crater lake, effectively smoothing this feature out. All editing of the point cloud was carried out using Pix4Dmapper's Point Cloud Editing Suite.

The 3D textured mesh was then created with a single texture. This – as opposed to a tiled texture, which could have increased the overall resolution further – was decided upon to make it as user-friendly as possible for the client. A size of 16,384 x 16,384 pixels

was used as it allowed a high-resolution output without creating a model that was too bulky to be displayed smoothly.

A 3D textured mesh with a lower resolution was also created at this point so that it could be loaded onto a phone using a third party augmented reality app for the client to view the model in real space – for example, on the coffee table – as well as on the computer using the higher resolution mesh. Delivery to the client was in the form of a single .LAS file for the point cloud and .OBJ files for the textured mesh.

A model to remember

The 3D model of Whakaari is valuable not just to the island's owners, but to New Zealand as a whole. The work may take its place in the pantheon of New Zealand art history and the country's collective memory alongside Charles Blomfield's enduring paintings of the Pink and White Terraces, a unique geographic feature that was destroyed by volcanic eruption in 1884. Showcased on New Zealand Geographic along with other VR experiences, visitors to the website can use it to explore New Zealand from the comfort of their own homes.

"The model obviously has a lot of relevance now, and also is being used for scientific and engineering applications," says Spyksma. "It was a pretty amazing opportunity to get to explore the island, not just for the filming we were doing, but to have the chance to create something special."

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