# Reconstruct WWII Concentration Camp under Heavy Canopy with UAV Lidar

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## Background

The island of Alderney, a British crown possession with its own government located 8 miles off the coast of France in the Channel Islands, was once home to a German SS concentration camp. Caroline Sturdy Colls, a professor of Conflict Archaeology and Genocide Investigation at Staffordshire University in the UK, travelled with her team to the island to investigate the camp as it was the only camp on British soil.

The investigation and the surprising results were the subject of a documentary 'Adolf Island' produced by the Smithsonian Channel. The documentary showcased Routescene's 3D mapping capability and demonstrated how lidar technology is currently being used in fields such as archaeology and forensics to create a bare earth model that identifies structures without disturbing protected land.

According to the documentary, the Nazis took over the island because they had plans to invade Britain. They used 4,000 slave laborers on Alderney to build a defence system that included gun batteries, bunkers, tunnels and massive fortifications.

Most of the structures were destroyed by the Germans after they surrendered and the number of people who were killed on the island remains a mystery. There are 336 Russian prisoners buried in a cemetery, but survivors claim that many more were killed.

However, the Alderney government prevented Professor Sturdy Colls' team from doing any excavation so she sought the assistance of UAV lidar technology which uses pulsed laser light to measure ranges to the ground under the vegetation canopy.

Professor Sturdy Colls contacted Routescene's customer and frequent collaborator, Flythru, to conduct a UAV lidar survey of the sites at Alderney. Lager Sylt, the concentration camp built and run by the SS, and Longis Common, a graveyard, were chosen based on records from a German War Graves Commission investigation from 1960.

The task was to investigate the sites primarily focusing on an area believed to contain mass graves adjacent to the current airport runway. Stringent restrictions placed by local residents and authorities prevented the archaeologists from breaking ground and it was only very reluctantly that permission was given for a non-intrusive aerial survey.

The surveyed area was overgrown with meter-high grasses, heathers and scrub and it was apparent from initial photogrammetry that the RGB imagery (although useful) was insufficient to fully establish where the structures of the camp had been.

It was not until the UAV lidar system was used and the data examined that the full extent of the camp and surrounding features could be identified and located. The use of UAV lidar allowed penetration of the dense vegetation and enabled the team to reconstruct the layout of the concentration camp.

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# Routescene's Technology

## Data Collection

Flythru used Routescene's integrated UAV lidar system for this task. Designed in 2014 for use on drones, Routescene's LidarPod comprises an array of sensors including the Velodyne HDL-32 Lidar scanner. With a pulse rate of up to 1.4 million points per second from 32 different lasers angled in a 40-degree field of view. The HDL-32 has a maximum range of 110m, which is benchmarked at 10% reflectivity on a white surface. Given that natural features have a lower reflectivity, the "usable" range is around 80m. This sensor enables high resolution vegetation penetration and helps users uncover ground features which are not easily visible from the ground or which are obstructed by thick vegetation.

The number of laser hits achieved on the ground is up to 400pts/m2 through thick vegetation. Lidar is an ideal method when surveying sites which are overgrown or woods and forests that are inaccessible using conventional survey methods. Without UAV lidar it would have taken considerable time to survey the Alderney sites. Due to the thick cover of vegetation it would not have been possible to visually detect the structures found, and the area was surveyed by the UAV lidar team with just a couple of 15-minute flights.

Alderney ground cover.

Routescene LidarPod.

## Speedy Data Processing

Michael Mays' team from Flythru, www.flythru.co.uk , processed the data on-site immediately after the UAV survey using LidarViewer, Routescene's 3D processing and visualisation software and presented it to Caroline Sturdy Colls the same evening.

The filters used in an automated sequence were sector reduction, laser ID reduction, coordinate conversion, grid creation, the purpose-built "Bare Earth tool", a skim grid and finally a LAS export filter. Using the Bare Earth Tool within LidarViewer the team quickly and easily removed all the non-ground points to reveal the surface below and produce a Digital Terrain Model (DTM).

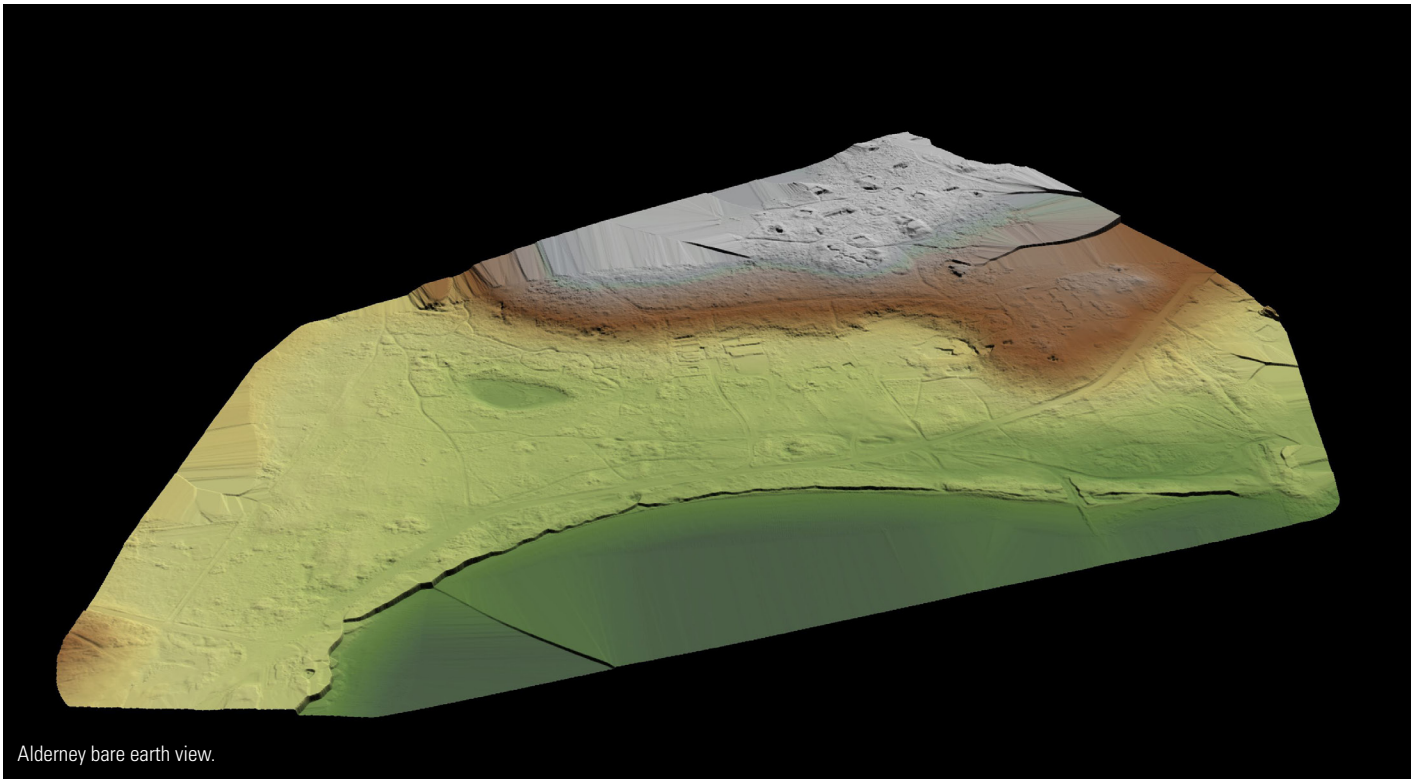
The DTM exposed structural remnants of the camp, and previously undiscovered features that had been completely obscured by the vegetation covering the site. The Bare Earth Tool is newly available in the Routescene LidarViewer software package. Designed specifically for heritage applications like this, it considerably reduces the amount of time it takes to digitally remove all features above ground level.

## Other survey techniques

In addition to using UAV lidar, Professor Sturdy Colls also used basic photogrammetry using hundreds of old Royal Air Force (RAF) photographs stitched together to create an overall three-dimensional model.

Ground Penetrating Radar (GPR), which sends radio waves into the ground and allows artefacts under the ground to be detected, was also used. Overlaying all of the results from the three different techniques provided an accurate, highly detailed 3D digital model of the camp, highlighting features of interest both above and below ground for further investigation.

In the Smithsonian documentary, Adolf Island, the results of the study helped recreate a digital representation of the prison camp and identify the location of possible grave sites.



Alderney bare earth view.

## Results and Discussion

Photogrammetry provided a detailed view of the area; but it was the UAV lidar that was able to penetrate the layers of vegetation and to reveal the location and details of the buildings' foundations. They were clearly visible on the Digital Terrain Model. By matching this to old RAF reconnaissance photographs taken of the area during the war it was possible to digitally reconstruct a 3D model of the prison camp for the Smithsonian documentary.

The lidar survey found building foundations, barracks, a canteen, the prisoner compounds, the location of fencing surrounding the camp, and four machine gun posts. The team was also able to identify possible mass gravesites suspected to contain more than 1,000 bodies, according to the documentary.

However, due to local government opposition, no further investigation of the potential graves was permitted at this time.

Professor Sturdy Colls said, "The lidar and photogrammetry UAV surveys that Flythru completed on Alderney assisted us greatly in our research. The overgrown vegetation and the size of the sites that we were investigating made ground-based surveys difficult and using UAV was the obvious choice. The results were better than we could have hoped for. At SS concentration Camp Sylt many additional structural elements were identified in the lidar survey that were previously hidden behind dense vegetation. This allowed us to complete, for the first time, a digital reconstruction of this important site."

## About the Author

Gert Riemersma, CTO of Routescene, has 20 years experience as a hydrographic surveyor and a private pilot since 1986. He worked with lidar since 2008 and UAV lidar since 2013. He is the CTO and founder of Routescene. Being used for such historically and socially important work, the system has proven to be ideal due to its portability and ease of use on such difficult and inaccessible sites. Combined with its high level of accuracy, the ability to penetrate vegetation and process the data on-site are real advantages.

## Reference

Nikolic-Dunlop, Alex. 2019. *Adolf Island* (Documentary), https://www.smithsonianchannel.com/shows/adolf-island/0/3462210.