Benefits of Using Drones at Aircraft Accident Sites

Introduction

Aerial images of accident sites are very useful for a number of reasons. They can capture the whole site from the initial impact point to the wreckage's final resting location. The ground marks and wreckage distribution help to identify how the aircraft hit the ground. Aerial images are also useful for showing the relative positions of obstacles, such as trees or buildings, that may have been struck before ground impact. They help to reveal the surrounding terrain and environment that the pilot faced if there was an attempted forced landing. And when it's a large aircraft at an accident site, aerial images help to document the damage to its upper surfaces.

The UK AAIB has, in the past, been primarily reliant on police helicopters and sometimes search-and-rescue helicopters to obtain aerial images. These images have been useful but did not always capture the angle or detail required, and often images would not arrive until a week or more after the accident. The AAIB could charter a helicopter, but this is expensive and can take time to organise.

About three years ago, it was noticed that small unmanned aerial vehicles (UAVs), or drones as they're now more commonly referred to, had become significantly less expensive and could provide aerial images within minutes of arriving at an accident site. Having the investigator controlling the drone's camera, all the angles and details needed are captured.

The AAIB bought their first drone, a DJI Phantom 2 Vision in February 2014 and first used it at an accident site on 14 March 2014 (Figure 1). The drone's 14-megapixel camera provided excellent stills, although the video quality was shaky due to a lack of a gyro-stabilized mount. After using it at five different accident sites an upgraded model, the Phantom 2 Vision Plus, with a gyro-stabilized mount was purchased in July 2014 (Figure 2, left), and has been used at 11 accident sites. As well as taking stable video, the additional benefit of the newer model was that the camera could be tilted 90 degrees downwards to take a series of overlapping images to map the whole accident site.

The expectation was to be able to use photo-stitching software to stitch all the images together, but the trials we did were of objects laid out in fields, and the lack of variation in the images, because they were mostly of green grass, was beyond the photo-stitching software. This led to exploration of what photogrammetry software could do. Not only could it generate 3D models from a series of overlapping images, but it could also create a stitched overhead image that was true to scale; an image that is called an orthomosaic.

The photogrammetry software the AAIB purchased was called Pix4Dmapper Pro. This provided some good photogrammetry results using the drone. In September 2015 the AAIB upgraded to the DJI Inspire Pro drone (Figure 2, right), which can operate in winds up to 20 kt and has a higher quality camera that can stream high-definition (HD) video to two tablet devices. This model is also available with dual controls for the pilot and camera operator.

Figure 1

First use of the AAIB's Phantom 2 Vision drone at an accident site on 14 March 2014

Figure 2

DJI Phantom 2 Vision Plus (left) and DJI Inspire Pro (right)

How the AAIB operates drones

Under UK regulations, the AAIB is not classed as a commercial operator flying for reward so can operate drones at accident sites under the standard regulations for recreational users. The main limits are maintaining visual line-of-sight, a minimum distance of 50 metres from people, buildings, and vehicles that are not under our control, and 150 metres from congested areas. Since operations are primarily inside a police cordon where everyone can be under our control, these limits have not been a restriction.

The AAIB operations manual lists flight limitations and training and currency requirements for our operators. The two main operators are AAIB engineering support staff. One of the operators will normally deploy to an accident site to assist with wreckage recovery and will fly the drone. The engineering investigator onsite will normally operate the camera. The AAIB requires two people to operate the drone, because to fly the drone safely the pilot needs to be heads up watching the drone and looking out for obstructions and people. To take good pictures, you need to be heads down. The only time single-operator flight is allowed is when the drone has been programed to fly an automated route and automatically take stills; in this case, the operator is monitoring the flight and is able to override the autopilot.

Benefits of drones for accident site imagery

The main benefits of using drones over manned airplanes or helicopters are:

- Significantly lower cost (a suitable drone can be obtained for about £800).
- Drones can be deployed immediately on arrival at site.
- The images and video from the drone can be viewed live on the ground.
- The engineering investigator has full control over the images and videos that are taken.
- A drone can be easily relaunched to take additional footage.
- A drone can be flown closely to trees and wreckage to obtain close-up images without disturbing them with rotor downwash.
- A drone can be easily programed to take a series of geo-tagged and overlapping overhead shots for photogrammetry purposes.
- A drone can operate in low-visibility and low-cloud conditions that would prevent an airplane or helicopter being operated.

The uses so far identified for drones at accident sites are:

- Wreckage and site survey,
- Wreckage search,
- Tree/object height estimations,
- Site safety assessments, and
- Flight path reconstruction/visualisation.

Figure 3

The AAIB's Phantom 2 Vision Plus being used to supervise the recovery of wreckage from a Jet Ranger helicopter that crashed in the sea below the cliffs

Creating orthomosaic images and 3D models of accident sites

With photogrammetry software like Pix4Dmapper Pro orthomosaic images and 3D models of accident sites can be produced using drone imagery. An orthomosaic is an image that is composed of multiple overhead images and is corrected for both perspective and scale, which means that it has the same lack of distortion as a map (Figure 4). The images are obtained by pre-programming the drone to fly in a grid pattern and to automatically take a series of overlapping shots with the camera pointing 90º down. The total flight time to capture the 59 images used to create Figure 4 was 9 minutes using our Phantom 2 Vision Plus. The processing time using a typical PC took about 2 hours but it can take longer for larger projects.

The photogrammetry software also generates a 3D point cloud and a 3D mesh from the images. An example 3D mesh is shown in Figure 5. The quality of the 3D model is improved by taking oblique images, and in this case we took images while flying the drone around the aircraft wreckage at two different heights with the camera pointing at the centre of the wreckage.

The 3D model can be used to take measurements of the site. In trials measurement accuracies of up to 1 cm using drone images captured from a height of 40 m have been obtained.

Figure 4

Pix4D orthomosaic generated from 59 overlapping images taken with a Phantom 2 Vision Plus from a height of 50 metres (a digitally zoomed-in section of this orthomosaic is shown in the lower right corner)

Figure 5

3D mesh created from oblique video from Phantom 2 Vision Plus while flying two circles at two different heights around the main wreckage

Benefits of photogrammetry software for processing accident site imagery

Taking aerial images of an accident site and processing them with photogrammetry software has a number of benefits.

- The 3D model is very useful for briefing people who have not attended the accident site. You can manually zoom in and out and rotate the model to show all the ground marks and wreckage distribution. This can make it easier for people to visualise the site compared to flicking through a number of still images.
- Pix4D can be used to create an animated video of the 3D model that can then be sent to people to view who do not have the Pix4D software.
- If some time has passed between attending the accident site and writing the report, then viewing the 3D model can serve as a useful refresher.
- The orthomosaic images serve as a very detailed wreckage plot.
- Measurements of the site can be made using the 3D model or orthomosaic that are more accurate than using a hand-held GPS, and can be up to 1 cm in accuracy.
- The orthomosaic is also a useful tool to search for missing wreckage and it can be reviewed in slow time back in the hotel or office.

Conclusion

The AAIB has found drones to be a very useful new tool at accident sites. They are very good for capturing the scene before we start disturbing it. They can be used to help us search for missing wreckage and to perform final flight path reconstruction/visualisations. A drone costs significantly less to operate than a manned aircraft and can be deployed immediately on arrival at site. A drone can be easily relaunched to take additional footage, and the investigator has full control over the images and video taken.

A drone can be easily programmed to take a series of geo-tagged and overlapping overhead shots for photogrammetry purposes. Photogrammetry software like Pix4D can then be used to create geo-referenced maps, orthomosaic images, and 3D models of an accident site. These are useful for both visualising the accident site, recording relative wreckage locations and for taking measurements.

(Adapted from a technical paper 'Using a Drone and Photogrammetry Software to Create Orthomosaic Images and 3D Models of Aircraft Accident Sites' *delivered by an AAIB Inspector at ISASI 2016 in Reykjavik, Iceland, 18-20 October, 2016. The full text of this paper can be found on ISASI's website at [www.isasi.org/Library/technical-papers.aspx)](www.isasi.org/Library/technical-papers.aspx)*