HOW TO CLEAR MINES USING UAV LIDAR

IN THE FIRST OF TWO ARTICLES, **EMMA THOMAS** DISCUSSES THE PRACTICAL CHALLENGES AND TECHNOLOGY NEEDED TO USE UAVS TO PLAN LANDLINE CLEARANCE, BASED ON THE EXPERIENCES OF A SURVEY TEAM IN ANGOLA

Last year was the 25 year anniversary of the adoption and opening for signature of the Mine Ban Treaty as well as the 30 anniversary of the creation of the International Campaign to Ban Landmines (ICBL). One of the greatest challenges is the new use of anti-personnel (AP) land mines. Casualties from land mines and explosive remnants of war (ERW) have been disturbingly high for the past seven years, following more than a decade of historic reductions. The stakes are high and there is a global need to enhance current mine clearance planning methods using new technologies.

Routecene constructed a demonstration unit specifically for The HALO Trust for a project intended to prove the impact UAV LiDAR can have on land mine clearance planning. Comprising a 16 channel LiDAR sensor, a GNSS/INS sensor and internal solid state data storage to capture 12 hours of data, the system was designed to be resistant to vibrations in flight and handling by users. Due to the remoteness of the survey sites, the system did not require mobile or internet connection to operate, providing operational autonomy and data security to the survey team.

The LiDAR sensor is capable of collecting approximately 600,000 points per second and the large volume of high-resolution LiDAR data gathered was processed using LidarViewer Pro software. GNSS data was collected for the post processing of the trajectory to ensure the data was as accurate as possible.

The UAV LiDAR system was mounted onto a DJI M600 Pro hexacopter capable of lifting a 5kg payload for approximately 15 minutes.

THE UAV LIDAR DATA PROVIDED EVIDENCE OF TRENCHES, CRATERS AND FOXHOLES AT ALL THE SITES SURVEYED

In-field challenges

The case study was undertaken across three sites around Cuito Cuanavale, in the province of Cuando Cubango, Angola. Angola was devastated by the civil war fought from 1975 to 2002, and AP and anti-vehicle (AV) mines still present a threat to lives and habitats. The three survey sites were specifically chosen because they are areas of known historical conflict: two were abandoned military bases and the other was an extensive defensive mine line.

This was the first time UAV LiDAR has been used to survey battlefields in Angola and the project presented several challenges to overcome:

Challenge one: ground truthing

As with any new approach, there is a need to verify results. In this case, the team needed to confirm the identification of each battlefield feature-type found in the LiDAR data. The features expected to be detected were main trenches, communication trenches, foxholes (one-man defensive positions), shell scrapes (shallow excavations allowing soldiers to shield from shell bursts and small arms fire) and craters from detonations.

Typically, verification is undertaken by visiting a site to ground truth – that is, to corroborate visually the features found in the dataset. However, physical access at these sites was limited due to land mines and vegetation coverage. In particular, the team needed to accurately differentiate between a foxhole and a crater, which often displayed similar dimensions in the LiDAR data.

To enable this in future surveys the recommendations are:

• In areas that are safe to access, measurements can be taken manually on-site to more accurately identify the features in the LiDAR data.

• In unsafe areas still hosting land mines and that have little or no vegetation, a UAV mounted with an RGB camera could be used to create high resolution orthophotos to confirm the identification of features.

Challenge two: lack of UAV take-off and landing sites

Uncleared land posed a threat to life to the survey team and reduced the choice of suitable UAV take-off and landing sites and locations to site the base station. At Sites A and B breach lanes and cleared land were available near the survey areas however Site C was limited by the surrounding uncleared terrain which contained mines. Instead, the cleared narrow sandy roads were used for both UAV take-off and landing sites and to site the base station, and the equipment needed to be moved to let vehicles past.

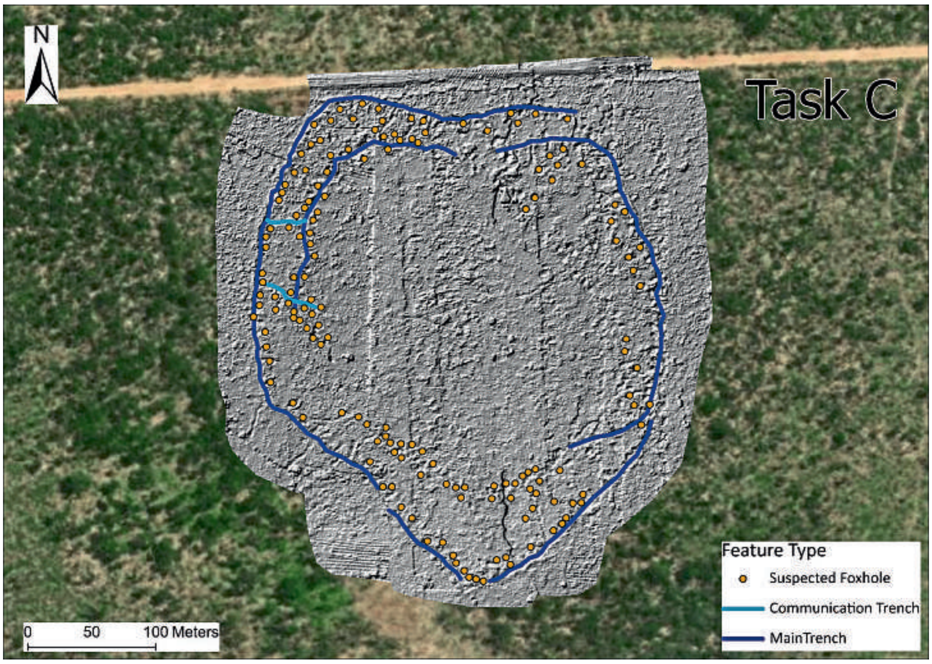
Challenge three: productivity

Many of the minefield sites in Angola are 20-30km long and the maximum distance that the DJI M600 Pro could fly was 1.0km-1.5km. Operational limitations during this project included short flight times and limited access to power to recharge batteries:

• Short flight times were a consequence of short UAV battery life combined with loss of visual line of sight of the UAV due to vegetation. The lack of suitable UAV take-off and landing points also restricted the size of area that could be surveyed in a day.

• Limited access to power to recharge the UAV batteries between flights due to the remoteness of the survey area. This limited the number of flights to two per day.

Using a generator in the field on future



projects to charge batteries would enable UAV LiDAR surveys to be scaled up. Longer endurance UAVs and beyond visual line of sight operations should also be considered. Hybrid UAVs rely on fuel rather than batteries and can fly for longer periods of time enabling larger surveys.

Challenge four: optimal data collection times

Site C, the largest site, was surveyed during the rainy season when vegetation cover was at its highest. Data was collected at 50m above ground level (AGL) over three days. The conditions meant there may have been water infilling some of the features. Sites A and B were surveyed during the dry season when vegetation cover was at its lowest. The LiDAR data was collected from 40m AGL, with one day of collection for each site.

UAV LiDAR can successfully penetrate through vegetation of differing densities, and this project clearly demonstrated this, as positive results were achieved across all three sites. However, the best outputs were from Sites A and B. In the future, consideration of the optimal data collection times should be factored into survey plans where possible.

In addition, the deployment of Routescene's 32-channel UAV LiDAR system would enhance future surveys. The increased number of channels provides increased vegetation penetration capability resulting in higher resolution outputs. This would also enable flights to be undertaken at higher altitudes above denser vegetation without compromising performance.

Challenge four: Survey planning

Routescene's LidarViewer Pro post-processing software is used offline and does not require internet access. However, post-processing of the trajectory is undertaken online using additional GNSS information, which is only available from specialist third-party portals 24 hours after a survey. This caused delays in data processing which can be factored into future planning.

Challenge six: improve feature identification

As described above, distinguishing different features directly in the LiDAR dataset would greatly enhance data processing. The dimensions, locations and age of battlefield features could be used to create a database to inform future analysis and enable work to be undertaken with a higher level of confidence and at greater speed. This information could also be used in the training of AI algorithms to speed up the analysis of the data.

Conclusion

This work proved that UAV LiDAR can be used to detect battlefield features that can be indicators of minelaying. The UAV LiDAR data provided evidence of trenches, craters and foxholes at all the sites surveyed – features that were either not detectable or only partially visible in satellite imagery, RGB and TIR imagery, or from the ground.

In total across the three sites the following battlefield features were identified:

- 2,425m of main trenches.
- 394m of communication trenches.
- 201 foxholes.
- 15 crater-like features which were suspected shell scrapes.
- Two suspected craters, possibly from exploded ordnance but unlikely to be from AV mines.

This information was used to inform clearance planning. The results made clearance efforts safer and expedited clearance through a targeted approach.

In the second part of this article, we will detail the approach used for post-processing to deal with the vast quantities of data obtained, as well as potential future improvements.

ANGOLA WAS DEVASTATED BY THE CIVIL WAR FOUGHT FROM 1975 TO 2002, AND MINES STILL PRESENT A THREAT TO LIVES AND HABITATS

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