Enhancing mine action operations with high-resolution UAS imagery

The GICHD (www.gichd.org), based in Geneva, Switzerland, is an expert organisation working to reduce the impact of mines, cluster munitions and other explosive hazards, in close partnership with mine action and other human security organisations (read its 2015 Annual Report).

From 2012 to 2014 the GICHD ran a wide-ranging UAS feasibility study, based on the use of senseFly’s swinglet CAM mapping drone. This project involved flight tests in Sweden, Germany, Switzerland, Azerbaijan and Iraqi Kurdistan, the aim being to explore the potential benefits and challenges of using fixed-wing ‘mini UAS’ in mine action operations, as well as to promote the civilian use of these technologies.

In its operational testing phase, the GICHD now works with senseFly’s eBee mapping UAS.

Following a two-year feasibility study, The Geneva International Centre for Humanitarian Demining (GICHD) last year moved its unmanned aircraft system (UAS) program into its operational testing phase, working with The HALO Trust and MAG in Angola to analyse the real-world benefits that unmanned aerial systems (UAS) can bring to demining activities.

“Most actors in the field of humanitarian demining today employ publicly available satellite data, like Google Earth, or old topographic maps of the areas in which they operate,” says Inna Cruz, an Information Management Advisor at GICHD and the organisation’s UAS project leader. “This assists mine action organisations over large areas, for example when observing a group of scattered minefields or a mined border. However satellite data can be quite low resolution, compared to UAS outputs.”

The first results of the GICHD’s feasibility study found that small, light mapping drone technology could become a valuable supplementary tool for mine action teams that require accurate, up-to-date imagery of suspected and confirmed hazardous sites.

The GICHD mapped the benefits and challenges of using UAS for mine action operations via several online surveys that its team conducted between 2012 and 2014. “The purpose of these surveys was to identify user needs and explore the potential use of UAS in humanitarian mine action,” Cruz explains. “The 42 respondents comprised representatives of international mine...
action organisations and nongovernmental organisations, predominantly consisting of information-management and operations staff with combined work experience that spans more than 20 mine-affected countries.”

“We saw from our feasibility study that images acquired with such an UAS can be used to enhance planning, recording and reporting capabilities at the different stages of the Land Release process, namely non-technical survey (NTS), technical survey (TS), and clearance,” Cruz explains.

Digging deeper

Following this positive start, in Spring 2015 the GICHD’s drone project entered its operational implementation phase. Due to run until the end of 2016, this sees the GICHD’s eBee UAS being used in Angola across a range of different demining applications, operated first by the GICHD’s partner The HALO Trust—the world’s largest humanitarian demining NGO—then due to be continued by Mines Advisory Group (MAG).

“While our feasibility study concentrated on selecting the most appropriate UAS and developing a hypothesis regarding the possible benefits of using this aircraft’s high-resolution images for mine action activities, the purpose of real-time testing with partners on the ground is to prove, or disprove, this hypothesis and to identify operational limitations,” Cruz says.

The senseFly eBee is a small, lightweight mapping drone, which flies, captures high-resolution aerial images, and lands automatically. Its eMotion flight planning software is used to determine what region on the ground the drone will map and configure related parameters such as the operator’s required ground resolution (in cm per pixel).

After the drone’s flight, The HALO Trust’s team uses professional Pix4D photogrammetry software to transform the drone’s images into geo-referenced orthomosaics (maps) and digital surface models. These drone outputs are then imported into Google Earth or ArcGIS software for inspection and analysis.

Working the matrix

During the program’s operational phase, the GICHD’s team is assessing the value of UAS technology by way of a Matrix of UAS Product Benefits (Appendix 1).

This means assessing the value that the drone brings—or more specifically, its high-resolution imagery and outputs—across a wide range of different applications, from the updating of cartography before mine action operations take place, and non-technical survey tasks such as geo-locating Suspected Hazardous Areas (SHAs), through to operational planning for technical surveys, clearance and post clearance land documentation.

“Potential benefits, grouped by mine action activity, are listed in the matrix. These are then scored by the UAS mine action operators on how useful the output products are during mine action operations. Challenges and alternative options are also listed in this matrix,” according to Cruz.

Feedback from the field

On the ground in Angola, the drone is operated by The HALO Trust’s Projects Officer, Harriet Houlbys. She says the aircraft’s operation regularly causes a stir.

“You have to be sure that the local authorities understand what you are doing and are happy with it before you start,”

“You can hear the drone flying overhead, so it’s very common that people notice and gather around to watch the drone being used, especially children,” Houlbys says. “This can be a safety hazard, particularly when the drone is landing, and it can sometimes draw negative attention. You have to be sure that the local authorities understand what you are doing and are happy with it before you start, and be prepared to explain to local people, as well as take safety precautions.”

The UAS typically flies at between 85 and 100 metres (280 - 330 ft) above the ground. This altitude allows its 18 megapixel RGB camera to achieve a ground resolution of around 3 cm (1.2 in) per pixel. “Compared to Google Earth, which almost all mine action organisations use, this is a much higher level of detail,” says Cruz.

In terms of flight permissions, GICHD typically relies on its in-field partners to facilitate such approvals, since these organisations are usually already in touch with local authorities when importing demining equipment.
The most common challenges faced when operating the drone, Houlsby says, span both operational challenges, such as finding safe take-off and landing spots, and infrastructure challenges, such as intermittent access to the electricity required, for example, to recharge the drone’s batteries and the laptop that runs its software.

Key findings

Of the different applications of UAS imagery that the GICHD has investigated, some have only come to light through using the technology in the field.

“The imagery collected with the drone was intended to help us monitor post-release development and to plan demining operations. However, since the digital surface model that is generated using the drone’s images also calculates the gradients of different slopes, we believe this output may also be useful in determining suitable access routes for machines getting to the sites, such as the demining machines themselves.”

Another interesting lesson has been how the drone’s data could potentially help staff predict the locations of further contamination. Houlsby explains: “The high resolution means that in some cases you can see craters from safe demolitions of landmines in the imagery. Some minefields are laid out in strict patterns, so being able to see the lines of craters may help to plan future operations.”

In addition, Houlsby adds, using a UAS could be helpful when collecting information on inaccessible or hazardous areas, for example for operational planning purposes.

Last but not least, the drone’s data allows mine action teams to more accurately record changes in land use, by providing precise before and after imagery. “Using the imagery from the drone, we’ve been able to produce interesting webmaps and case studies to demonstrate the impact of mine clearance for vulnerable communities. We took historical ArcGIS Online imagery from before clearance and compared it to detailed post-clearance drone imagery. It’s a really effective way to communicate change.”

HALO Trust and MAG staff planning their next automated UAS flight.

The HALO Trust will use a Swiss-produced Digger Foundation tilling machine in its clearance operations. The data above—an ArcScene representation of an orthomosaic with the DSM as base heights—was used for slope analysis, which it is thought could prove useful in determining suitable access routes for the machines to reach the sites.

“A this flight was also carried out in preparation for the deployment of the D-250 to the area,” explains Houlsby. “The areas on each side of the road have been surveyed as Confirmed Hazardous Areas. Flights such as these could for mechanical deployment planning, as they give more detailed imagery of land that is not visible from the ground.”

Craters from the controlled demolition of anti-vehicle mines in a minefield in Cuito Cuanavale, Angola. New crop cultivation, planted after the demolition, can be seen within metres of the mine line. (Image: GICHD/HALO)

A drone-produced orthomosaic combined with a digital surface model, shown in Esri ArcScene, that details the extent of clearance by manual deminers on a HALO Trust minefield (the clearance activity is visible as a lighter coloured grid). Image: GICHD/HALO.
Conclusions

In summarising the GICHD’s UAS findings to date, Cruz is positive about the impact unmanned aircraft can have. “We have proved that UAS imagery—when infrastructure and permissions allow this data to be collected—helps in the planning and monitoring of humanitarian mine action operations. It can also be used to record proof of cancellations for suspected hazardous area and the DSMs generated from the UAS imagery could be used to help teams to prepare the paths for the demining machines that will carry out future technical surveys. The fact that we can use the UAS to accurately document land use changes, such as urbanisation and agricultural development, is also a big help in communicating the effects of demining to donors.”

“Looking ahead, Cruz is monitoring other GICHD-supported projects where drone technology might be applicable and produce immediate benefits. "We have lots of countries with completion dates arriving soon, and we will be turning our UAS program’s findings into product training packages that help countries use and manage UAS imagery for this type of work—so whoever needs this information can access it easily.”

As for the wider, ‘Holy Grail’ application of detecting mines themselves from the air, Cruz suggests that while this could happen in future, the technology has yet to be proven to a high enough degree. “This type of application is still at the research stage,” she explains. “There are studies and projects out there, but no-one has yet proven a 100% detection rate and false alarms still exist. The costs of this type of detection could also be very high, due to the cutting-edge sensors required.”

Houlsby agrees: “At present there is no reliable alternative to a human locating mines.”

About GICHD

The Geneva International Centre for Humanitarian Demining (GICHD) (www.gichd.org) is an expert organisation working to reduce the impact of mines, cluster munitions and other explosive hazards, in close partnership with mine action organisations and other human security actors. Based at the Maison de la paix in Geneva, and founded in 1998, the GICHD employs around 55 staff members from over 15 nations. This makes the GICHD a unique and international centre of mine action expertise and knowledge.

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## Appendix 1: Matrix of UAS Product Benefits

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Benefits</th>
<th>Audience</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. UAS Imagery show impact of uncleared land to donors and public</td>
<td>Fundraising, Increase public awareness</td>
<td>Donors, public</td>
<td>HALO trust case example</td>
</tr>
<tr>
<td>1.2. Proof of blockage of agricultural lands, paths, access to water, roads, important infrastructure objects</td>
<td>Fundraising, Local prioritization analysis MRE (Mine-Rik Education)</td>
<td>Donors, Operators, Public</td>
<td>HALO trust 1 example</td>
</tr>
<tr>
<td>1.3. Update cartography material</td>
<td>Planning, Prioritization, Collecting information about environment of inaccessible areas</td>
<td>Operators, Information Management</td>
<td>HALO trust case study, MAG</td>
</tr>
<tr>
<td>Before</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1. Indicate visible indirect evidence of contamination/ remnants of war</td>
<td>Proof of indirect evidence for SHA identification</td>
<td>Operators</td>
<td></td>
</tr>
<tr>
<td>2.2. Document evidence for Land Cancellation</td>
<td>Land Cancellation justification, Liability</td>
<td>Operators, QM personnel</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>2.3. Use to record coordinates of hazardous area polygons/ points</td>
<td>Collected and recoded coordinates for hazardous areas and demining operations</td>
<td>Operators</td>
<td></td>
</tr>
<tr>
<td>NTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1. Assist in planning of demining operations</td>
<td>Selection of appropriate tool, Select the best TS paths, analyse of environmental conditions of terrain</td>
<td>Operators</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>3.2. Monitoring of demining operations, report on progress and completion</td>
<td>Monitor of MA operation progress, estimation of completion date, evidence in completion documentation</td>
<td>Operators, MAC, Donors</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>3.3. Map demolitions &amp; identify patterns</td>
<td>Completion documentation, identification of possible patterns for future NTS activities</td>
<td>Operators, MAC</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>TS and Clearance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.1. External communication with public and donors</td>
<td>Use of high resolution imagery during land handover to local communities, illustrate MA clearance progress to donors</td>
<td>Operators, Donors, MAC, Local communities, Public</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>4.2. Show Land Use changes</td>
<td>Changes in Land Use after demining operations can prove the prioritization choice by MAC and Operators to Donors, prove of used resources, collection of socio-economic data</td>
<td>Donors, MAC, General Public, Local communities</td>
<td>HALO trust case study</td>
</tr>
<tr>
<td>4.3. Liability justifications</td>
<td>Reliable justification in case of accident/Incidents inside released area</td>
<td>MAC, QM, Operators</td>
<td></td>
</tr>
<tr>
<td>Post Clearance</td>
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