12-2016

Enhancing Mine Action Operations with High-Resolution UAS Imagery

Geneva International Centre for Humanitarian Demining
GICHD

CASE STUDY

Enhancing mine action operations with high-resolution UAS imagery

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.

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.

"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."

> "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"

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.

The HALO Trust's drone operator, Projects Officer Harriet Houlsby (left), at work in Chicala Cholohanga in Angola's Huambo province. When local children became interested in her operation, this presented a good opportunity to liaise with the community but also safety challenges when landing the drone. (Image: GICHD/HALO)

"We are currently [Summer 2016] just over half-way through our operational phase in Angola and we have confirmed that the UAS' high-resolution imagery can assist in operational planning, show land use changes after clearance operations, and help to monitor the clearance process. Now we are testing the use of this imagery during the NTS (non-technical survey) stage," Cruz says.

Feedback from the field

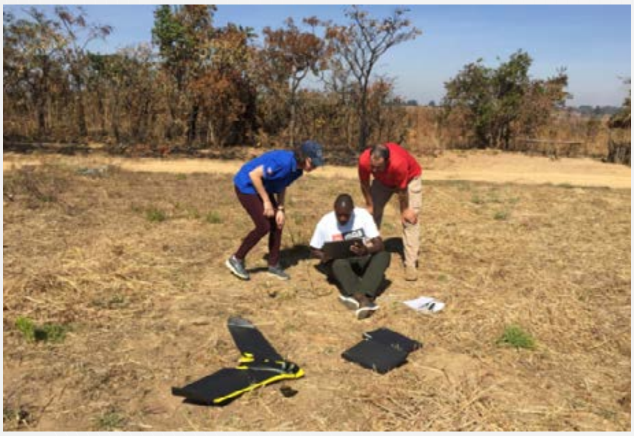
On the ground in Angola, the drone is operated by The HALO Trust's Projects Officer, Harriet Houlsby. She says the aircraft's operation regularly causes a stir.

> "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," Houlsby 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.



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

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."

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.

"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."

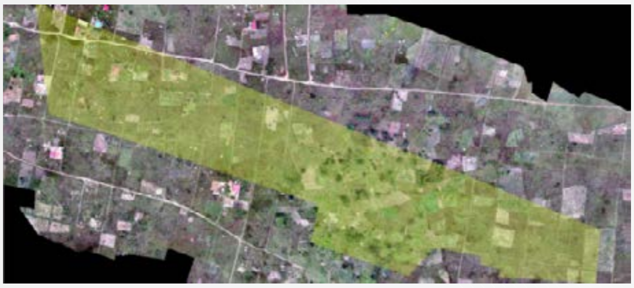
Craters from the controlled demolition of anti-vehicle mines in a minefield in Cuito Cuanavale, Angola. New crop cultivation, planted after the demolition, can be seen within metres of the mine line. (Image: GICHD/HALO)

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."

> "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"



"This flight was originally carried out in preparation for the deployment of the D-250 into the area. In the end however, this image—combined with information collected on the ground—was used as supporting evidence that the area had already been used for some time by the returning local population for agriculture, was not mined and could therefore be cancelled," says Houlsby.

With respect to the GICHD's matrix of potential UAS benefits, many have now been checked off the list. However some limitations do still exist, Cruz adds. "These largely relate to mine action organisations and the areas in which they operate, such as staff availability, electricity and infrastructure limitations."

"The drone offers high-resolution, georeferenced imagery, which can be very useful in operational planning and communicating with donors and the public," Houlsby notes. "Plus, as long as you are respectful of local authorities and communities, and bring them into the process wherever you can, we have found that using a drone can be a positive way to build relationships and interest in the work HALO does. However, although in Angola there are not many legal or governmental limitations on using drones, in other countries the regulations can be very strict, and there are still limitations to drone use in mine action, such as terrain, satellite connectivity, electricity, training needs and cost."

A drone-produced orthomosaic, or map, showing The HALO Trust's compound (centre) in Kuito, central Angola. The northern section of this compound, plus a large part of the bairro around it, was previously a minefield, which was subsequently cleared by The HALO Trust. (Image: GICHD/HALO)

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.

Appendix 1: Matrix of UAS Product Benefits

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