WIDE ANGLE

DRONES AND MINE ACTION: THE BALKAN FLOODS CASE

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RESEARCH CENTRE ON CIVILIAN VICTIMS OF CONFLICTS

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This paper examines a practical and innovative example of the use of drones in support of mine clearance operations in the context of the humanitarian response to the Balkan floods of Spring 2014. This experience, a milestone in the development of unmanned technologies for humanitarian purposes, is in a geographical area no longer marked by conflict but on the path of recent migration and refugee routes. It is the first example of the use of drones for mine clearance operations following a natural disaster. The risk posed by the return of populations displaced by the floods towards zones which are now contaminated by unexploded devices, and the re-opening of migratory corridors through poorly-controlled rural areas calls for particular attention to be paid to the speed of evaluation of and intervention in the areas at risk.

This research focuses on the activities performed by drones in emergency situations in relation to traditional methods of mine clearance, in order to then review the impact made by drones and analyse the conclusions drawn by experts from this experience. Whilst underlining the vast potential for development, this analysis of the humanitarian use of drones highlights their advantages in terms of reduced costs, portability and the variety of possible uses on the ground, especially where operations are dangerous and have difficult access. A purely empirical approach concerning the role of unmanned or remote-controlled devices has therefore been adopted.

In the last few years, the use of unmanned aerial vehicles, commonly known as drones, has played a major part in the debate about the prospects and limits of the use of technology in the humanitarian field. Known in the international arena for their military use, and in particular for the selective elimination of highly strategic objectives, drones suffer from a widespread unfavourable perception which inhibits their application in the humanitarian sphere. In spite of this, recent successes in responding to natural disasters and the overwhelming commercial success of drones are progressively weakening this stigmatization. The value of case studies carried out in Balkan countries like Croatia and Bosnia-Herzegovina also lies in contributing to the debate on the basis of factual and quantifiable elements. In this way, distance can be taken from partisan positions and informed strategic choices can be made.

Keywords: Drones, UAV, Mines, Demining, Technology, Balkans, Migration, Croatia, Bosnia Herzegovina, Innovation

Contents

Recent evolution of mine clearance tools

With the entry into force in 1999 of the International Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction (also known as the Ottawa Treaty), the signatory states committed to working together in demining all contaminated territories by 2009. This objective was reached by two-thirds of the signatory states and, instead of diminishing over time, the number of unexploded devices has increased consistently since 2013 due to the new conflicts arising in Africa, the Middle East and Asia; furthermore, the emergence of so-called "improvised explosive devices", which are unpredictable and often undetectable by traditional mine clearance procedures, has slowed down mine clearance operations even further.[1] Faced with such dynamics, radical change in favour of less expensive and more efficient practices has become an imperative at international level.

In 2011, the European Union devoted considerable resources to supporting not only mine clearance operations but also technological research and development in the sector. Two major projects were born from this initiative, the first co-ordinated by Airbus Defence/Space SAS (D-Box), and the second by the Royal Military Academy of Belgium (Tiramisu, from the English acronym Toolbox Implementation for Removal of Anti-Personnel Mines, Submunitions and UXO). The Tiramisu project, formed by 26 partners from 11 European countries and from Japan, had as its main goal to equip mine-clearers with new instruments for the planning, removal and reclamation of the contaminated territories.

The project was structured in 10 modules to be completed in 2015. One module, focusing on remote sensing and on decisional support systems, aimed to improve the tools used to prioritize areas at risk, and was designed to maximize the efficiency of the other modules in the programme. In contrast, another module was aimed at developing non-technical tools for removal, encompassing those tools based on the identification of indicators which reveal the probable presence of explosive devices: the function of this module was above all tied to facilitating the release of land to its population. Furthermore, two complementary modules were dedicated to the development of advanced systems of ground-level recognition (by metal detector, terrestrial radar penetration and manually or remote-controlled chemical sensors on terrestrial platforms) and for short ranges by micro or mini drones, or aerial biosensors (for instance, honey bees).[2]

In the course of the first year, the Tiramisu project began developing; it reviewed a series of tools for the management of territorial data, the acquisition of satellite data, and the management of mine clearance operations based on the information supplied by the first two systems. Notable progress was made in various sectors, including the development of detectors on terrestrial robotic platforms and, following a number of tests in Croatia, even the use of honey bees as explosives detectors. However, the project recorded much more modest results concerning the development of sensory instruments. These instruments proved sufficiently efficient in the identification of medium and large-scale devices, but their real value in the detection of devices of smaller size or lesser density remains to be seen. Previous studies had already confirmed that the combined use of new sensory instruments alongside electromagnetic inductive sensors (EMI's) like the metal detectors of new systems of terrestrial radar penetration, can considerably improve performance in the detection of devices with a low metallic composition even in highly mineralized terrain.[3] Whilst the new prototypes for georadar, hyperspectral imaging,[4] chemico -aromatic sensors[5] currently being developed hold out promise, they are not yet capable of guaranteeing a level of accuracy and portability which would allow them to be substituted for the systems currently in place. Drone research therefore points towards improving the performance of drones themselves as facilitators of this integrated approach, and aims towards developing new systems for the deployment of sensory solutions complementary to traditional instruments.

The role of drones at the European level

After emerging and evolving in the military sphere from initial attempts to develop unmanned vehicles and devices,[6] the application of unmanned or autonomous aerial vehicles (better known as drones owing to the sound made by the worker bee) has in recent times extended first to the commercial sector and then only later to the humanitarian one. Despite the fact that drones only recently became part of the technological portfolio of humanitarian tools, they have rapidly established themselves as one of the most promising instruments thanks to their flexibility of use and their capacity for overcoming one of the major obstacles that had prevented the full realization of terrestrial robotics projects, namely the need to operate in rough or rubble-ridden ravaged terrain. After an initial period of reflection among experts in the field on finding ways to avoid problems of perception tied to the use of technology with such strong military associations, drones rapidly found their role in humanitarian intervention first in disaster response, and later also in damage evaluation operations. Demining is still one of the areas in which the role of drones remains speculative and uncertain.

In order to study the potential limits and possibilities of such solutions, and to develop a set of tools appropriate for the intervention teams, a number of drones were evaluated and acquired during the Tiramisu project and one of these is currently being tested for use in demining. One of the main objectives of the programmes was indeed to improve aerial technologies in support of tactical systems (Advanced Intelligence Decision Support System, AIDSS) used by mine clearance squads in zones suspected of contamination. The introduction of new techniques (marked by the transformation of AIDSS into T-AIDSS, where the added T indicates the new model developed by the Tiramisu programme) should allow for the identification of new areas suspected of contamination over which no previous data exists without requiring an exploratory role for mine-clearers,[7] thus reducing risks, costs and delay.

In 2012, the ICARUS programme, promoted by the European Union to develop strategies and technologies for relief operations using pilotless means[8] and formed by a consortium of 24 technical partners at European level, was added to the initiatives already underway to create an understanding of the real impact made by the introduction of drones in humanitarian action. After years of study and tests on the ground, the European project allowed for not only the improvement of numerous autonomous mechanisms of terrestrial, maritime and aerial relief, but it also demonstrated how such systems can improve by integrating their respective systems. The notable progress achieved was highlighted by the many acknowledgements received by members of the consortium in the 2015 edition of the Eurathlon, a sector-specific competition dedicated to control operations of autonomous vehicles out of the line of sight. The potential for the role of drones, already defined as extraordinary in the conclusions of the Tiramisu project, was confirmed by the preliminary results of the Icarus programme[9] and by the introduction of drones in the context of the relief operations in the Balkans following the floods of May 2014.[10]

In the light of these excellent results, the European Commission's Humanitarian Aid and Civil Protection Agency (ECHO) recently commissioned the Swiss Foundation for Mine Action and CartONG to carry out a biennial study intended to consolidate the different practices and technologies for the use of drones in humanitarian actions.[11] Conclusions are expected in 2017, and the initiative has already produced some case studies, field tests and seminars dedicated to various tactical and operative aspects; in particular, it has highlighted the value added of using aerial solutions for mapping purposes. This 'Drones for Humanitarian Action' programme has in the course of its analysis devoted special attention to the Balkan intervention, treating this evidence as a study case of particular relevance.[12]

The Balkan context and the use of drones for humanitarian ends: two challenges

Introduction

ccording to the latest estimates dating from 2015, the Balkan region, which includes Bosnia-Herzegovina and Croatia, remains one of the areas with the highest number of landmines. In particular, Bosnia-Herzegovina is to date one of the countries most contaminated by landmines in the world. The zones suspected of contamination amount to 1,176.50 km2 or 2.3% of the country's total surface area. The authorities have identified 1,417 communities as being at risk out of a total of about 540,000 inhabitants (15% of the total population), endangered by the presence of 120,000 landmines and explosive fragments which have yet to be found. Since 1996, a total of 1,732 people fell victim to incidents relating to mines or explosive fragments, out of which 603 were fatalities. In 2015, in Bosnia-Herzegovina alone there were 4,500 mine clearance projects awaiting implementation.[13] The zones at risk or identified as mined are mainly concentrated along the borders and the internal fronts of the Balkan conflict, as shown in Figure 1.

Figure 1: Mine concentration in the Balkan region in 2008.
Source: UNEP/BIHMAC

Contamination by explosive devices and the 2014 floods

Between 13 and 18 May 2014, cyclone Tamara/Yvette brought about the worst floods in Bosnia-Herzegovina, Croatia and Serbia in 120 years. In total, the zones flooded in a short space of time were estimated to extend 831.4 km^2, of which 48.96 km^2 were considered potentially contaminated by mines or explosive devices.[14] As shown in Figure 2, the flooded areas largely coincide with the zones identified as being contaminated or at risk of contamination. The heavy rains, landslides, and the over-flowing of rivers and torrents affected the mined terrain in the region, thus changing the pattern of contamination by explosives as understood prior to the floods.[15] In the areas known or reputed to be contaminated alone, a total of 35 landslides transformed local hydrogeological structures to the point that all identification references were lost[16] and the positions of landmines were substantially changed. For example, the explosive device which was displaced the farthest was found more than 23 km from its point of origin,[17] which makes it easy to understand why the United Nations estimated that 70% of the area affected by flooding could now be considered contaminated.[18] The Mine Action Centre Bosnia and Herzegovina (BHMAC)[19] quickly realized the risk of displacement of explosive devices to new locations, and the increased danger to returning local populations afflicted by the natural disaster but unaware of the new situation of contamination. Conscious of the need for immediate action, the BHMAC went into action in response to the emergency upon the request of the Commission for National Mine Clearance.

From 15 May 2014, BHMAC conducted a series of communication and monitoring initiatives with the aim of preventing accidents and preparing rapid intervention to ensure security in the areas at risk. Following preliminary investigations, BHMAC identified certain priority micro-areas needing mine clearance, emergency demarcation and urgent terrestrial surveying.[20] In the hours following the end of the rains, the local intervention groups carried out mine clearance operations in 28 localities in a total area of some 555,000 m^2, identifying and destroying 47 anti-personnel mines and 26 explosive fragments. The accredited intervention groups intervened in 4 cities and 41 municipalities in Bosnia-Herzegovina, recovering and destroying 1,266 explosive fragments, 140 landmines and more than 42,488 small calibre cartridges.[21]

Figure 2: Map of 2014 floods (in blue) superimposed by the Author onto the map of zones contaminated by explosive devices (in red) according to information available in September 2008.
Sources: ECHO, BHMAC, UNEP, MINE.BA and EUFO.R/NATO.
Note: The superimposition is purely indicative and is for informative purposes only

Migratory flows on the Balkan route

The Balkan route has been a very popular path for entry into the European Union since 2012, when restrictions relative to the Schengen visa were made less stringent for the five countries in the region, namely Albania, Bosnia-Herzegovina, Montenegro, Serbia and the Republic of Macedonia. Following the deterioration in security conditions in wide areas of the Middle East and East Asia, some 20,000 people crossed the Hungarian border illegally in 2013. In reaction, the Hungarian authorities immediately tightened controls at the frontiers and modified the laws regulating entry into their country, thereby obtaining a temporary reduction of migratory flows in the area. In 2014, following an intensification in conflicts, the number of migrants, above all Syrians and Somalis, significantly increased. Specifically, numbers increased due to the irregular movement of nationals from Balkan countries (mainly coming from Kosovo).[22]

Faced with the rise in migratory flows at its borders, together with internal tensions over the management and capacity of its own reception centres as well as internal political pressures, Hungary responded by repeatedly declaring the closure of its borders. This was accompanied by the construction of physical barriers and the reinforcement of military and police forces at the main crossing points. As a consequence, the migrants' route moved eastward towards Bosnia and Croatia (Figure 4). As can be seen in Figure 3, in Croatia in 2015 alone, some 764,000 crossings were logged, representing an increase of 16 times the number for 2014.

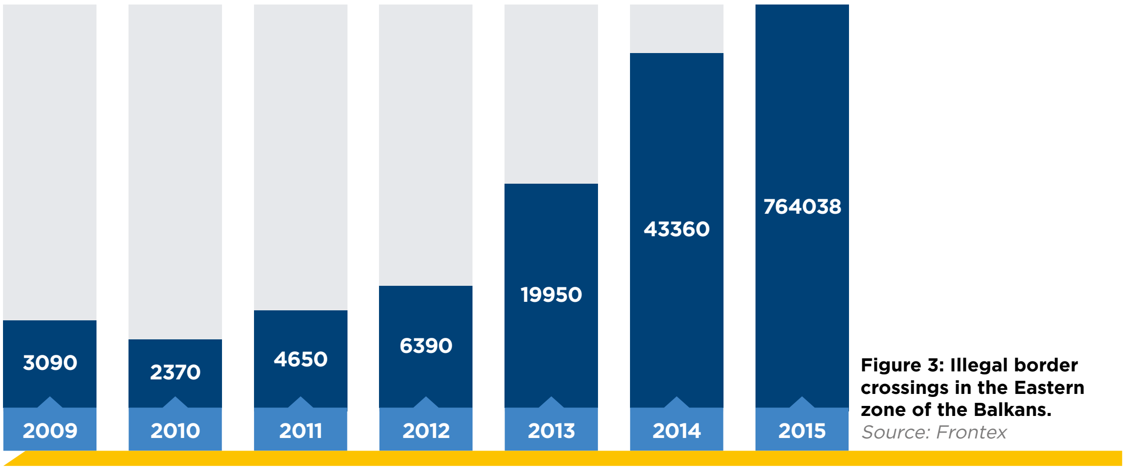

Figure 3: Illegal border crossings in the Eastern zone of the Balkans.
Source: Frontex

The closure of the traditional Serbia-Hungary migratory axis and the opening of the less tested Serbia-Bosnia/Croatia route also brought an increased risk for refugees and migrants crossing areas potentially contaminated by explosive devices.

Despite the fact that, according to BHMAC, the main regional border crossings do not present any contamination problems,[23] the presence of illegal migratory flows outside the official entry points could expose migrants to the risk of entering mined areas. In normal times, almost all of these minefields are duly marked and signposted, thus reducing the risk of accidents but, due to the floods, BHMAC has been forced to consider all official sign postings in the disaster affected zone as unreliable and thus devoid of value. Consequently, BHMAC has had to face up to yet more pressure in its response: every mine movement had to be traced, verified, documented and the newly contaminated zone had to be marked out before migratory flows could resume crossing the areas affected by the flooding.

Figure 4: Map of the new Balkan migrant route following the closure of the Hungarian border (detail of original map).
Source for original map: Gene Thorp/The Washington Post

The role of drones in the response to the Balkan crisis

Mine clearance support operations

The complexity of the Balkan scenario as outlined in the previous section has challenged both national and international response teams with important and atypical choices in terms of resource deployment. At the European level, many European states have responded to requests for assistance from the flooded countries with human or technical resources, notably via coordination of organizations forming part of the EU Civil Protection Mechanism. In particular, the Belgian Royal Military Academy (RMA) has deployed its own rapid support team (Belgian First Aid and Support, B-Fast). The B-Fast team was mobilized mainly to provide assistance in re-establishing access to water to civil and sanitary facilities. By agreement with BHMAC and working in coordination with the Tiramisu and Icarus programmes, the team also continued its efforts in initiating intervention protocols for providing support in mine clearance operations.[24]

Reinforcing the tools already available, which include a Bosnian armed forces Gazelle helicopter, B-Fast provided a MD4-1000 Multicopter drone manufactured by Microdrones, and two sensors: a high resolution photographic camera (Sony NEX-7 24.3 megapixel)[25] and a near infrared (NIR) spectroscopy sensor. The model of drone employed has a flying autonomy of up to 88 minutes and a range of some 40 km. The response team manned by personnel from B-Fast and BHMAC logged a total of 20 flights in 13 different localities. Flight times lasted around 25 and 30 minutes on average, and each flight enabled the capture of between 200 and 500 images at a resolution of 2-5 cm over several hundred square metres.[26] In respect of existing legislation and of agreements previously reached with authorities in the course of joint operations, all flights were conducted below an altitude of 150 m within their operators' line of sight, and all operators were equipped with valid licences for flying drones over national territory.

The drones were used in zones where the use of a helicopter would not have been possible or sustainable; they were used to create high resolution 2D or 3D models, limit research zones to a reduced area, as well as to curb the time, costs and risks posed by intervention. Firstly, thanks to their high definition, the images collected were analysed algorithmically in order to carry out initial identification of any landmines which had emerged, or for identifying signs of the possible presence of such objects (Figure 5).

DETECTED:
PMR-3 Yugoslavian
anti-personnel stake mine

Figure 5: Identification of mines dislodged by floods and landslides using aerial images.
Source: ICARUS

Subsequently, the data produced by the flights was processed by the response team and placed at the disposal of Sarajevo University's specialists who, after cross-referencing with information previously culled from "non-technical"[27] methods of detection, elaborated complex 3D maps, ortho-photographic projections and digital models of the terrain in order to reconstruct the displacement of the landmines (figure 6).[28]

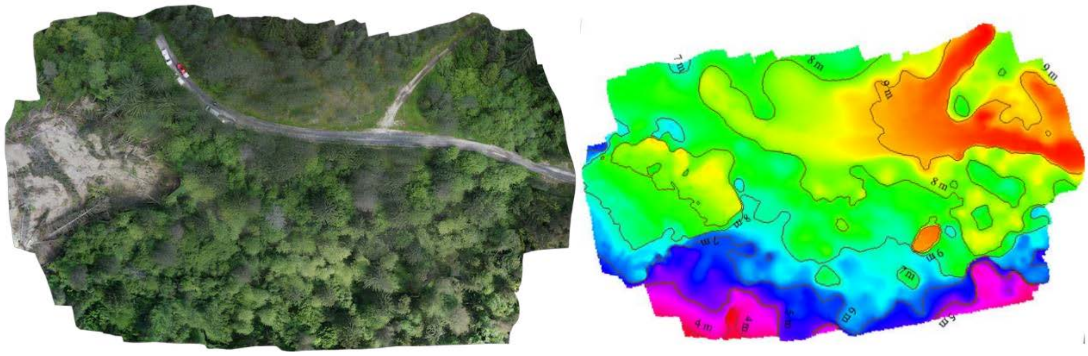

Figure 6: Post-processing and graphic data supplied by drones for the purposes of mine clearance. Left: High-resolution ortho-mosaic of a minefield affected by landslide. Right: the corresponding altimetric digital model.
Source: ICARUS

Lessons learned and conclusions

The instruments installed on the drones provided information whose value varies considerably according to the specific context of the operation, even in the same geographic region. For example, infrared detection systems analyse changes of temperature between the device and the surrounding ground. However, their usefulness depends on meteorological conditions as well as the size and composition of the device, and they are less reliable when the device is more deeply embedded. In general, this system is compatible with the search for minefields rather than the identification of single explosive devices.[29] Instead, data provided by imaging spectroscopy allows for identifying classification and changes in compositional matter of the objects by measuring their specific spectral characteristics.[30]

In the Balkan example, Hyperspectral Sensing has shown itself extremely effective in identifying minefields in Croatia. In Bosnia-Herzegovina, the aim was instead the identification of new locations of small groups of mines dislodged by the 2014 floods. The use of a photographic camera accompanied by a near infrared spectroscopy sensor enabled the intervention teams to observe changes in the ground and to support the mine clearance operations.[31] The choice of strategy and equipment deployed, as well as the specific technical expertise of the personnel thus proved fundamental in enabling the intervention teams to provide the necessary support to the humanitarian effort in the shortest possible time.

The helicopters flew over a much greater area to monitor damage and bring assistance compared to the drones. However, helicopters could not have been used in many of the areas covered by the drone. The drone proved essential for covering a large number of small and scattered minefields (the most extensive area covered by the drone measured 2.5 km), and this would have rendered the use of a helicopter excessively costly in terms of time and resources. In contrast to the helicopters, the drone also had the advantage of flying at lower altitudes in greater safety and without causing disturbance to local inhabitants.[32] In short, the predominant use of helicopters in the context of the floods is attributable to the simultaneous execution of classic operations of research and relief, as well as to the limited availability of drones and qualified operators on the ground rather than to any effective superiority of the technical means. As BHMAC itself has affirmed, the results of rapid mapping realized thanks to drones proved crucial in evaluating damage and identifying the new locations of the numerous explosive devices dislodged by landslides.

In terms of safety and budget, the operation encountered only one incident of a fallen drone which needed repairs costing some €6,000. Yet, even including this sum, the total cost of the drone deployment following the floods came to €15,000 (excluding the costs of personnel provided by the RMA, and local transport and lodging covered by the Bosnian government).[33] It can be seen how costs are considerably lower than those required by the use of helicopters for the same function, not excluding the increased risk posed for crew and for populations over which helicopters fly.

Amongst the most frequent observations about logistical aspects made by the experts involved in these operations, is the importance of including in the intervention teams some local experts whose linguistic, geographic and cultural knowledge is fundamental to the successful development of operations (the B-Fast team was guided by an expert native to the region). The experience in responding to the flooding emergency of the international intervention group also demonstrated the value added of appropriate joint operations between the various teams in countries at risk so as to ensure that members have all the documents necessary to operate in the local context, and that they are familiar with relevant regulations. In this case, for example, the operators already had licences to guide drones in Bosnia, knew the procedures for obtaining the necessary authorisations for bringing equipment into the country and the rules of the national civil aviation authority for the use of unmanned or remote-controlled aircraft.

In conclusion, in operations where access is difficult and even dangerous, the use of drones is advantageous because of lower costs, ease of portability and the variety of possible uses on the ground. Above all, where infrastructure is limited, the fact that drones do not rely on take-off or landing strips makes them an option which is both flexible and efficient. On the basis of the Balkan experience, not only in the study and test phase but also in the course of operations during the emergency, considerable added value emerges from the use of drones in the tactical phase of mine clearance. Monitoring, evaluation, non-technical mapping (namely by the identification of signs compatible with possible ground contamination) and planning occur incomparably faster and more economically thanks to the support of drones accompanied by appropriate capabilities for post-processing data. Altogether, this also allows the teams on the ground to concentrate on priority operations without having to enter high risk zones unless strictly necessary.[34] A diametrically different argument is to be made regarding operations for the technical identification and neutralization of mines. The current limitations of sensors, their size and respective weight still render necessary the intervention of ground teams equipped with traditional instruments, relegating drones to the role of observation and monitoring of operations as we await new more stable and larger models of drone, and lighter and more accurate sensors even at greater distances above ground.

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