

In Bosnia, the presence of many Explosive Remnants of

War created an extremely dangerous situation for the local population and the relief workers. Therefore, on the field, the mission also assisted a team of the Bosnian Mine Action Centre (BHMAC) which was deployed to multiple regions of the country in order to localize the displaced ERW. The relief efforts were rendered very difficult due to the destroyed infrastructure, broken telecommunication links, blackouts, etc. The problem of shifting minefields also hampered the provision of aid and relief and debris clearance.

II. UAS DEPLOYMENT FOR RELIEF OPERATIONS SUPPORT

The UAS mission received the full support from the Federal Civil Protection of Bosnia and Herzegovina, the Ministry of Security and the Bosnian Mine Action Centre (BHMAC). After a coordination meeting in the Bosnian capital Sarajevo with the Bosnian Ministry of Security, a flight permit was issued for the UAS for the complete Bosnian territory to support the relief and demining operations.

One of the cities which was hit most by the floods was the city of Orasje (located north-east) where B-FAST was deployed. The UAV was first deployed here to assist the B-FAST team for assessing the optimal location to install their high-pressure pumps and to monitor the water levels, as shown on Figure 2a to 2c. The problem with the installation of the water pumping system was that water levels were not decreasing after multiple days of pumping, due to an undetected dike breach. The ICARUS-TIRAMISU UAS was able to locate this broken dam, as shown on Figure 2d. Expert analysis indicated that this dam breach could not have been caused by natural means, so the Bosnian Ministry of Justice has started a justice case against the individual(s) who may have caused it and commissioned the ICARUS-TIRAMISU UAV image material as evidence. The UAS proved very useful in support here to quickly detect dike breaches and to map the area quickly. Landing on dry land was a challenge, however, as there were virtually no spots of clear and open land suited for takeoff and landing. As a result, all takeoff and landing operations were done on remote control by a trained pilot.

Next to the operations in support of the B-FAST team, the UAS was also deployed on request of the German Federal Agency for Technical Relief team (Bundesanstalt Technisches Hilfswerk - THW) and Austrian relief workers working on the incident site. These teams asked for assistance of our UAV system for aerial inspection, damage analysis and improving their situation awareness and for selecting the optimal location for the installation of the high-pressure water pumps.

The Ministry of Security and the Federal Civil Protection of Bosnia and Herzegovina also asked for UAV aerial support in the region of Kopanice (Southeast of Orasje), where the flood waters from Sava River broke the dams. The flood waters flowed through these breaches and completely submerged the agricultural lands and all the people needed to be evacuated. This mission was especially risky because the location of the broken dam area was in a mine suspected region.

During the mission, we often faced the problem to get around from one place to another, as this was very difficult due to the damaged infrastructure (see Figure 2e).



(a) City of Orasje



(b) UAS used for the operations



(c) Optimization of the location for the B-FAST water pumps



(d) Broken dam on the Sava river detected by the UAS



(e) Damage assessment for mapping infrastructure damage

Fig. 2: UAS used for relief operations support

III. UAS DEPLOYMENT FOR DEMINING OPERATIONS SUPPORT

Bosnia and Herzegovina was contaminated with land mines due to the war from 1992 to 1995 and as a result the country has one of the most serious land mine problems in the world. By the end of the war in 1996, around two million land mines and unexploded munitions littered the country. By September 2013 land mines and unexploded munitions remained scattered in 28.699 locations. From 1992 to 2008, 5.005 people were killed or injured by land mines or unexploded munitions [6], [7]. Before the floods, approximately 540.000 citizens (of around 4 million total population) were affected by mines, and around 1.230,70km (2,4 percent of the country's territory) was mined [6].

One of the cities which was hit hard by the floods was the city of Maglaj, as shown on figure 3a. An additional problem in this region was the presence of many Explosive Remnants of War (ERW), rendering the deployment and work of the relief teams extremely dangerous. As a result, it was decided to deploy the UAV system for inspection flights, especially into areas where the relief teams could not access due to the high risks. The UAV was used for aerial assessment and mapping of the mine-suspected areas and to find indicators of where the minefields were shifted due to the floods and landslides. Figure 3b shows a re-allocated minefield due to landslides. The data of the UAV was mostly important in assessing the ground movement due to these landslides.

Figure 4 shows the first post-processing results of the region Zavidovici- Dolac (central Bosnia and Herzegovina). The UAV was used for providing 3D-maps of the environment to analyze the effects of the landslides on mines and ERW. This results has been used by BHMACH for the localization of displaced ERW, damage assessment, and documentation purposes.

To give an indication of the scale of the problem, it can be reported that mines were detected up to 23 kilometers from their original location. This means that the search area is huge and that the effectiveness of area reduction techniques like the use of the UAV, combined with 3D mapping predicting the ERW-movement and thereby limiting the search area, can be dramatic.

IV. CONCLUSION

In this paper, a report on the operational deployment of novel technological tools for crisis relief in an actual crisis situation has been presented. An unmanned aerial system equipped with sophisticated 3D data processing algorithms was deployed to help with the relief efforts after the 2014 floods in the Balkans. The tools were used in support of relief teams for damage assessment and for helping to localize landmine-suspected areas. The response from the response teams brought into contact with the unmanned tools was very positive. As a closing remark, one of the end-users (the B-FAST team leader), noted that the aerial assessment done by the UAS in 2 hours saved the team 3 days. Such important time-savings can be a matter of life and death in crisis response scenarios.



(a) City of Maglaj



(b) Re-location of mines due the landslides



(c) Detected Anti-Personal Mine (re-allocated mine due to the landslides)

Fig. 3: UAS used for demining operations support

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(a) High-resolution orthomosaic



(b) Digital terrain model of a landslide

Fig. 4: Post-processing of UAS data for demining

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