DG ECHO LEAPFROG (GA 872233)

Deliverable E.3: White Paper

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The project has received funding from the European Union's 2018 Call for proposals for buffer capacities for addressing temporary shortcomings in extraordinary disasters under grand agreement ECHO/SUB/2018/BUF01/782233.

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1 Introduction

RPAS are becoming a very robust solution during emergency response operations due to their extreme capabilities and relatively low cost. RPAS technologies give the first responder the ability of aerial observation of an event and help towards better understanding of the scene and magnitude of the catastrophe quickly and effectively. For instance, the first responder teams are able to constantly monitor, collect and analyze data in real-time from the aerial platform and save crucial time while at the same time increase the safety of personnel and costs by minimizing the use of manned resources.

Although, RPAS could be a very important tool in the first responders' hands, the effective use of the technology still requires operators to have adequate knowledge of its capabilities and risks. It is very important that the team responsible of deploying the RPAS equipment, should have adequate training, experience and a well-structured team with roles, responsibilities and standard operating procedures that have to be followed at all times. This combination will ensure that the team will always operate in a professional manner, while at the same time respond as quickly as possible to changes and maintaining a very high degree of competencies.

2 RPAS team structure

As explained in the introduction, the RPAS team should be well structured, with clearly defined roles. The team should consist of at least four members each having different responsibilities and duties during an emergency response operation. The fundamental roles of a flight crew are as follows:

a) **Remote Pilot in Command** is the pilot and ultimately responsible person for the aircraft during flight.
b) **Visual Observer** is responsible for controlling any non-flying related equipment attached to the RPAS, for example to control and view the camera feed.

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c) **Technical and Safety officer** is responsible for any technical aspects regarding the equipment as well as ensuring safety of the equipment during an operation.
d) **Liaison Officer** is the communication link between the RPAS team and the incident commander during an emergency event.

It is important that all the flight crew members are well trained in their role both in theoretical and practical aspects. Of course, it is vital that the flight crew members are continuously kept trained by participating in exercises and theoretical training sessions on a regular basis. The following images illustrate the RPAS team of Cyprus Civil Defense during an exercise. In Figure 1, the visual observers are monitoring the live video feed of the RPAS platform and trying to identify any possible victims in a Search & Rescue operation. In Figure 2, the software used by the pilot to control the aircraft is illustrated on the left, and the actual RPAS platform is illustrated on the right.

Figure 1: Visual observers analyse real time video feed

Figure 2: Flight control software and RPAS platform

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3 Equipment and software

Emergency response operations have a wide range of possible events including for example search & rescue, firefighting, post-disaster evaluation, earthquakes disaster evaluation, etc. The equipment should always be chosen depending on the needs and requirements of the mission in order to ensure the best possible outcome.

The equipment of an RPAS team includes both hardware and software. The main equipment components of an RPAS system consist of the actual flight platform, the ground control station, the payload used to collect data (e.g., thermal and RGB cameras, radar, CBRN sensors, etc.) and the software used to control the aircraft and analyze the data.

The RPAS platform is selected based on its flight characteristics and capabilities in relation to the actual operational needs. For example, if the operation requires locating people on shore, then, the RPAS platform should be capable of accessing complicated terrain while at the same time be able to hover in place. Furthermore, it should favorably carry both optical and thermal cameras. Figure 3 shows thermal imagery of an actual Search & Rescue nighttime operation of the Cyprus Civil Defence.

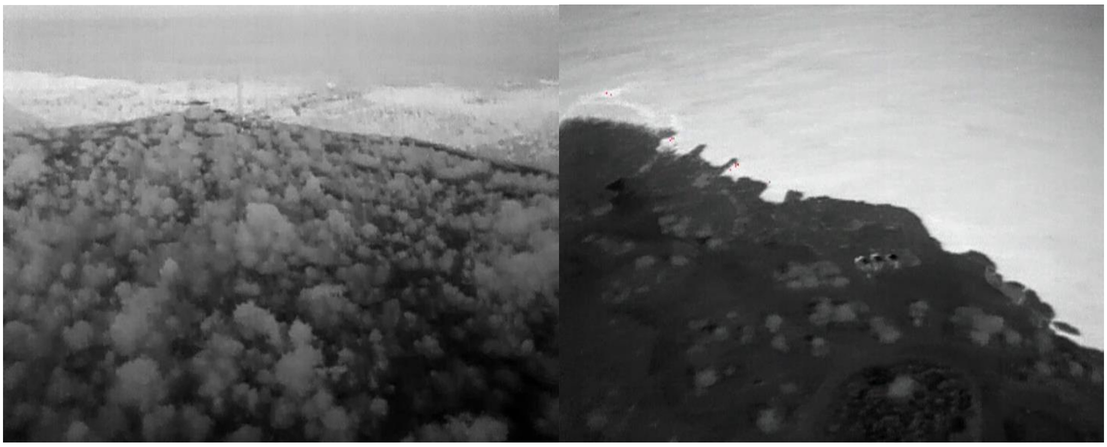

Figure 3: Thermal Imagery of a real Search & Rescue mission in Cyprus.

During an emergency response mission, Visual Observers assume the task to continuously monitor and evaluate the information taken from RPAS sensors. However, for this task to be executed effectively, a live video feed should be send out to a mobile command and control

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(C2) Center (video streaming). In order to send a live video feed from the RPAS unit to the C2 Center, a multimedia server infrastructure should be setup in the field. This server could be a regular laptop that will be able to collect live video from each RPAS in the field without having any dependency to the Internet (local area network). The video feeds are then displayed within the C2 Center for analysis. If Internet access exists, then the local server could transmit the live video feed from the RPAS to receivers outside the area of operation for higher-level decision making.

Beside the actual hardware equipment, software used to operate the RPAS and process the data is equally important for the success of the mission. Software used during an operation includes both the flight control of the RPAS platform and the data analysis platform. It is vital that any software used should be designed bearing in mind the first responder needs and also be user-friendly and practical. For instance, the flight control software should be able to operate without depending on other parameters such as downloading geographical maps from the Internet, since Internet access may be absent in the field. Additionally, it is very important to give the first responder pilot the ability to pre-program a flight plan quickly and easily for purposes of searching a specific area and ensure that the RPAS platform will collect images for the whole area without missing out parts of it. Thereafter, the data may be used to assess a geographical area either for a Search & Rescue mission or for a post-disaster evaluation. This could be done using an aerial mapping methodology as elaborated next.

Aerial mapping is a very useful tool during emergency response missions. The RPAS platform can be pre-programmed to fly autonomously in a specific area and collect imagery in order to perform photogrammetry mapping. Photogrammetry has been established as a new and capable survey methodology, giving new possibilities and prospects in this field. The data required for the implementation of the photogrammetry method is a set of images of the area of interest and a software for the analysis.

In order to have a credible survey, it is necessary to give the correct values to specific parameters prior the flight. These parameters include the overlap percentage of the images, the camera field of view, the RPAS altitude etc. The set of such parameters govern flight planning. Flight planning should be very carefully prepared, following some standard procedures as elaborated in the bullet points below to maintain accurate and quality aerial maps:

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1. The area should be divided into segments called "chunks" depending on the RPAS flight time capabilities. Each chunk's size should be selected according to the maximum flight time capabilities of the RPAS and the wind intensity. Additionally, each image taken should have at least 80% overlap with the previous one for accurately stitching together images and 2D reconstruction.
2. For very large areas the RPAS take-off site may need to change due to the RPAS range limitations. In this case it is important that the operator chooses a site and flying altitude to maintain an approximately equal altitude (Above Sea Level) for completing the survey in order to maintain the accuracy of the overall map.
3. Finally, the operator should always bear in mind that the processing of the data collected may require large computational capabilities depending on the quality of each image as well as the number of images collected and the quality of the stitched map to be produced.

Figure 4 illustrates a flight plan of several "chunks" that are combined together for an photogrammetry mapping of an area. It is important to understand how these "chunks" are overlapped together. The images in each "chunk" in the example below have 80% overlap.

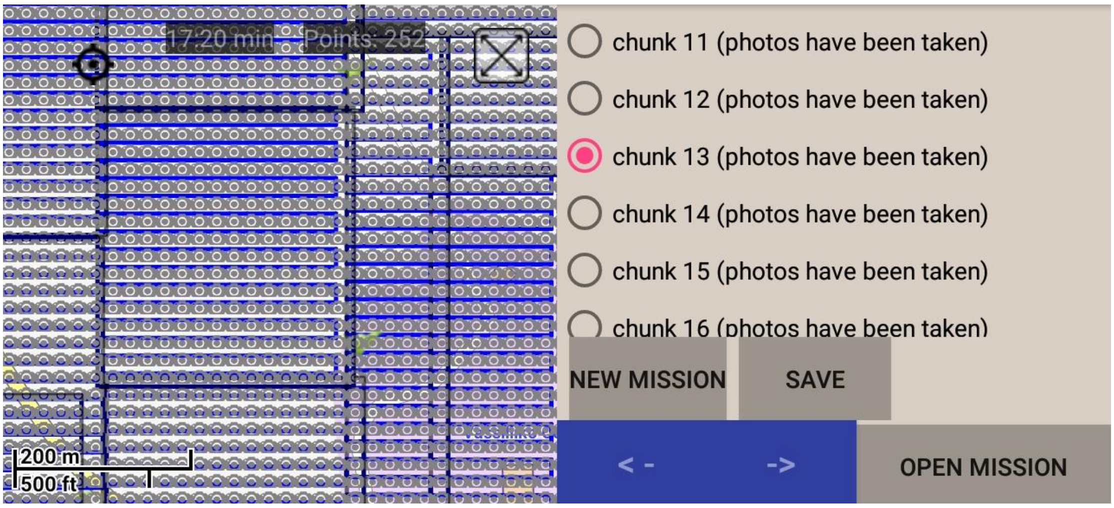

Figure 4: Flight plan for photogrammetry mapping of an area.

The completion of the flight follows the analysis of the images. This analysis is necessary to get the photogrammetric image and construct a model of the geographical area. The 2D/3D visualization always helps in better understanding of the area and its characteristics and can

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clearly illustrate the physical dimensions of the objects. Therefore, photogrammetry is a cost-effective way to construct a model as shown in Figure 5.

Another equally important result of the photogrammetry method, is the orthomosaic (or orthophoto). Orthomosaic is a map of the area which has embedded geographical information that can be used to superimpose the high-resolution image into a map (for example on a Geographical Information System) as shown in Figure 6.

The photogrammetry method gives much more spatial information than other survey methods in much less time, cost and effort. As a result, the photogrammetry methodology is applied in many cases such as the study of natural phenomenon either for prevention or for recording damage disaster.

Figure 5: 3-Dimensional aerial mapping

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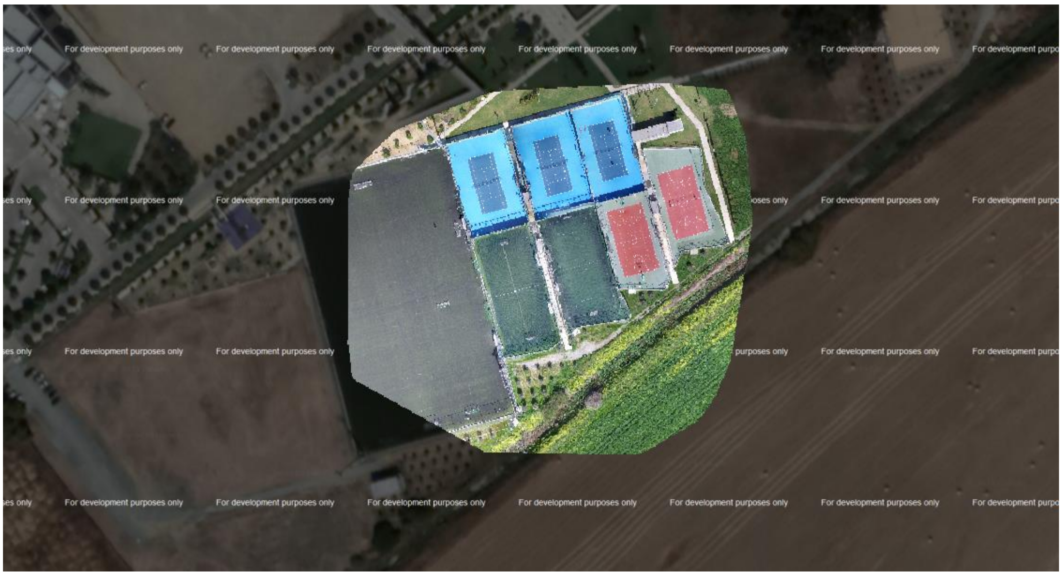

Figure 6: Orthomosaic mapping superimposed onto Google Maps

4 Conclusion

The use of RPAS in emergency response operations offers enormous potentials and unlocks a large set on new capabilities for first responders to safely and rapidly conduct their missions. In order to achieve the best possible results while maintain airworthiness safety standards, it is important to combine a well-structured, trained and professional flight crew team with the suitable state-of-the-art hardware and software solutions and build the competencies in effectively using this equipment in practice through continuous training activities.

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