UAVs Use for the Support of Emergency Response Teams Specific Missions

Sorin-Gabriel CONSTANTINESCU*

*Corresponding author
*UDJG – "Dunarea de Jos" University of Galaţi
Domneasca 29, Galati, Romania,
csg_2364@yahoo.com

DOI: 10.13111/2066-8201.2013.5.1.7

Abstract: *This article presents various methods of implementation for a new technology concerning the assessment and coordination of emergency situations, which is based upon the usage of Unmanned Aerial Vehicles (UAVs). The UAV platform is equipped with optical electronic sensors and other types of sensors, being an aerial surveillance device as efficient as any other classically piloted platform. While currently being in service as military operations support for various operation theaters, they can also be used for assisting emergency response teams, providing full national coverage. For these special response teams, the ability to carry out overview, surveillance or information gathering activities and locating fixed or mobile targets are key components for the successful accomplishment of their missions, which have the purpose of saving lives and properties and of limiting the damage done to the surrounding environment. More concretely, the presented scenarios are: response in emergency situations, extinguishing of large-scale fires, testing of chemically, biologically or radioactively polluted areas and assessment of natural disasters.*

Key Words: *UAV (unmanned aerial vehicle), natural disasters, mission scenarios, large-scale fires, chemical/biological/radioactive pollution.*

1. INTRODUCTION

Due to the increasing occurrence of natural and man-made disasters and also to their rapidly growing proportions, emergency response forces have to identify new and innovative technologies that will enable them to fulfill their missions more effectively. In order to organize judicious interventions and to properly protect their team members, it's necessary to employ means for real time data collection over large area surfaces of land, that are not directly exposed to aggressive conditions of the environment in which they operate, and that are able to relay the collected information to a safe distance. All of these requirements can be fully met only by an aerial platform which is able to cover the whole area of interest, to collect the necessary information using the onboard sensors, and to relay that information to the forces engaged in action. Usually, there are used conventional aircrafts – such as airplanes or balloons – that have a human crew on board for the flight management and the handling of craft sensors [2, 3].

These types of aircrafts are a relatively expensive solution as compared to similar terrestrial and naval ones, which in addition expose the human crew to the dangers of the environment. The development of flight management and telecommunication areas have allowed the design of aerial robots that are able to fly on the same principle as conventional aircrafts, can be remotely controlled and can operate in automatic flight patterns [4]. Having a size and weight much smaller than conventional aircrafts, these platforms are able to carry a great number of on-board sensors, like electro-optical sensors for day or night vision, or

sensors used for determining environmental characteristics (concentration of various gases, detection of biological agents or radioactive material, etc), that can collect data for on-board storage or for real-time transmission to the ground station.

By comparison with conventional aircrafts, these platforms have been named Unmanned Aircrafts (UAV). Having miniaturized on-board devices, which has led to a considerable reduction of their weight and size, they can stay airborne for much longer than real-scale planes due to their lower energy consumption. Because of their low operating and acquisition costs, the elimination of potential danger for the human operator, and the ability to collect information over large areas and make them available shortly after the occurrence of the event, the UAV can be used as support for emergency forces, when they are engaged in high risk large-scale hazardous activities [2, 3, 5].

2. POSSIBLE MISSIONS

2.1 Emergency situation response

Summary: After floods, dam breaks, landslides, storms, avalanches, heavy snowfalls, industrial accidents, nuclear reactor damage, the access in the affected area can no longer be made using the usual roads, which are destroyed or blocked on long distances, therefore any human presence could be dangerous. The only method of gathering information from the affected area is therefore the air observation by satellite, airplane or helicopter. The usage of these means of observation is costly and life-threatening for the human crew.

The cheaper and risk free alternative is the UAV platform. This platform can stay airborne for a long period of time over the affected area, entering safely in areas that are polluted with chemicals released in the air from a chemical or nuclear accident. Real-time aerial footage is available on the ground for the response teams that analyze them with experts in various fields of science in order to assess the risks and determine intervention scenarios which limit damage and reduce any threats to population and infrastructure in the area.

Also, the interventions can by monitored from above in order to achieve a better team coordination on the ground, and to have advance warning of any risks that may emerge during the development of the intervention. Any population that has taken refuge in a safer place and needs to be evacuated can be more easily detected and localized from the sky.

In case of accidents or damage to industrial or nuclear plants, the situation assessment can be performed without any need of human presence in the area. The UAV platforms may also have on-board sensors for determining the concentration of chemical agents in the air, or the intensity of the radiation, allowing the drawing of a map with risk area, based on which routes for the emergency teams will be established.

The UAV can keep under surveillance for a long time a dam that may break at any time and endanger the lives of the population. Airborne imaging of a river basin can be taken consecutively at a certain interval, allowing the speed and direction of a flood to be determined by comparison of the imaging, thus ensuring a timely decision of evacuation for a certain area.

Most UAV flights would take place in difficult weather conditions, during a long-term mission that targets the surveillance of large areas of ground.

Purpose: Overseeing the development of natural phenomenon. Determining the location of endangered people. Detecting threats to critical infrastructure.

Objectives: Protection of life. Protection of national economy.

Methods:

- continuous shooting by day and night, in low visibility conditions;
- infrared film;
- high-resolution photos.

Monitored activities:

- evolution of natural phenomenon;
- endangered population;
- critical infrastructure elements in risks.

Land Characteristics: Missions can take place all over the country. Flood affected areas are located in major rivers areas or at the base of mountain slopes, in valleys. Rescue missions objectives are smaller or larger settlements, villages or cities. Landslides occur in mountainous or hilly areas. Land subsidence takes place over abandoned mining galleries in hilly or mountainous areas. Explosions accompanied by large-scale fires occur at chemical plants or refineries. Earthquakes, depending on the direction of propagation of seismic waves, may affect various areas situated all over the country.

Climate/ weather: Even though industrial accidents, earthquakes, land subsidence, may occur in any season of the year, the floods and landslides occur especially in warm seasons, inside areas where usually fall large amounts of precipitations, or alongside the course of large rivers. In the latter case, missions usually take place on stormy weather with low visibility and strong wind.

Scenarios:

- A small UAV platform will be launched by members of a mobile patrol. It will survey areas of 10x50 km, at heights of 1000-1500m, and it will transmit images which by comparison over a period of time allow the evaluation of the evolution speed and direction of the phenomenon. Based on these images, evacuation plans for affected settlements may be established, or infrastructure consolidation or repair works may be further decided. The ground search and rescue teams will be coordinated also on the basis of real time aerial footage. After the occurrence of the phenomena, property damage will be assessed and potential survivors will be identified. The UAV will be recovered only inside a safe area.
- A small UAV platform will be launched by members of a rescue team. It will ascend to a height of 150-300m, where it will perform stationary flight above and area with a radius of 500-1000m. Survivors that have taken refuge in safer areas (rooftops, hilltops) are detected from the air. They are localized, and rescue teams are dispatched to their location. The rescue operation is overseen from the air in order to avoid any other hazards that may emerge over the duration of the mission. After this is done, the UAV resumes its search mission. The UAV will be recovered only inside a safe area.
- A small UAV platform will be launched by a surveillance center. It will move quickly over the area in which the phenomenon has been reported. It transmits live imaging from the site to the center. The images are analyzed thus providing a base for establishing the action plan and the number and type of teams that are to be dispatched on the scene. The UAV overviews the area until the arrival of the teams. Optionally, it gathers information about the state of the channels of communication in the region and about the evolution of the phenomenon. On arrival of the response teams, it hands over the mission to a more specialised UAV or it continues to survey the area in search of survivors.

2.2 Large-scale fire extinguishing

Summary: Aerial surveillance of forest fires has great value in the support of the firefighting teams on the ground. The UAV is the only mean of carrying out these missions

where it is too dangerous or too expensive to use a conventional aircraft. With the help of the on board equipment fire outbreaks can be located, real time mapping of the area can be executed, and an analysis in different spectral bands can be done.

The aerial footage allows rapid development of an action plan, before it engulfs other areas in the nearby vicinity. Where suburbs of human settlements are threatened, evacuation decisions can be taken with enough time left to save lives and a considerable part of private property.

The analysis of the operational situation based upon an overview of the fire affected area allows for a correct evaluation of risks before sending the firefighters in action. Certain operations maybe cancelled because of the high risk that they pose to the ground team's lives. The initial action plan can be altered, and other means of intervention may be deployed instead of the firefighter team.

In case of sudden changes in the tactical situation, because of a change in the direction or intensification of the wind, the firefighters will be called back in time and secured.

The various spectral bands analysis of the fire may lead to a better air deployment of extinguishing material with much more precision over the focal points of the fire.

The coordination of the manpower and means that take part in the fire extinguishing is much more effective when based on the general overview of the area, which can only be acquired from the air.

Purpose: Fire detection and fire fighter teams' coordination.

Objectives: Protection of life. Protection of national economy. Protection of environment.

Methods:

- continuous shooting by day and night, in low visibility conditions;
- infrared film;
- high-resolution photos.

Monitored activities:

- discovery of fire outbreaks;
- detection of human and animal life endangered by the fire;
- coordination of the firefighting teams.

Land Characteristics: Large-scale fires occur in the forest, regardless of terrain, or in areas with wild vegetation (in the plains, plateaus or hills). Stubble fires occur in plains, where large areas of grains are cultivated, after the harvest. They can be caused by extreme heat or by human negligence. The main features of these fires are that they cover large areas of tenths or hundreds of hectares and extend rapidly due to the wind and are difficult to locate and extinguish. The extinguishing action may last from several days to several weeks, involving a large number of people that have to act coordinately even though they are spread over a large area. Fires often break out in areas with rugged terrain that have few or no roads, where firefighters can only act on foot.

Climate/ weather: The main season in which vegetation fires break out is the summer, during the very high temperature moments, above $35 \div 40^0$C. They are favored by the action of wind. In the proximity of the fires, the temperature rises to about $60 \div 70^0$C and creates ascending hot air currents.

Scenarios:

- A small UAV platform is launched by members of a mobile firefighter team. It will fly to an altitude of 800-1500m over areas that pose a fire risk travelling on various trajectories in order to cover as much ground as possible from the surveyed area. The images will be transmitted back to the mobile unit or directly to the command center. When fire outbursts are confirmed, they will be located, and firefighting teams will be dispatched. The

platform will constantly monitor the fire in order to be able to predict its evolution pattern and to coordinate the firefighter teams for a successful and fast containment. With the help of infrared photography, potential human or animal beings endangered by the fire will be detected and rescue teams will be sent to help them. Furthermore, air tankers and helicopters that are helping in the extinguishing of the fire will be guided more to launch their cargo more efficiently.

- A small UAV platform that is patrolling an area will detect fire outbursts. Based on the acquired information, those spots will be located and firefighter teams will be dispatched to deal with them. The UAV will perform stationary flight over the fire and will relay tactical information to the command center and to the mobile teams on the ground. With the help of aerial photography, the evolution pattern of the fire will be predicted, and measures will be taken in order to evacuate human or animal beings and property endangered by the fire. Ground actions will be coordinated based on the aerial footage received. The UAV will hand over the mission to more specialised platforms that will be launched by firefighters. Due to the rugged terrain in which it operates, a relay network is required through which the data transmission, the command and the control of the UAV will be conducted.
- A small UAV platform is launched by members of a firefighter team that are responding to an emergency. It will rise to an altitude of 300-500m from where it will transmit video footage with the affected area. The range of action will be limited to about 500-1000m. The images will be analysed on the ground, where an action plan will be devised. The affected area will be continuously monitored in order to be able to make the necessary changes in the action plan. The UAV will be recovered by the response team in an area where it can safely land.

2.3 Investigation of chemically, biologically or radioactively polluted areas

Summary: Polluting substances are lethal for the human body over certain quantities. These harmful concentrations must be avoided, therefore prior to entering into an area damaged by these toxic substances, it is necessary to know the concentrations released into the air. These determinations are made by research teams wearing protective suits, but they can still be exposed to a certain extent. Nowadays, terrestrial robots are used, but they might still be impaired by a harsh terrain with obstacles, leading to an increase in the operation duration, which could prevent timely intervention for the removal of the damage causing agent and restraining of the effects.

In order to overcome all these problems, there is only one viable solution, which is to use an aerial platform for the transporting of the sensors. Most areas where such problems occur are usually tightly packed with industrial facilities, pipes and tanks, therefore conventional aircrafts cannot operate in such crowded places. A very efficient alternative is the UAV, which has very small dimensions. Based on the gathered information, a map of the substance concentration can be executed, and decisions to dispatch intervention teams can be made in order to locate the sources of pollution. The life and safety of the team members will be better protected, and the action will be executed more precisely.

Purpose: Detection and tracking of hazardous substances.

Objectives: Protection of life. Protection of national economy. Protection of environment.

Methods:

- continuous shooting by day and night, in low visibility conditions;
- infrared film;
- high-resolution photos;
- detection of substance content and radiation level.

Monitored activities:

- detection and tracking of pollution sources;
- detecting the level of danger for human and animal life.

Land Characteristics: Pollution usually occurs in the area of an industrial objective or along the route of a special transport. Inside an industrial area there are industrial facilities, pipes, tanks and high chimneys. Special transport deliveries are done on common infrastructure ways.

Climate/ Weather: Accidents might happen in any season of the year and in any region of the country.

Scenarios:

- A small UAV platform is launched by members of an intervention team. It will fly at a low altitude of 5-10m detecting the presence and concentration of the substances. It will follow a brushing pattern of the objective at low speeds of 5-10 km/h. The information will be received by the intervention teams in order to be able to execute a map of the pollution sources, base on which the intervention plan will be devised. When the team enters the area, the UAV will be raised to 10-15m in order to monitor the development of the intervention. To avoid contact with the installations in the area, the platform will be equipped with anti-collision sensors. After recovery, the UAV will be decontaminated.

2.4 Natural disasters assessment

Summary: Natural disasters are phenomenon or accidents which result in serious disruption in social and economic life of a community through material damage accompanied by the loss of many lives. Communication routes, electricity supply, water and sewerage networks are destroyed over large area. Many people remain homeless or are reported missing. The food and water supplies are very hard to procure.

Access to these areas by terrestrial means in order to gather in site information is very hard or nearly impossible.

The access can be more easily achieved by conventional aerial means, but they can have a damaged take off infrastructure or even flight restrictions over areas that are clogged with smoke or dust.

An UAV platform has far fewer limitations and can take off the ground almost immediately. The real time footage acquired by the platform is used to identify destroyed buildings, damaged infrastructure elements and quality of life in the affected settlements. Based on the analysis of this information by the specialists, an evaluation of the resources and manpower needed in order to rescue people trapped under the debris and to protect the survivors can be done. Fire outbursts can be detected and localised.

Rescue teams can be dispatched to the most affected areas, and in order to reduce the response time, the best paths for these teams can also be identified from the air.

By means of aerial surveillance, robbers, speculators and those who disturb the order at the supplies distribution points can be detected and located.

In such situations the UAV are the only „surveillance eyes", as most probably all the ground monitoring systems are out of service.

Purpose: Damage evaluation and the state of critical infrastructure assessment.

Objectives: Assessment of social and economic consequences of the disasters.

Methods:

- continuous shooting by day and night, in low visibility conditions;
- infrared film;
- high-resolution photos.

Monitoring activities:

- assessment of civil and industrial buildings;
- state of critical infrastructure;

Land Characteristics: Disasters occur as a result of particularly violent natural phenomena or large proportion industrial accidents that paralyze the activity of a community. They can occur anywhere in the territory of a country, and have the worst consequences when they affect a densely populated area, usually a large urban settlement.

Climate/ Weather: Disasters can occur in any season and in any weather conditions. Their consequences can be aggravated if followed by heavy rain, strong winds and very cold or very hot weather.

Scenarios:

- A small UAV platform is launched from a monitoring center. It flies at an altitude of 800-1000m in a brushing pattern over the affected area. In order to identify various critical objectives it may descend to an altitude if 300m. Real time footage acquired by the platform is interpreted and a map of the affected area is executed.
- A small UAV platform is launched from a monitoring center. It has on board sensors used for the detection of chemical, biological, nuclear substances. It flies at an altitude of 100-150m in a brushing pattern over the affected area. A map illustrating the degree of air toxicity caused by various substances is executed. After a while, the operation is resumed on the same trajectory as the first time, in order to compile a new map of the affected area. The two maps are compared, allowing the determination of the pollution expansion speed and spread pattern and thus ensuring timely measures of evacuation for surrounding areas. After landing, the UAV is decontaminated.

3. CONCLUSIONS

According to the scenarios described above, we can conclude that the ideal UAV platforms for emergency response situations are the mini-UAV type platforms, with fixed or rotating wing, that can fly at altitudes of just a few meters to 1500 meters above the ground, have a flight autonomy of 20 minutes to 1, 5÷2 hours and can reach speeds from 5 km/h up to 60÷100 km/h [5].

They usually support individual response teams and are launched in the proximity of the affected areas. Due to their reduced size and weight, they can be easily transported to the launch site by 1÷2 team members wearing special backpack type containers, or by light terrestrial vehicles. Furthermore, their operation can be easily handled by 1 or maximum 2 medium skilled team members with basic training in radio-commanded model airplane piloting, because the take-off, landing, flight plan and navigation are mostly automated. The mini-UAV take off is done „from the hand" or by using simple devices (elastic ropes or catapults), and the landing can be executed on any terrain that is relatively level, with or without amortization systems or aerodynamic braking (pneumatic bags or brake chute), therefore it does not require any additional infrastructure (take-off and landing runway). The energy consumption is considerably lower than any other conventional aircraft. The propulsion system is usually electric, allowing a quick and simple renewal of the flight range (by changing the discharged batteries with charged ones) and ensuring a very short downtime. The maintenance is almost inexistent, requiring only minor tweaks and rarely a component replacement or on board equipment changing. The progress which has been made in the field of automatic flight control allows the usage of mini-UAVs in harsh weather conditions with strong winds and lateral shears.

Considering the above described qualities of the mini-UAVs, we can definitely affirm that these platforms are able to perform the same missions as conventional aircraft while reducing the costs by at least an order or two of magnitude.

A more special situation is the case of UAVs that are designed for natural disasters evaluation missions and are required to travel distances greater than 40÷100 kilometers at a speed of 150÷200 km/h. These platforms will have a larger size than that of mini-UAVs. Being medium-sized, they will be able to store considerably greater on board energy supplies, in the form of fuel for internal combustion engines. Also they will be able to perform completely autonomous flight[6], from take-off to landing, and will require special infrastructure for their operation (take-off and landing runways or larger catapulting systems). In order to efficiently transmit the collected data, they will require a connection between the on board communication systems and the terrestrial communication networks. These platforms are especially useful in increasing the efficiency of the ground teams by providing the much needed first overview of the disaster area, which allow the commanders to dispatch the manpower and material support needed for the mission much more effectively[7].

Fig. 1. Aerial Photography. Floods.

REFERENCES

[1] G. Ladislas, B. Freire, *Sitemas aereoes no tripolados*, IDS. C/ Vitario, MADRID (Espana), 2009.

[2] S. G Constantinescu, F. Nedelcuț, *UAV Systems in support of law enforcement forces*, AFASES XIII, Brașov, 2011. pag. 1211-1219, ISSN: 2247- 3173, ISSN-L 2247 – 3173.

[3] F. Nedelcuț, S. G. Constantinescu, *LUAV's are the right approach for surveillance civil missions*, AFASES XIII, Brașov, 2011. pag. 1237-1240, ISSN: 2247- 3173, ISSN-L 2247 – 3173.

[4] G. Bălan, S. G. Constantinescu, B. Ciobanu, *The Coandă VTOL-UAV Aeromechanical Aspects*, AFASES XIII Brașov, 2011, pag. 1205-1210, ISSN: 2247- 3173, ISSN-L 2247 – 3173.

[5] S. G. Constantinescu, G. Balan, F. Nedelcut, *The current use of UAVs for monitoring environmental parameters*, Program & Proceeding of the International Conference "ENVIROMENTAL CAPACITY BUILDINGS", 11th-13th 2011, Bucharest, Romania, pag. 19, ISBN 978-606-8035-37-6.

[6] B. Mettler, T. Schouwenaars, J. How, J. Paunicka and E. Feron, *Autonomous UAV Guidance Built-Up: Flight-Test Demonstration and Evaluation Plan*, AIAA 2004-5142.

[7] G. Romeo, M. Pacino, F. Borello, First Flight of Scaled Electric Solar Powered UAV for a Mediterranean Sea Border Surveillance Forest and Fire Monitoring, *Aerotecnica Missili & Spazio, The Journal of Aerospace Science, Technology and Systems.* Vol. **88**, no. 1-2, January-June 2009. pp. 8-19, ISSN 0365-7442.