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Disaster Management Supported by Unmanned Aerial Systems (UAS) Focusing Especially on Natural Disasters

Abstract

This paper evaluates some experiences and describes some initiatives using UAS to support disaster management especially focusing on natural disasters. This paper focuses mainly on operational and tactical UAS application in disaster management using a time-scaled separation of the application, like pre-disaster activity, activity immediately after the occurrence of a disaster and the activity after the primary disaster elimination. Paper faces to 3 disasters, like floods, earthquakes and forest fires. The author has gathered international examples and used his own experiences in this field. An earthquake is a rapid escalating disaster, where, for a long time, there is no other way for a rapid damage assessment than the aerial reconnaissance. For special rescue teams, the UAS application can help much in a rapid location of survivors. Floods are typical for a slow onset disaster. In contrast, to manage floods is a very complex and difficult task. It requires continuous monitoring of dykes, flooded and threatened areas. UAS can help managers largely keeping an area under observation. Forest fires are disasters, where the tactical application of UAS is already well developed. UAS can be used for fire detection, intervention monitoring and also for post-fire monitoring.

Keywords: disaster management, flood, earthquake, forest fire, UAS, UAV, RPAS, drone

Wspomaganie zarządzania w kryzysie przez bezzałogowe systemy latające, ze szczególnym uwzględnieniem ich wykorzystania podczas katastrof naturalnych

Streszczenie

W artykule przedstawiono doświadczenia i opisano inicjatywy dot. użycia UAS do wsparcia zarządzania w kryzysie, szczególnie podczas katastrof naturalnych.

Opracowanie przedstawia głównie taktyczne i operacyjne zastosowanie UAS w zarządzaniu w kryzysie w trzech fazach: przed wystąpieniem katastrofy, natychmiast po wystapieniu zdarzenia niekorzystnego oraz po wyeliminowaniu zagrożenia. Publikacja odnosi się do 3 rodzajów zagrożeń: powodzi, trzęsień ziemi i pożarów lasów. Autor przedstawia międzynarodowe przykłady, jak i własne doświadczenia w przedmiotowym zakresie. Rezultaty i dyskusja: Trzęsienie ziemi jest gwałtownie nasilającym się zjawiskiem, gdzie niejednokrotnie jedynym sposobem na szybką ocenę zniszczeń jest powietrzny rekonesas. Dla grup poszukiwawczo – ratowniczych, UAS mogą okazać się pomocne przy identyfikacji miejsc, gdzie istnieje możliwość zlokalizowanie ocalałych osób.Powodzie są typowym przykładem stopniowo nadciągającej katastrofy. Jednakże zarządzanie w czasie powodzi jest złożonym i skomplikowanym działaniem.Wymaga ciągłego monitorowania stanu wałów, zalanych i zagrożonych terenów. Aby zapewnić odpowiednią obserwację terenu osobom odpowiedzialnym za zarządzanie kryzysowe pomóc mogą UAS.W przypadku pożarów lasów taktyczne użycie UAS jest powszechne. Mogą być używane do wykrycia pożaru, monitorowania przebiegu akcji ratowniczo – gaśniczej, jak również obserwacji zagrożonych terenów.

Slowa kluczowe: zarządzanie w kryzysie, powódź, trzęsienie ziemi, UAS, UAV, RPAS, drony

1. Introduction

A disaster is a natural or man-made (or technological) hazard resulting in an event of substantial extent causing significant physical damage or destruction, loss of life, or drastic change to the environment. A disaster can be defined as any tragic event stemming from events such as earthquakes, floods, accidents, fires, or explosions. It is a phenomenon that can cause damage to life and property and destroy the economic, social or cultural life of people.

The name, "UAS" is common name of the unmanned aerial systems; its abbreviation is UAS. In many cases we can find other appearance such as "drone", UAV (Unmanned Aerial Vehicle) but in Europe the Remotely Piloted Aircraft Systems (RPAS) is also commonly used name. [1] Today there are more and more initiatives to use UAS at different disasters [2] [3] [4].

There are many ways to scale different disasters. Disasters can be scaled from limited to escalated, by the affected area or population, from the erup-

tion to slowly spreading by the time it develops, or in many other ways depending on the condition we take into account. This paper uses namely some disasters such as floods, earthquakes and forest fires, however demonstratively expresses that topic is so huge, all presented work is just touching the surface.

Stating the eruption in the center of the disaster's time scale any activity, so logically also all UAS applications supporting disaster management can be thematically separated like it can be seen at Figure 1. Before the eruption as a pre-disaster activity UAS application can support the prevention or be able to supply the early detection. In case of man-made disasters like a chemical accident during illegal transport, the UAS road observation belongs to prevention, following a toxic smoke spreading belongs to early detection, while avoiding the an escalated forest fire by UAS flight patrol can belong to both prevention and early detection. After the eruption UAS can support the management with real time monitoring that means mostly the quick and relevant information regarding the intervention or mitigation. Based on the by UAS supplied information the effect of the disaster can be mitigated more effectively and all of relevant information can support making better decision. Finishing main interventions, commonly it means after disaster, UAS can support the quick damage assessment and also help recovery. This UAS application is titled as post-disaster activity. This application is the closest to the civil life or commercial applications.

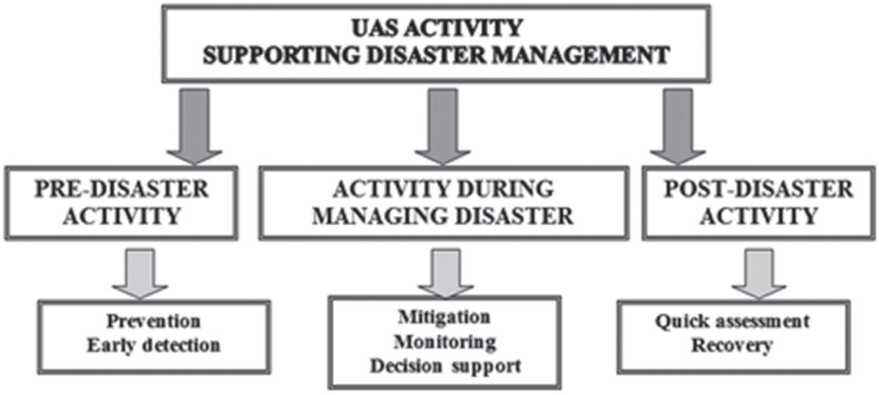

Fig. 1. UAS activity is in time scale of disaster eruption
Source: author

Depending on the type of disaster, the affected area, severity, etc. the above activities can be totally different from each other's. The response at erupted earthquake requests different UAS activity than the slowly escalated flood. Other side UAS applications can depend also on the level of managing disaster. At the headquarter management require strategic information but end-users needs information immediately about the situation. Therefore UAS applications in managing level can be divided into 3 groups such as strategic, operational and tactical levels.

2. Earthquakes

Earthquake is a typical disaster that is broken out without any pre-sign and causing not just seriously building damages but also many human die. The chance for survive of the people trapped in collapsed buildings depends mainly on the damage types of the affected buildings. Therefore, a rapid mapping of the affected area is very important not just for assessing the damages but even more to optimize sharing our rescue sources. Since the limited sources in disasters a small UAS can be a good solution for rapid mapping.

After the rapid mapping injured buildings can be characterized by an international standard. [5] Based on the scaled ruins special rescue teams can optimize their work depending on the rate of assumed (measured) surviving holes. Since the chance for survive is drastically reduces in time the rapid mapping can effectively raise the rescued lives (Figure 2).

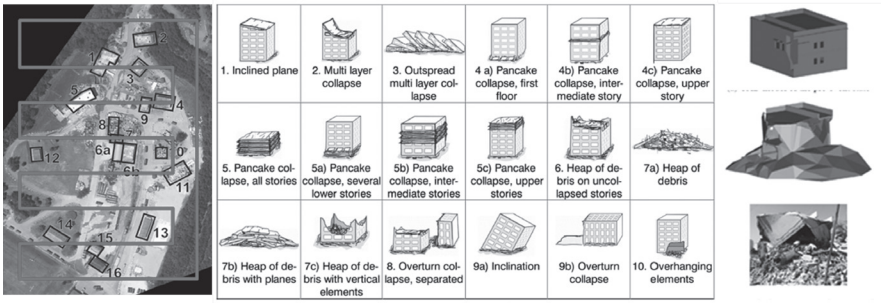

Fig. 2. Mission planning above the affected area (left) [6], classification of collapsed building (middle) [5] and 3D modeling of the ruined buildings (right) Source: [7]

Even if the above process seems to be very logic, it is under developing, and there has no real applications yet, however for a simple reconnaissance or area monitoring can easily support rescue teams.

3. Floods

Floods are a typical for a slowly developing disaster. In many times authority or disaster management headquarter have enough information to predict the scale and serious of this disaster. Against the slowly developing but in many times the country large affected area citizens can be trapped. Manned aerials can help in these situations demonstratively, especially using imagery collection [8], UAS activity around a limited area also can help for the management.

As pre-disaster activity, UAS following the stream of rivers can control the state of dams. In case of any unusual recognition the responsible authority can react in time for the problem. This activity is very flexible; the flight patrol can be optimized depending on time or other work load. Since affected areas are usually oversized, managing floods by aerials is always suffered from limited sources. It means UAS can support disaster management at local level. This task requires tactical or operational UAS.

The stability of dams hangs on many conditions like the time it suffers, from water press, how structure of dams built, what materials made of it. There is yet not enough information about it, however it can be supposed, with a procedure, what is able to analyze the state of dam ,it is a help for managers. Knowing the state of dam managers can optimize the sources making the critic parts of dam stronger or in case of escalated problem can order the evacuation in time.

In case of unaccepted broken dam citizens can be trapped in the flooded area. Even if they can find higher point in the area like sitting on the roof, the evacuation is unavoidable. If the evacuation is possible by motorboats, small UAS in the hand of local or regional management can help to find trapped citizens.

Since floods are a slowly developing disaster UAS can help for the management in many ways. With UAS observation we can predict how flooded the area is, what buildings are in risk, where from and where to evacuate the citizens, etc. The essence of this application is the gap of aerials what means the missing of manned aerials but UAS can be offered as a satisfied solution (Figure 3).

Fig. 3. UAS mission during flood at the Aggtelek National Park, Hungary (2010). Source: author

4. Forest Fires

The UAS application supporting forest fire management is surely the most developed and practically demonstrated activity among all disasters [9]. Following the thematically separation of UAS activity used above, logically UAS can be used before fire for hot spot detection, during the intervention helping fire management with real time information and after suppression for post fire monitoring. The method of prescribed fire can be also in the focus of UAS use as a special application for fire prevention. [10]

Detecting hot spots by aerials earlier than reporting it by civilians obviously helps fire managers limiting the damages fires cause. [11] Unfortunately the main reason why this method is not always used is the huge costs of aerials. If this procedure made by UAS is a cheaper solution than the traditional one (manned aircraft) it will mean that the option of UAS use is better. Naturally this case assumes the similar professional efficiency of different methods.

During this task UAS makes a patrol, following the pre-programmed flight path and based on the real time video supply, the staff in the control station can detect and check any hot spots (Figure 4). In case of real danger ,the staff reports it to the fire service.

There is no doubt, aerial patrol by UAS can detect hot spots very quickly and is able to give the first fire report to fire brigades. It can reduce the time of first attack but the study says that based on economy issues, this applica-

tion can be effective just in special condition such as at extremely high Fire Weather Index and at geographically high articulated area. These criteria are explained detailed in other article. [12]

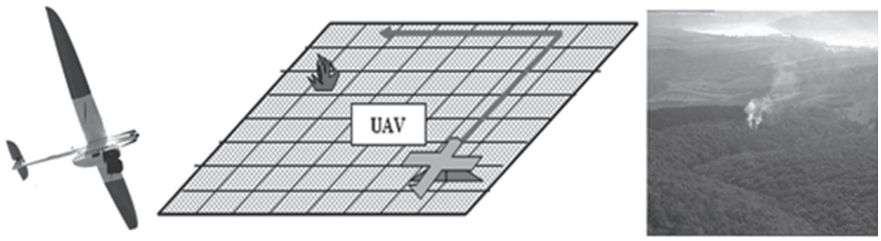

Fig. 4. Fix wing UAS with modelling its activity and real hot spot detection in Szendro, Hungary (2006)
Source: author

In case of aerial reconnaissance before starting intervention the situation is totally different. Fire managers require some basic information about fires immediately and for this task a high qualified UAS service is not applicable. The quickness of the information is much more important than the quality (ex. resolution of the video, photos) of that. Thus the simple but immediately ready for start UAS is required for this type of task. Capability of this type of UAS is limited. Fire manager needs objective information about the fire characteristic, fire intensity, speed of fire spreading, smoke emission, wind direction, etc. but they need them very quickly. For this task a hand launch, by electric engine powered UAS is required as the best solution.

During rescue operations, where aerial reconnaissance is required but manned aircraft is above price, UAS could give also a cost effective solution. If the commander of fire-fighting operations is at the scene, he is too close to the fire to be able to manage it along with its environment. Quite literally, he cannot see the forest for the trees! As the extinction of forest fires is a protracted process in time, and since during that time the fire will continue to spread, the ability to manage a fire together with its environment is an indispensable precondition for the efficient extinguishing the fire.

During intervention the UAS use can be very effective because obtaining an overview of several hundred or even thousand hectares of forest it allows

intervention measures to be coordinated. Without air reconnaissance, coordination of measures can only be based on the information circulated between the commanders of individual units at various locations. But the assessment of the gravity of their individual situations by commanders located at various sites may be completely subjective and not made in relation to the other sites. Air reconnaissance helps to eliminate subjectivity in such assessment and to rank the individual sites in relation to the others.

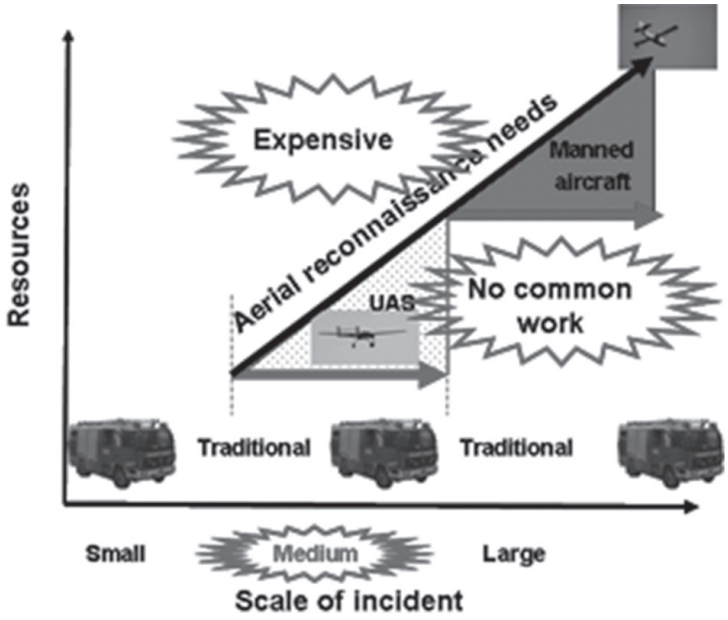

Fig. 5. Efficiency of UAS application depends on fire size
Source: author

At huge fires using manned aircraft for bombing water or just for supporting with information the reconnaissance is a normal procedure. On the other side, small fires don't require aerial support; these are managed by traditional equipment. Between these extremes logically there is a sector, where fire size is larger than could be suppressed successfully just with traditional equipment, but not enough large for asking manned aircraft for help. In this case the manned aircraft is economically obviously not effective, but a solution such as UAS, cheaper than the use of manned aircraft, – certainly is (Figure 5).

5. Summarizing

Based on the above examples UAS can be a very effective tool in the hand of disaster managers. After launching, the UAS can continuously supply real time data, therefore within the first few minutes it can provide an effective support for the decisions of the commander. One such element of the decision support is that even before the UAS returns, it will be possible to establish the extent of the affected area and to request the assistance of further units. This will save a significant amount of time.

Another example of decision support: if commanders are able to manage the entire area in a complex way, it may be the case that protecting the area where – e.g. in case of forest fire – the fire is currently more intense is the most important task. It is possible that our forces need to be concentrated in a location other than furnished by the initial assessment. The above examples show that the most efficient intervention is not necessarily the same as the rescue operation at the point where the fire is the most intense. In order to make the best decision, the area of the fire must be managed in a complex manner, together with its environment.

The tactical UAS, which has proven to be effective, can be made available to even the smallest rescue teams or fire brigades as first responders. Traditional reconnaissance no longer provides information of a quality and quantity sufficient for today's applications. Increasing the efficiency of reconnaissance will result in increasingly efficient interventional measures. This will increase the area of saved while reducing the areas destroyed.

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