Agoston RESTAS[1]

HOW DRONES CAN SUPPORT FIRE SERVICES. PREVENTION, INTERVENTION AND POST FIRE MONITORING

Abstract: This paper describes many initiatives and shows also practical examples which have happened using drones to support fire managers in different ways. Today more and more experts say drones can give real alternatives for aerial reconnaissance even if this application is far from manager's mentality yet. Author used thematic division of drone applications; it is based on two key elements, one of them is the time flow of fighting forest fires, the other is its tactical requirements. Research used mainly author's own experiences in this field, accompanied by function analysis, practical experiments, economic analysis and also expert estimation. Logically, drones can be used before fire for hot spot detection, before starting the intervention for fire reconnaissance, during the intervention for intervention monitoring and after suppression for post fire monitoring.

Key words: drone, tactical analysis, firefighting, fire detection, fire monitoring

КАКО ДРОНОВИ МОГУ КОРИСТИТИ ВАТРОГАСЦИМА. ПРЕВЕНТИВА, ИНТЕРВЕНЦИЈА, МОНИТОРИНГ НАКОН ПОЖАРА

Резиме: Аутор приказује безброј иницијатива односно могућности коришћења дронова у гашењу пожара. Стручњаци из ових области се слажу у томе да је веома широка примена дронова у гашењу пожара, али менталитет ватрогасаца засад ту чињеницу не прихвата. Аутор приказује тематску поделу могућности употребе дронова у гашењу пожара, коју намећу са једне стране временско-динамичке а са друге стране тактичке потребе. Коришћена су сопствена искуства аутора и ватрогасаца, економске као и логичке анализе. Дронови се могу користити у превентиви, раном откривању пожара, у прегледу терена пре гашења, опсервацији интервенције као и приликом отклањања последица.

Кључне речи: дрон, тактичка анализа, гашење пожара, откривање пожара, праћење пожара

[1] Associate professor, PhD, National Universty of Public Service, Budapest, Hungary, Restas.Agoston@uni-nke.hu

1. INTRODUCTION

The operation of manned aircraft at forest fires is usually expensive, therefore in many cases managers miss the aerial activity even for reconnaissance or supporting decision making, even if that would be required for the effective intervention. Today's experiences say drones or with other words Unmanned Aerial Systems (UAS) can give real alternatives of manned aircraft's operation not just for aerial reconnaissance but even other activities. This paper describes many initiatives and shows also practical examples which have happened using drone to support fire managers in different ways.

Drone activities regarding forest fire is not new. We can reel off activities using drone to fight against forest fire in the United States [1], in Croatia [2], in Spain [3, 4]. In Hungary the Szendro Fire Department carried out many activities helping fire management using drone [5].

This paper gives an approach for thematic division of using drone at forest fires; it is based on the tactical differences. Logically drone can be used before fire for hot spot detection, during the intervention helping fire management and after suppression for post fire monitoring. The method of prescribed fire can be also in the focus of drone use as a special application for fire prevention [6].

The paper uses the chronological flow of fighting forest fire for thematic divisions, although the last part of this paper, the drone generated prescribed fire can be disputed; it could have been also the first part. As a latest development of this application author found it as the latest place for the best.

2. PREVENTION AND EARLY WARNING

Aerial patrol as an early warning method with manned aircraft is a commonly used procedure for preventing huge fires with detecting hot spot. Many countries such as Australia, Canada, France, Russia, Spain, and United States regularly use this procedure while others such as Germany and Poland used to apply it but today not.

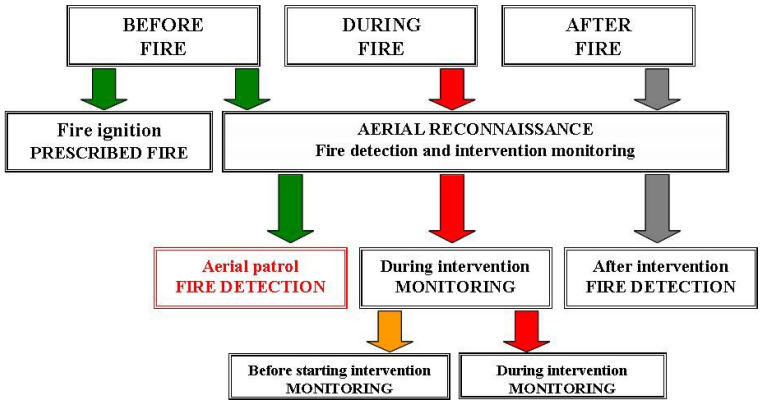

Figure 1. Aerial patrol for hot spot detection in the structure of thematic division of drone use. Source: author

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

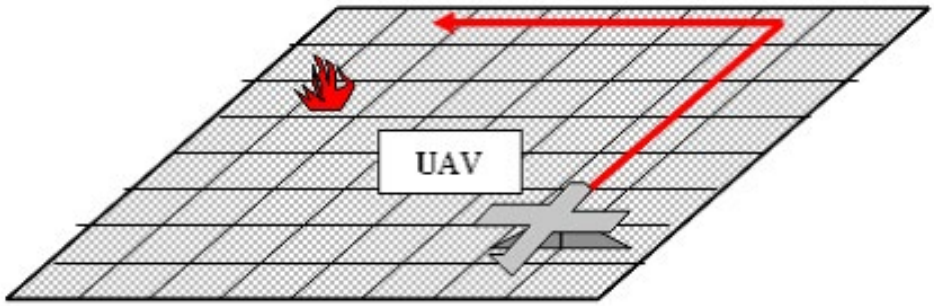

Figure 2. Planning drone mission for hot spot detection. Source: author

During this task drone 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. In case of real danger staff reports it to the fire service.

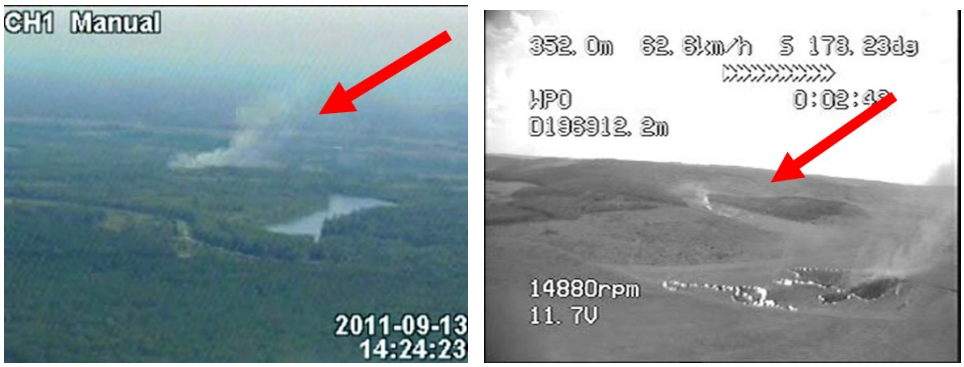

Figure 3. Drone based hot spot detections: in Croatia (2011) and the first one in Hungary (2004) Source: 6DOF (Croatia) and author

No doubt, aerial patrol by drone can detect hot spots very quickly and it is able to give the first fire report to fire brigades. It can reduce the time of first attack but study says that based on economic calculations, this application can be effective just under special conditions such as at extremely high Fire Weather Index and at geographically high articulated area. Detailed criteria must be developed in the future for optimizing the effectiveness of drone applications.

For effective hot spot detection different type of drone can be used. Depending on the area staff responsible for both strategic and operational drone can be effective tool for the early hot spot detection. In the United States the high altitude long endurance (HALE) Ikhana was used for both early detection and intervention monitoring. In Croatia and Hungary tactical drone were also used for hot spot detection.

3. RECONNAISSANCE BEFORE STARTING INTERVENTION

When starting intervention the main problem is the lack of objective information regarding the affected area, fire intensity, etc. [7]. Operational used drone could help in this case; below just a few minutes it can be ready for launch and 2-3 minutes later it transmits the real time pictures about the fire and their circumstances.

Figure 4. Launch of fix wing drone (Fenix) for fire reconnaissance before starting intervention. Rotary wings drone (Bee) hovering at forest fire. Source: 6DOF (Croatia) and R-Fire Ltd. (Hungary)

Figure 5. Differences between fire fronts can be seen face to face or from the air after arriving. Source: 6DOF (Croatia) and R-Fire (Hungary)

In case of aerial reconnaissance the quick access to the information is much more important than the quality (e.g. resolution of the video, photos) of that. Therefore the simple but *immediately ready for start* drone is required for this type of task. Capability of this type of drone is limited. Fire manager needs objective information about the fire characteristic, fire intensity, speed of spreading fire, smoke emission, wind direction, etc. but very quickly. For this task a hand launch, by electric engine powered drone is considered the best solution.

The simple criterion for economic effectiveness is that all costs of drone use must remain below the value of the forest saved by this process.

4. AERIAL RECONNAISSANCE DURING INTERVENTION

During intervention, where aerial reconnaissance is required but manned aircraft is above price, drone 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 of a fire.

During intervention the drone use can be very effective because obtaining an overview of several hundred or even thousand hectares of forest allows intervention measures to be co-ordinated. Without air reconnaissance, co-ordination of measures can only be based on the information circulating between the commanders of individual units at various locations. But the assessment of the scope 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 judgements and to rank the individual sites in relation to the others.

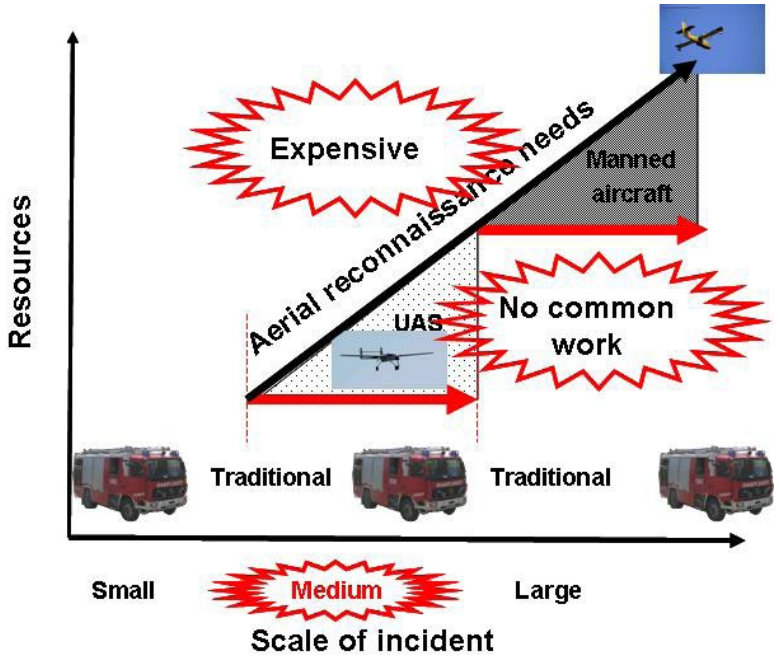

Figure 6. Efficiency of drone application depends on fire size. Source: author

At huge fires using manned aircraft for bombing water or just to support the reconnaissance with information is a normal procedure. On the other hand, 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 management could suppress successfully just with traditional equipment, but not large enough to ask manned aircraft for help. In this case the manned aircraft is economically, obviously, not effective, but a solution such as drone, which is cheaper than the use of manned aircraft – can already be.

If the drone based aerial reconnaissance satisfies the minimum criteria of the professional requirements of the effective reconnaissance, it means that this solution can be even economically effective.

We can demonstrate the effectiveness of drone based aerial reconnaissance also by the *damage – time function.* This kind of applications is not just reducing the damages caused by the fire but even reducing the time of the intervention. Shorter intervention is reducing also the risk posed to citizens caused by the lack of fire fighters who are ready for alarm in case of accident, house fire, etc. Unfortunately this kind of risk is usually assessed much lower than the reality requires.

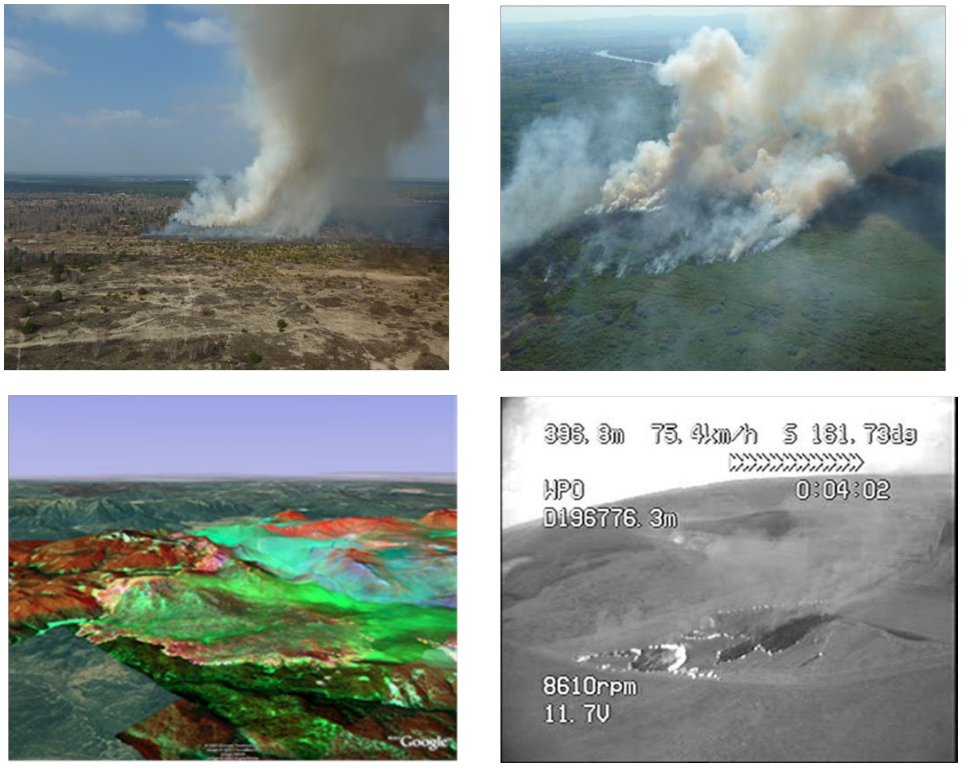

Figure 7. Intervention supported by drone: forest fires in coloured (Bee, Germany, 2010, and Phoenix, Croatia, 2011), artificial coloured (Ikhana, US, 2007) and black and white photos (Hungary, 2004)

5. POST-FIRE MONITORING

After suppressions, many times, area surveillance is required to prevent starting fire again by remained cinder. Drone equipped with IR camera can detect the critical points easily and with a small team can manage hot spots while let fire fighters leave the area.

Burnt area monitoring besides the tactically advantages gives also other options. Since many cases drone use is optimal when it is in the hand of fire service, the post fire monitoring is ideal for training recruit. After the intervention, there is no stress regarding success, no pressure from media or residents. But post fire monitoring is a real task while its environment means a reality. It means hot spots, remained cinder what also requires responsible management.

Figure 8. Thermo cam is installed on drone board and able to detect the remained cinder. Source: author

Planning the post-fire monitoring drone must fly around the extinguished fire front instead of monitoring the whole area (hot spot detection). For this task a simple but with IR equipped drone is required.

6. CONCLUSION

Based on the above examples drone can be a very effective tool in the hand of fire managers. After launch the drone can supply real time data continuously, therefore within in the first few minutes it can provide effective support for the decisions of the commander. One such element of decision support is that even before the drone returns, it will be possible to establish the extent of the burning 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 the fire is currently most intense is the most important task. It is possible that our forces need to be concentrated in a location other than that furnished by the initial assessment.

While firefighting is in progress, the fire continues to spread in the areas where no countermeasures are taken, and indeed it may meet natural obstacles or barriers. A river,

a wider road or glade may stop the fire as a natural barrier, so beginning fire-fighting measures at a distance of 100 or 200 metres from such a natural barrier can only be considered efficient if we have plenty of resources.

On the other hand, it is also possible that in a direction which currently has low parameters for spread and is thus assessed as lower priority, there lies a much more valuable area, such as a highly protected plant community, a habitat of protected animals, or perhaps an area of vegetation with higher parameters for spread.

The above examples show that the most efficient intervention is not necessarily the same as intervention 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 drone, which has proven effective, can be made available to even the smallest fire brigades. 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 forests saved while reducing the areas destroyed.

The workload of fire-fighters may be reduced; in many instances there may be no need to mount a response at all. The elimination of unnecessary responses will reduce the level of risk to citizens, resulting in a higher level of fire safety.

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