Forest Research
Open Access

de Dios, Forest Res 2015, 4:1
DOI: 10.4172/2168-9776.1000e115

Editorial Open Access

Fleets of Small Unmanned Aerial Systems for Forest Fire Applications

J Ramiro Martínez de Dios*

Professor of Robotics in University of Seville, Spain

***Corresponding author:** J Ramiro Martínez de Dios, Professor of Robotics in University of Seville, Spain, Tel: +34954551 00; E-mail: jdedios@us.es

Rec date: Dec 10, 2014; **Acc date:** Dec 10, 2014; **Pub date:** Dec 17, 2014

Editorial

Unmanned Aerial Systems (UAS) technologies experimented one of the strongest growths in the last decade. Advances in mechanics, sensing, communications and control systems together with a significant cost reduction are originating an explosion in the use of UAS in a growing number and variety of applications in a wide range of sectors including law enforcement, civil security and industry. Nowadays, the level of maturity of UAS technologies enables their use and effective exploitation in a number of unprecedented applications, which were constrained to piloted aircrafts only some few years ago. All prospective reports, white books and strategic research agendas developed by the most relevant scientific and technology institutions agree in concluding that UAS is one of the technologies that will have deeper impact on society and economy in the near future.

Airborne means have traditionally played a very important role in forest-fire fighting activities. In addition to transportation of brigades and fire extinguishing, they have also been widely used in forest surveillance and forest-fire monitoring, among others. Piloted aircrafts are also used by forest-fire services for measurement of the burnt area and evaluation of fire effects. UAVs have interesting potential advantages over piloted vehicles. First of all, UAS can effectively reduce the human risk level. Aerial vehicles are involved in many accidents during forest-fire extinguishing and other fire fighting activities, originating a high number of casualties every year. The use of unpiloted -remote controlled or autonomous- vehicles can help to reduce the risk also to the rest of personnel involved in fire fighting activities. Cost is another clear advantage. Forest-fire fighting activities employ extensive resources and a high number of aerial means. Many of them are directly involved in fire extinguishing and are very difficult to be substituted by UAS. However, others are used for data gathering in activities such as mapping, forest surveillance, fire detection and confirmation, fire monitoring and fire evaluation, among others, and, in these activities, the use of UAVs can involve important advantages.

The high cost of piloted aerial vehicles frequently leads to schemes where each aircraft is equipped with all necessary sensors and devices for the missions it has been designed. This, in most cases, involves installing expensive equipment and requires well-trained personnel for their operation. Besides, these piloted aircrafts require significant infrastructure including long runways for taking-off and landing. This centralized scheme has been adopted by the first prototypes of UAS for forest-fire applications. One good example is the ALTUS UAV, an evolution of the Predator UAV, which was first demonstrated in fire experiments at the beginning of the last decade. However, the use of UAS instead of piloted aerial vehicles also provides higher flexibility. In the last years, in contrast to the centralized approach, the distributed paradigm is attracting more and more attention from the research community. Instead of one single high-performance UAS, this scheme comprises a fleet of simple, small, low-cost UAS that cooperate in order to perform the mission. Each of these small UAS could be equipped with different but complementary sensors. They can take off manually by throwing the UAS or using small catapults and require little infrastructure and lower training for their operators. The use of small UAS instead of high-performance UAS is also convenient in terms of costs and also to reduce the potential damage in case of accident.

In contrast to the lower capabilities of each individual small UAS, the strengths of the distributed scheme come from the cooperation between usually different unmanned aerial systems. For instance, in forest-fire detection, one small UAS is equipped with a simple sensor to perform the first detection of potential alarms, which are transmitted to a Decision & Control Station. These alarms are used to dynamically command other small UAS equipped with specific fire sensors, which are sent to the location of the potential alarms for confirmation. The data of the alarm collected by all the small UAS is combined using fusion techniques in order to reliably confirm or discard the alarm and accurately locate it on a map. In forest-fire monitoring UAS equipped with visual and infrared cameras execute automatic image processing and geo-referencing techniques in order to compute in real-time the fire-front location, geometry and speed. Each UAS of the fleet is assigned to the detailed monitoring of the fire at a certain area. The perception of all the UAS is fused enabling forest-fire monitoring with higher spatial and temporal resolutions, which can significantly improve safety and efficiency of fire fighting. Besides, this decentralized approach has relevant advantages in terms of flexibility and robustness, which are very interesting in forest-fire fighting scenarios, potentially dangerous and prone to disturbances and unpredictable changes. This decentralized approach also has advantages in terms of modularity and scalability. These small UAS can organize into networks composed of as many nodes as necessary, enabling system extensibility, necessary for instance for the monitoring of large forest fires.

Below is a brief description of the main forest-fire fighting activities that are or can be performed by fleets of small UAS. These activities refer not only to the direct tasks related to extinguishing. They include others that can be classified into pre-fire, during-fire and post-fire activities.

Forest surveillance is a very important task in forest-fire fighting. People with profound knowledge of the terrain in watch towers are traditional and most extended way of forest surveillance. In the last twenty years a wide variety of systems for automatic forest-fire detection have been developed. They are installed in high visibility ground observation sites and use automatic processing techniques of images from infrared cameras to detect the radiation of the fire or from visual cameras to detect the smoke plume. Their main drawbacks are their limited coverage and the lack of reliability of the automatic detection, typically originating high false alarm rates. Other fire detection systems use images gathered by satellites. Satellite-based forest-fire detection has been successful in unpopulated, large and homogeneous areas. However, the low spatial and temporal resolution of satellite imagery can involve constraints to automatic detection in areas with intense human activity and potential false alarm rates. Although satellite systems have been applied to automatic fire detection, the detection delays and low resolution of satellite data are still significant drawbacks. Stratospheric, HALE (High Altitude Long Endurance) UAS and MALE (Medium Altitude Long Endurance) UAS can be an alternative: they are able to provide data with higher temporal and spatial resolutions overcoming this drawback. Also, fleets of small low-cost UAS can be used to perform not only automatic detection but also reliable confirmation and precise localisation. UAS suitable for forest-fire detection should have high endurance capabilities. Thus, fixed-wing UAS can be more suitable for performing the first detection. Rotary-wing UAVs have Vertical Take-off and Landing (VTOL) capabilities and can hover at a desired position to obtain detailed images and other data of a fire. On the other hand rotary-wing UAVs have significantly lower endurance, which constrains its applicability in operational conditions.

Another relevant pre-fire activity is forest state evaluation and assessment, which involves extracting measurements or estimates of the vegetation mass, hydric stress, topography, vegetation height, among others, in order to build maps of interest e.g. for fire fighting planning. These tasks have been traditionally carried out with satellite data and images from hyper spectral sensors and LIDARs, among others. Even in the latest generation of satellites, the lack of sufficient spatial and temporal resolutions in satellite data is still an issue. In this application, fleets of small UAS can be also used to obtain high-resolution data suitable for local mapping, which can be useful in special protected areas. The advantages of UAS over satellites in terms of spatial and temporal resolutions are also interesting in during-fire tasks such as forest-fire real-time monitoring and measuring. Besides, another important function that can be performed by UAS is communications relay. In fact lack or bad communication is behind a good percentage of the accidents and casualties in forest-fire fighting. A HALE UAS could be placed on top at high altitude acting as a repeater for different communicating systems. UAS is also a suitable technology for post-fire tasks. They can be used for burnt area mapping and assessment involving cost and safety improvements when compared with piloted aircrafts. UAS fleets flexibility enables their use for novel applications such as the detection of the presence of active fire embers.

UAS are here to stay. They have revolutionized the sectors in which they have been introduced. The above are just some examples of how this technology can be applied in forest-fire perception. UAS technology has reached an advanced level of maturity and has demonstrated its feasibility in many applications in harsh environments and conditions. Of course there are still issues to be solved. The integration of UAS in air traffic management together with piloted aircrafts and the lack of UAS regulations have been identified as two of the main difficulties in the development of UAS for civilian applications. Aware of this fact, intense effort by national and international agencies is being developed in both directions. Once the regulatory frame of UAS is established, their use will experiment an intense explosion improving efficacy and reducing costs in many applications and sectors, including fire fighting.