American Journal of Engineering Research (AJER)
e-ISSN: 2320-0847 p-ISSN : 2320-0936
Volume-6, Issue-7, pp-36-41
www.ajer.org
Research Paper Open Access

Classification of Drones

Eleftheria Mitka[1], Spiridon G. Mouroutsos[2]
[1](Department of Electrical and Computer Engineering, Democritus University of Thrace, Greece)
[2](Department of Electrical and Computer Engineering, Democritus University of Thrace, Greece)

ABSTRACT: *The main core of this paper is a categorization that has been drafted based on the specific task to be performed by Drones, also known as unmanned aircraft systems (UAS), and considered a critical piece of equipment. Parameter that is discussed for sorting out is the scenario depending on their purpose. In this paper, the authors address, tentatively, the need of categorization for drones since emerging on the technology have demonstrated that they enhance speed and quality in popularity aimed at the consumer market. Generally, it is clear that it doesn't exist, so far, a single systematic classification of task scenarios for these appliances that can vary greatly in size, wingspan and shape and they are far more than a toy.*

Keywords: *Classification, Drones, UAS*

I. INTRODUCTION

Let them fly and they will create a novel market all around the world is the message to all UAS stakeholders and policy makers [1]. The official terminology UAS is adopted by some regulators of Federal Aviation Administration (FAA) under various names and acronyms like pilotless aircraft, robot plane, remotely piloted vehicles while the term "drone" comes from military. The FAA Modernization and Reform Act of 2012 define unmanned aircraft as "an aircraft that is operated without a possibility of direct human intervention from within or on the aircraft [2]" The Office of the Secretary of Defense, in its March 2003 unmanned aircraft vehicles (UAV) Roadmap, uses the following definition: "A powered, aerial vehicle that does not carry a human operator, uses aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or non-lethal payload. Ballistic or semi-ballistic vehicles, cruise missiles, and artillery projectiles are not considered unmanned aerial vehicles." The British, in recently published guidance, defines a UAV as "an aircraft that is designed, or modified, to carry no human pilot and is operated under remote control or in restricted autonomous mode of operation. [3]" The International Civil Aviation Organization (ICAO) and the European Commission define the UAV as a part of a broader technology unmanned aircraft that can be programmed to operate autonomously [4].

Drones are usually embedded with diverse range of cameras such as powerful and lighter video, infrared cameras that sent the up-to date data subsequently to the ground-based equipment with or no payload. They are commonly equipped with IMU/GPS system or access to Google Earth data, thermal/power/distance-/photometric high-resolution sensors and circuit board with IP software to record data in secure format. A wide range of tachymeter, altimeter, mobile hotspots, RFID tags and other cutting-edge technologies are used both in aerospace industry and in UAS. Generally speaking, they complete a wide variety of tasks but differ in shape, cost, and capabilities, depending on their purpose. Drones have the form of small multicopter with diverse array of sizes, take off vertically either fixed-wing or rotary-wing and multi-rotor to fly and balance while they run on researchable batteries operated by brushless electric motor. The majority are remote-controlled, autonomous or semi-autonomous while some of them can move, hover or perch with a minimum required human intervention. The human pilot is allowed to program the ground control using communication equipment such as tablet, on-board computers, and smartphone with a Wi-Fi connection or hobby-type airplane radio-controlled for low altitude and display with buttons, switches and virtual sounds. Some of them manage fully autonomous missions with flight plan and time taking account of measurement of wing, lithium polymer battery level, national flight regulations, and site data, lateral obstacles based on artificial intelligent models with little or no fossil fuels.

Recent technology allows drone to land autonomously and are easily transported back-pack or by hand. Failsafe technique frequently tests for the quality of signals from the ground radio control, and if the signal is lost, the drone goes into hover mode; after a few seconds, the drone returns like a homing pigeon to wherever it took off and lands automatically [5]. The operator may use a "come home" button, and the drone will come back to the takeoff coordinates at a preset altitude and land automatically [5]. It is important to understand the potential use of drones for commercial application. The authors make an effort to address the most important milestones on drone categories throughout the history. The classification of the available UAS has been a noteworthy and constant need beyond the drone community as Everaerts [6] provided a comprehensive list of drones: airborne and satellite platforms, low and high altitude UAS. This research analyze that categories covers a wide range that differs on spectral resolution, flexibility, remote sensing missions, quality, economic cost, spatial accuracy, target, update rate and coverage. In the geological field, Eisenbeiss [7] present a summary that provides the main actors that separates the applications scenarios in powered and non-powered, heavier and lighter than air-platforms. The applications were classified, according to this study, to the following features: manoeuvrability, endurance, weather and wind. There are a few noteworthy initiatives by Van Blyenburgh [8] stating that drones are classified based on size, weight, operating range and certification while defines two diverse ecosystems: nano-micro-mini and close-short-medium-range UAS. Another classification refers to operator: civilian or military [9]. Furthermore, there are two categories by flight type such are primarily rotor-aircraft or fixed wing [9]. Finally, they are classified by size that range in length and weight and by payload referring to carrying sensors, spectrum analyzers, video cameras.

Conditioned by the lack of standardization for drones to a certain degree, harmonised regulatory panorama has been stepped up significantly over the last years. A comprehensive overview of categorization and classification of civil unmanned aircraft systems is established by ISO/AWI 21895 [10] but is still under construction. Hereafter, recent events and decisions are proof of the active work carried out by ISO. ISO progress brings together ISO/TC 20/SC 16/WG 1, General (Convener: Anton Shalaev, Russia) [11], ISO/TC 20/SC 16/WG 2 Product (Convener: Doug Davis, USA) [12] and ISO/TC 20/SC 16/WG 3, Procedure (Convener: Bob Garbett, UK) [13] that are still under development. More specifically, ISO/TC 20/SC 16/WG 1 [11] specifies the general requirements for UAS for civil and commercial applications. ISO/TC 20/SC 16/WG 2 [12] specifies requirements for the design manufacture and continued airworthiness of any UAS. It includes the aircraft, any associated remote pilot station(s), the required command and control links and any other system elements as may be required. Scope of ISO/TC 20/SC 16/WG 3 [13] defines the requirements for UAS operational procedures.

II. CLASSIFICATION OF DRONES

During the past 50 years, surveying and engineering measurement technology has made five quantum leaps: the electronic distance meter, total station, GPS, robotic total station and laser scanner. Unmanned aircraft systems or drones will be the sixth quantum leap in technology [5]. UAS have demonstrated capabilities operating in dark, fog, and difficult decreased visibility situations. Furthermore, this platform is considered perfect for aerial view of areas in confined airspace using accelerometer and gyroscope when manned helicopter cannot operate. Referring to a plethora of a new class of appliances, some are capable to access structures using auto-controlled navigation systems. These areas are too small, tall and inaccessible for a manned aircraft (top of the banks or bottom of the valley) or satellite multispectral imaginaries to get up close. This explosion of electronic intriguing and most published technology is driving to a rapidly expanding market in search and rescue tasks, monitoring the status of water bodies, highways, conservation.

Drones, also, assist in detecting and mapping the region of natural and other types of disaster risk-analysis, transport and agricultural aviation, forest fires. They are finding increasing application in the area of search and rescue. In addition, they revolutionize management of natural hazards like tornado, flood, or earthquake, drones with proximity sensors. They support aiding actions and monitoring to relocate people in remote and wild areas (steep slopes or dam facings) and deliver emergency supplies and medication. UAS are leading to the organization of communication and the regulation of traffic in major cities.

They are often used for close-range oblique aerial photography, and surveillance. Drones are, perhaps, recognized mostly for prescribing solutions to problems with delivery and, like other type of robotic devices, can be developed to execute other operations based on dam engineering. These compact remote-controlled devices could offer intervention and surveillance, protecting property from sudden dangerous situations and particularly against crime. With many researchers and manufacturers willing to build new drones to support daily life, the lack of a systematic categorization does not allow operators to choose a device that fulfil their own requirements. The drone sector has a significant potential but the noticeable question that arises is what a drone can or cannot do in relation with its class. The authors, in this paper, recognize five potential sectors of drones: emergency, earth observation, infrastructure monitoring and inspection, environment, defense and security. All existing products can be sorted in the following detailed groups according to their metric of performance understanding the motivation of industry. Each device must have a specific set of specifications, fundamental similarities or differences in order to be grouped in the above sectors. Firstly, basic characteristics and main technologies of every single sector are presented, taking account the motivations and attitudes of public in detail. Secondly, in this approach, some products are being shown for purpose of illustration and identification of fundamental distinctions that need to be made among categories. The classification of commercial products is shown in Fig. 1.

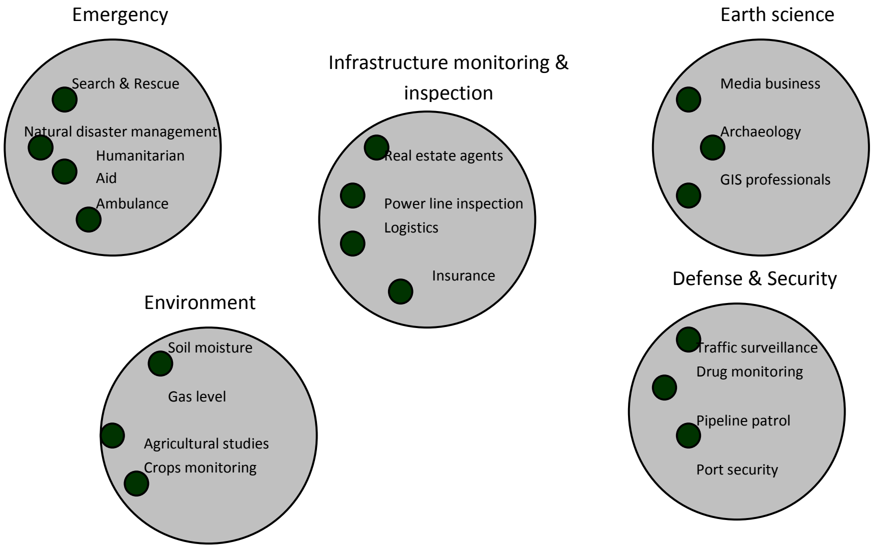

Fig. 1. The fundamental categorization including the proposed, by the authors, subclasses of drones.

The categories and subclasses are analysed in the following paragraphs.

2.1 Emergency

Firefighters can operate drones to find if anyone alive is caught in a building on fire. The noteworthy example is shown in Fig.2. They can assist firefighters in safely accessing building on fire, and they perform a navigation to coordinate a not dangerous traceable flight path through the fire. Moreover, unmanned vehicles deals with forest fire monitoring and automatic route flights.

Fig. 2. Aerial view from firefighter drone in order to rescue for victims or alive (source http://www.fireengineering.com)

Search and rescue and disaster management missions with drones share many objectives. Drones for surveillance carry out a location that must be observed with geographically accurate models over time such as hurricane, volcanic eruptions, earthquake, or flood. The concept of humanitarian aid in natural hazards research and monitoring include flood mapping, hyperspectral imaging, sea ice flow observations and plume dispersion and tracking. In addition, unmanned vehicles access road weather information systems collecting weather, fire and flood information while communications interface software send data to ground station.

Cargo drones can play a key role in courier services, retail operations, and hospitality venues that perform delivery services delivering certain items. For example the ambulance drone created from Alec Momont is ready for emergency response as it is shown in Fig. 3. It focuses on the most pressing use case: delivery of an automated external defibrillator - where a decrease in response time of just one minute leads to an increase of 10% in the survival rates [14].

Fig. 3. The ambulance drone (source http://www.top10drone.com)

2.2 Infrastructure Monitoring and Inspection

Of the special interest for construction industries this tool gets a big picture view and video so as to archive the development of a building or a project in progress. Drones help in distinguishing any security deficiencies, regulatory and safety compliance issues. Any industries that require high accuracy surveys, such as the environmental data or chemical and petroleum spill monitoring can have great opportunities using a UAS for ongoing surveying vast amounts of farmland. Industry can easily monitor a work in progress, detect the material left or small changes, achieving a quickly 3-D model view and keep track of large facilities. A good example of topographic survey of surface or volume determinations that take place can be a conventional station operating 2 days for 24 hours per day on a land of 16.000 tones while for the same product, the drone would operate only 2 hours.

Fig. 4. Drone assisting insurance claims monitoring (source http://www.top10drone.com)

Real estate agents might operate UAS to support aerial data gathering, site monitoring and remote viewing of landscape that is for sale or rent offering easily translation of information by even a non-experienced user. Insurance agents can add 3-D drawing and landscape quick map by a drone (Fig. 4) to their underwriter using special planning and volumetric calculations. Insurance company inspectors and adjustors could operate drones for observation activities (such as rooftops).

Drones also assist real-time surveillance of logistics. The advance in technology of cheaper, light-weight thermal cameras with smaller, lighter package expands the use of drone in this field while flight duration and featherweight battery are possible limitations. Drones might tremendously save time when it comes to scan large or remote land. On the ground level cameras are mounted on a 10m high telescopic pole or handheld.

UAV also assist in power line inspection and they prove to be more accurate, economical, easier and faster the conventional way. They offer volumetric scanning, final deliverables in AutoCAD, thermal imagery and 3D laser scanning equipment. They save vital time and give electrical utility clients the opportunity to focus on repairing and maintenance issues improving safety. Drones can help electrical, mechanical and plumbing engineers in upgrading or replacing parts in the power plant.

2.3 Earth science

Surveyors and GIS professionals could rely on UAS mapping to save time and cost on surveying and mapping projects. Time require for gathering precise data is drastically minimized. By producing accurate detailed data below the cloud level – geo-referenced digital form – surveyors can collect repeatable 3-D point clouds autonomously in a small flight for some square kilometers surface. Relatively short time-frame spent on the ground-level indicates staff safety is ensured by evaluating hazard to surveyors when out metering areas named with construction location, actual slope shapes or heavy traffic paths with inexpensive collection. Advances in photogrammetric and CAD software in drones assist in professional orthophotography. Other complementary activities involve main litho logical limits, identification of differences between slopes and soil stockpiled volume and geo-structural features such as slope geometry identification. Furthermore, drone could help scientists in cloud microphysics, weather forecasting and meteorology, physical oceanography, magnetic fields, vegetation, ozone chemistry, radiation levels, tropospheric pollution and air quality.

Media businesses, such as film and motion picture industry, newscasters, and professionals could operate a UAS that shown to achieve spectacular aerial images or live-streaming videos shot. This flying platform is capable of generating high spatial resolution photos in cases where a conventional manned helicopter for aerial footage does not exist, or for areas that cannot be reached by aircraft or plane. Drones also assist in aerial advertising and commercial imaging and an illustrative example is shown in Fig. 5.

Fig 5. A commercially available product for aerial photography in media (Source: www.quadcopters.co.uk)

Archaeology can be supported with ortho photo stereo plotted on the geological map. The UAS can be programmed by students who operate the latest model calibrated camera systems and scan land not easily reached capturing geo-referenced 2-D ortho-photo mosaics, 3-D data, contour lines and design perspectives. Huge demand has stimulated competition regarding scientific applications of drones involving atmospheric monitoring, hyperspectral imaging.

2.4 Environment

With increased frequency, these devices can support activities evaluation of crop's health (Fig. 6), agricultural surveys, fend off pests. Farmers are permitted to survey drone-generated maps to recognise farmland of crop variation and subtle changes with the Digital Terrain Model. UAS assist in estimating root-causes of damage (nutritional stress on corps) and offering solutions, pasture performance in considerable detail for future verification. Additionally, farmer experts use satellites to monitor crop health below the cloud level from large scale to small scale palm tree counts and coconut oil yield and are able to conduct irrigation and drainage models with thermal cameras.

Fig 6. A product for monitoring crop's health (Source: www.michfb.com)

Drones are finding a growing number of uses for scientific purpose and learning activities, in scholarly research both for faculties and students. The use of UAS in labs, group projects, class is still new but gaining in popularity while could support from filming of student movie to an opening of a variety of academic fields not previously available. These highly sophisticated machines offer new dimensions capturing easily repeatable imagery for biology, wildlife, botany and agricultural studies. Finally, they support sea ice flow observations, plume dispersion and tracking, soil moisture imaging and aerosol and gas level in clouds.

2.5 Defense and security

On the defense side, traffic surveillance (Fig. 7) is a fast growing area for drone adoption. Unmanned vehicles are used for transportation surveillance data and planning while they are programmed off-line and combined with real time navigation. Close to the emergency segment, applications such as incident/accident/-emergency response, choose the best route above the road network, track a network of traffic signals, traveler times, provide emergency vehicle services and inform the police for the best route, track vehicle movements in an intersection, measurement of traditional queue lengths, assist in parking, monitor Origin-Destination (OD) flows [15]. Drones intended for use in traffic control are reaching incredible speeds, relatively lower cost, fast and safer while they are not prevented from road network, very bad weather or evacuation conditions aim at observation of gathering flows, speeds, estimate traffic densities and vehicle trajectories [15].

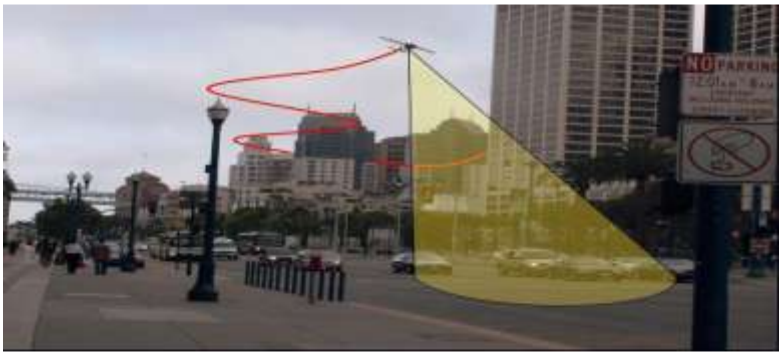

Fig 7. UAV monitoring traffic (source: www.web.mae.ufl.edu)

Ranchers and fishery technicians are trying to test the technology in order to examine drones' feature for cost-saving benefit of performing patrols and inspection work representing an important step in the investigation process. Long-range inspection drones are being used as a blocking out technology, catching illegal fishing vessels in nature region. They allow a bird's-eye view assisting the continuous distributed surveillance forces of government organization assisting in inspecting of sensitive sites, drug monitoring and intervention, domestic traffic surveillance, pipeline patrol and port security. Finally, they assist in Nuclear, biological, chemical (NBC) sensing/tracking.

III. CONCLUSION

Till nowadays, numerous drones have been invented and have entered the market. Only a few are widely known and accepted for flying safely in aggregated space. In this paper, few typical examples and application scenarios were analyzed and reviewed so as to make clear the plurality of the subclasses that are identified. There are major issues that step up the successful opening to a new application era of these smart appliances. The authors presented another approach trying to explain the categorization of this field and they hope to help future researching efforts and the acceptance of this emerging technology.

REFERENCES

[1] I. Colomina, P. Molina, Unmanned aerial systems for photogrammetry and remote sensing: A review, *ISPRS Journal of Photogrammetry and Remote Sensing 92*, 2014, *79-97*, Centre Tecnologic de Telecomunicacions de Catalunya, Spain.

[2] FAA Draft Advisory Circular, *Unmanned Air Vehicle Design Criteria*, Section 6.j, 15 July 1994.

[3] Unmanned Aerial Vehicle Operations in U.K. Airspace – Guidance, CAP 722, Section 2.1, Directorate of Airspace Policy, Civil Aviation Authority, 2002.

[4] ICAO, ICAO Circular 328, *Unmanned Aircraft Systems (UAS)*, Technical Report, International Civil Aviation Authority. Montreal, Canada, 2011.

[5] Frank Willis http://www.pobonline.com/articles/96996-how-can-drones-transform-surveying [last accessed 17-6-11]

[6] J. Everaerts, *NEWPLATFORMS – Unconventional Platforms (Unmanned Aircraft Systems) for Remote Sensing*, Technical Report 56, 2009, European Spatial Data Research (EuroSDR).

[7] H. Eisenbeiss, *UAV Photogrammetry*, Ph.D. Thesis, Institut fór Geodesie und Photogrammetrie, ETH-Zórich, Zórich, Switzerland, 2009.

[8] P. Van Blyenburgh, *RPAS Yearbook: Remotely Piloted Aircraft Systems: The Global Perspective 2013/2014*, Technical Report, UVS International, Paris, France, 2013.

[9] K. Kim, J. Davidson, Unmanned Aircraft Systems Used for Disaster Management, *Transportation Research Record Journal of the Transportation Research Board*, 2015, University of Hawai.

[10] ISO/AWI 21895, Categorization and classification of civil unmanned aircraft systems.

[11] ISO/TC 20/SC 16/WG 1, Unmanned Aircraft Systems -- Part 1: General specification.

[12] ISO/TC 20/SC 16/WG 2, Unmanned Aircraft Systems -- Part 2: Product systems.

[13] ISO/TC 20/SC 16/WG 3, Unmanned Aircraft Systems -- Part 3: Operational procedures.

[14] Alec Momont http://www.alecmomont.com/projects/dronesforgood/ [last accessed 17-6-25]

[15] B. Coifman, M. McCord, M. Michalani, and K. Redmill, Surface Transportation Surveillance from Unmanned Aerial Vehicles, *Proc. of 83rd Annual Meeting of the Transportation Research Board*, 2004.