Research on the potentiality of using aerial vehicles for monitoring the environment agent - air

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Abstract. Unmanned aerial vehicles, "drones", are the most important invention the military field achieved in recent years. These are used in more and more fields such as agriculture, archeology, journalism, border control, inspection of high voltage power lines, small items transport, mapping, etc. This paper studies the possibility of using aerial vehicles in the field of environment protection for performing gas measurements at industrial exhaust sources, at different heights and for drawing isoconcentration maps. Also, they may be used in case of accidental releases of hazardous substances into air, resulting from a fire or explosion at industrial sites. Another possible use of aerial vehicles, under study to monitor air as an environmental factor is measuring industrial emissions over combustion plants. In this case, air currents created by drone and exhaust gas temperature will be taken into account. This method has a high degree of novelty as currently the standardized method for measuring emission of gases requires taking samples from the interior of industrial chimneys or pipes using heated probes. In practice, the situation where access to industrial chimneys is saddled or the chimney has no access holes is often met. In this respect, the use of an aerial vehicle, in case that research conducted will prove that it is possible and does not affect the quality of measurements, will be helpful to improve services, quick reaction in case of an event at a facility, for worker's and environment security.
Key Words: drones, environment, gas measurements, isoconcentration map, industrial emissions.

Civilian drones (aerospace vehicles) - modern investigation equipment with multiple applications. A drone is an aircraft or more precisely an unmanned aircraft (Unmanned Aerial Vehicle - UAV), which can be considered as a flying robot able to move without being controlled from outside - which in specialty terms is called autopilot, or be guided remotely via a remote control or other control device.

What differentiate drones from other unmanned aerial vehicles (UAVs) is firstly their much reduced size and weight, then the fact that power supply is provided by a battery or other power source.

Except for military drones, areas of use for civilian drones (Figure 1) are multiple, applications being even scientific. They have the following features and benefits:

- positioning and movement is usually based on GPS system;
- feature a powerful onboard computer and sensors, or other devices such as high-resolution and infrared video or photo cameras, range finders, radars, etc;
- data transmission or communication with the checkpoint is done either by radio or via the internet and devices including PCs, tablets and smart phones can be used as control devices;
- are able to independently come back to where they left;
- because power is supplied from a battery, they have a reduced period of operation - the drones autonomy expanding from tens of minutes to several hours;
- are silent when in use and at high altitudes/ distances they become difficult to see with the naked eye;
- are able to maintain stable at a fixed altitude or within a certain position;
- are resistant to shocks and exposure to water or high temperatures.

Figure 1. Examples of civilian drones (http://www.forbes.com; http://www.digitaltrends.com).

Main users of civilian drones can be: government, public security forces (police, firemen, and civil protection), research institutions, agriculture, journalism, real estate agencies, etc.

Examples of drone applications (Croize et al 2015):

- for meteorological measurements;
- surveying power lines, gas lines, aqueducts, bridges, dams;
- monitoring biodiversity in national parks;
- transport of small and lightweight materials in critical areas hit by natural disasters (earthquakes, floods, snow, etc.);
- taking geophysical and geomagnetic measurements, mapping;
- performing aerial footage or images with non-military purposes, for example in journalism;
- for help and assistance in emergency situations;
- monitoring crops;
- prevention and detection of vegetation fires, etc.

Miniature drones can be fitted with four or more brushless motors (with permanent magnets) and bear names depending on the number of independent motors: quadcopter - 4 engines, hexacopter- 6 engines, octocopter- 8 engines. 4 engine drones have the advantage of higher handling and movement, while 6 or 8 engine drones have the advantage of higher lifting power and air support. Drones with more engines are more stable in flight, because they are less influenced by wind.

Lately drones have become smarter and given the complexity and performance of hardware and software exists today, we might say that this development will take place rapidly.

Depending on type and objective pursued, drones can be equipped with various sensors, GPS positioning systems, camera equipment for high quality live recording or broadcasting, etc.

Regulations on the use of drones vary from country to country, in some countries or in some cases a permit being required to use drone into the open. European Union aims to complete the regulatory package for civil aircrafts weighing less than 150 kg by the end of 2016.

In Romania, the Ministry of Transport issued Order no 8/2014 for unmanned aircrafts weighing less than or equal to 150 kg, which for some reason has been withdrawn.

Analysis of experiments conducted abroad on drone use in measuring gas emissions in the atmosphere. Researchers at the BAM Federal Institute for Materials Research and Testing conducted a series of field experiments to study the possible use of micro-drones to measure methane dispersion in the atmosphere (Neumann et al 2012).

The experiment was conducted at ground level as follows: in the symmetrically arranged pipes (Figure 2), nozzles were placed, as a source of emission, at a constant distance of 1 m. In order to was ensured by a canister of pressurized gas.

To study the dispersion of methane generated by the emission sources in the atmosphere, a micro-drone equipped with sensors for measuring gas concentrations was used, which flew in the air over the pipes at different emission sources heights.

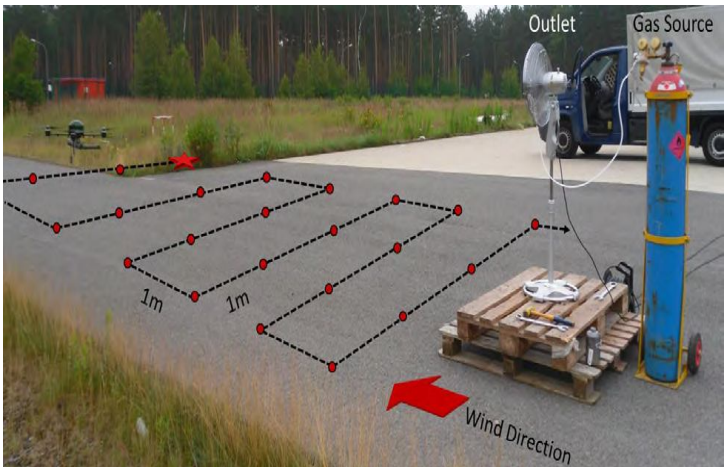

Figure 2. Placement of symmetrically arranged pipers.

With the help of advanced software, and having the gas concentrations measured by the micro drone, gas dispersion at certain height maps were plotted (Figure 3).

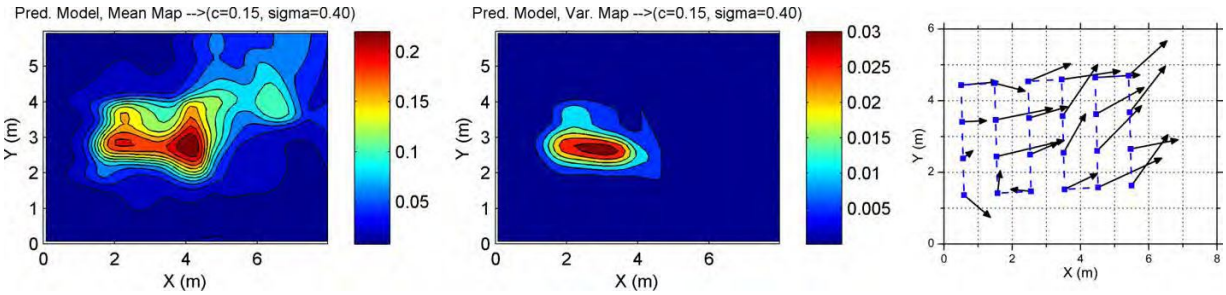

Figure 3. Plotting gas dispersion maps.

Following experiments carried out, German researchers concluded that (Bartholmai et al 2014):

- gas dispersion in the natural is difficult to model, due to air currents produced by drone;
- in a non-artificial environment, gas plume evolution is difficult to predict because of chaotic dispersion of gas in the atmosphere;
- modeling gas distribution in the atmosphere using a drone is a highly challenging research area;
- plotting gas dispersion maps for large areas using drones is very costly and time consuming;
- micro-drones equipped with gas sensitive sensors can be successfully used in detecting and monitoring gas leakage;
- reproducibility of measurements is possible when wind and weather conditions remain constant over a longer period of time.

Another institute, namely the Federal Institute of Materials Research and Testing along with AirRobot GmbH & Co. KG Company have collaborated to develop a system for measuring gas using remote drones, called "PLUM system" (Bartholmai & Neumann 2010).

Following investigations, they concluded that this system can be successfully used to measure toxic gases from stationary sources (chimneys), accidents caused by hazardous chemicals (Seveso II), active geodynamic phenomena like volcanic eruptions, thermal waters, etc, storage areas for waste dumps, tailings, storage areas for carbon

dioxide, various polluted industrial sites, etc. Also the results have clearly demonstrated its applicability in various fields.
Analyzing a series of papers developed by researchers in Germany, USA, England. Us Journal of Sensors, it was found that drones are useful in monitoring the environmental factor air.

Usability of civilian drones to measure gas emissions in the atmosphere. According to environmental law, any human activity that generates a significant environmental impact is subject to assessment of environmental impact procedures. In this sense, for acquiring the environmental permit, competent authority require a specific environmental study to analyze the impact of project implementation.

For plans and programs, public or private new projects, environmental studies are developed in accordance with regulations in force, guidelines and manuals developed by the ministry. Among the specific environmental protection studies we mention: environmental report (RM), assessment report of environmental impact (RIM), the environmental review (BM), and security report (RS), location report (RA) and adequate assessment (EA).

Within the procedures for environmental impact assessment (RIM, BM and RM) environmental authority also requires measurements for air, water, soil, in order to know their level of pollution (initial state).

Air quality measurements at a polluting unit should focus on stationary / fixed sources of emissions that generate large quantities of hazardous gases to human health and the environment.

Choosing sampling points at a stationary source (chimney, canal, and pipeline) should be performed in a manner that distribution of pollutants (gas, dust) in source section is homogeneous and speed, temperature and pressure are as stable as possible.

In order not to influence the quality of measurements, the effluent flow (air gas) must have, as much as possible, a laminar flow, presence of deviations, fittings, fans being avoided as possible.

For measuring stationary sources, reference standard SR EN 15259/2009 "Air quality - Measurement of stationary source emissions. Requirements for measured sections and sites, measurement plan and report" as well as SR ISO 9096/2005 indicating the number of sampling points depending on the outlet section of the source and placement of these points must be observed.

For sampling exhaust gases from stationary source (chimneys) there must:

- exist a proper visiting (access) hole in the chimney, for the sampling probe;
- the measuring equipment must be power supplied;
- gas flow must be laminar and without turbulences.

There are situation when the chimney doesn't have a sampling orifice or doesn't have a work platform placed at the proper height (recommended by legislation).
There are also situations when the stack is 30-50 m high so that makes sampling flue gases impossible.

In all these cases, the use of drones equipped with sensors (CO_2, SO_2, CO, O_2 C) is the most advantageous and reliable method of measurement (in terms of health and safety at work) and the quality of measurements is higher because they are taken right at the gas discharge into the atmosphere.

To perform gas measurements using drones at large combustion plant chimneys, having high air flow rates and large sections, some safely recommendations/conditions must be observed, namely:

- use of drone must consider the reduced autonomy of equipment (max 40 min depending on drone load weight and battery);
- knowledge of exhaust stacks height so that the vehicle is able to reach in time to mediate gas concentrations;
- knowledge of exhaust gas speed and temperature, because drones can be used at temperatures up to 600C and a maximum wind speed of 40km / h;
- handling equipment should be made so as to avoid its damage or deterioration;

- areas where there are high voltage wires should be avoided to eliminate risks of dropping the vehicle;

- wind speed should not exceed 40 km / h to not influence stability of the drone, and to not cause significant turbulence during measurements.

Therefore, undertaking experimental measurements at high stationary sources without working platform or having inaccessible platforms would be useful, so that personnel conducting measurements is not exposed to risk of injury.

Using a drone for emission measurements presents a number of dangers and disadvantages as well:

- the presence of toxic gases, hot, flammable dust and noise;
- equipment short-circuit or static electricity;
- flow rate of gas in the chimney should not be to high to not affect the stability of the drone, and to not cause significant turbulence during measurements, etc.

Drones can be used in developing any kind of environmental study (RM, RIM, BM, RA, RS) to collect various environment related data and information in the field, namely:

- local geodynamic phenomena (landslides, erosion of banks, tectonic accidents, etc.)
- polluted soil and surface waters areas;
- monitoring deforestation in natural parks;
- monitoring of protected areas types of ecosystems, habitat types and species that may be affected;
- identify sources of air pollution by pollutants cloud moving;
- identification of areas affected by wildfires, etc.

In Romania, at present, environmental monitoring using drones is not used. Thus, given research performed and analysis of abroad experiments and research as well as INSEMEX Petrosani experience in forensics in case of explosions and fires generated by explosive gases, the use of drones is a great support in the research of an event.

Conclusions. Study of experiments carried out by abroad researchers demonstrated that the use of drones to monitor air quality is a increasingly studied and experienced phenomenon.

Drones can be equipped with sensors for determining gases concentration at stationary sources or the environment, with photo/ video cameras and GPS tracking for flying over polluted areas or monitoring air quality parameters in protected areas.

The use of drones to measure concentrations of toxic flue gases from exhaustion chimneys of large combustion plants emission eliminates the danger (platforms at inaccessible heights) for staff that has to monitor such chimneys.

Considering INSEMEX Petrosani experience in forensics in case of explosions and fires generated by explosive gases, the use of drones for detecting sources of explosive gases leaks in pipes as well as emanation of gases released into the atmosphere following a event, is very useful.

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