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Occupational Hygiene of Unmanned Aerial Systems and Emergency Response

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Abstract

Unmanned Aerial System (UAS) technology is evolving rapidly, lowering cost and technology barriers to use in many applications. This review and commentary summarizes the relevant literature in related fields and assesses the potential applications and utility of UAS technology in the occupational health field. Areas closely related to industrial hygiene are investigating potential applications and in some cases already using this technology for research or commercial purposes. The literature is screened to produce a cross-section of how UAS technology is used in these closely related fields and can inform or guide potential uses in industrial hygiene. We discuss UAS applications in environmental monitoring, emergency response, epidemiology, security, and process optimization. The rapidly evolving state-of-the-art shows that this technology can be useful in industrial hygiene. Benefits include cost savings, time savings, and remote sensing to avoid hazardous environments. The occupational health community can look to relevant areas for insights and apply them to their own practice.

Keywords: Environmental monitoring; Industrial hygiene; Occupational hygiene; Sampling

Introduction

Unmanned Aerial Systems "UAS" ("UAS", short for unmanned aerial systems, is used throughout this article. These systems are sometimes referred to as unmanned aerial systems, remotely piloted aircraft, unmanned aircraft, micro aircraft, etc.). The media and literature are rapidly changing and can offer researchers and commercial companies new ways to accomplish their tasks in an efficient manner. In recent years, the market for relatively inexpensive, high-performance off-the-shelf commercial systems has thrived, and UAS technology has spread rapidly. Commercial UAS sales are expected to double over the next decade [1]. Recreational users, in particular, are not expected to be the main source of growth for the UAS market. Both military and non-military uses of UAS are expected to grow significantly [2]. A number of commercial and governmental (non-military) applications of UAS technology are being considered to see if the business case and other benefits can be realized. Many potential UAS applications can be found in related or closely related professions and disciplines where industrial hygienists, researchers and safety professionals often congregate. Therefore, it is important for industrial hygienists to have a brief introduction to this technology and understand how it can benefit their field and practice. Simply defined, a UAS is probably more than a layman might imagine when thinking of either remotely operated recreational aircraft on the "low end" of the technology spectrum, or military Predator drones on the "high end" is. One of many examples is America for Defense's Unmanned Systems Integrated Roadmap, FY2013 – 2038 [3], which classifies systems based on aircraft weight, maximum speed, and maximum operating altitude) US Department of Defense, 2013. A modern small UAS typically includes an airframe, power supply, mission-specific sensors, electronics, and software. Devices often also have communication and navigation capabilities, such as 3G or 4G cellular chips, WiFi or other wireless network protocols, global positioning chips, and the ability to communicate with commercially available smartphones and tablets [4]. Just as smartphones have become very powerful tools, so too can a small UAS take advantage of the same computing power. Industrial hygienists should be aware of this technique for two reasons. First, the technology could be an additional tool in a toolkit for rapid exposure assessment, screening, environmental data collection, or situational awareness in new ways. Its high mobility in a 3D environment and the ability to carry advanced sensors has the potential to be applied to all the predictive, detectable, and assessable and control activities performed by hygienists. Second, some industrial tasks involving occupational hazards may be suitable for her UAS employment because hazards to workers can be avoided or minimized.

Monitoring Chemicals

Deployment of UAS has potential as a flexible mobile platform for contaminant sampling, detection, characterization, and/or remote sensing. Several applications have been pursued by researchers who can directly inform methods of employment and restriction in occupational health and exposure assessment roles studied and derived source terms for modeling [5]. Particulate matter, metals, polycyclic aromatic hydrocarbons, and volatile organic chemicals were monitored in this study. Using a balloon platform is likely to be less costly than traditional UAS, and this approach may impact workers and other vulnerable populations requiring long stays and a stable sampling platform useful for measuring pollutant emissions. UAS has been used by researchers trying to characterize volcanic plumes. In particular, the technical methods used in these studies can be easily transferred to industrial hygiene for monitoring hazardous atmospheres. One study investigated SO_2 and CO_2 fluxes using mobile infrared spectrometers and electrochemical sensors [6]. Another study examined biases that can be introduced by UAS migration speed and sensor response time [7]. For example, if your UAS platform is logging georeferenced data with timestamps, but the t90 (time to 90% response) for a given sensor is a few seconds, it lags behind Global Positioning System

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coordinates. There is a bias between the sensors response. This is an important complication to consider whether these devices will be used for industrial hygiene and deserves additional research and remedial measures. A miniature mass spectrometer with sensors was used to monitor, H_2S, CO_2, pressure, temperature and relative humidity [8]. Note that the more powerful sensors used in this study are not only suitable for monitoring human exposure to chemicals, but also for heat, cold or cyclonic stressors. An active research area is the use of UAS with chemical sensors and software algorithms to track or map contaminant concentration gradients and autonomously identify or characterize pollutant sources. A researcher developed his UAS platform based on a small balloon with the aim of chemically detecting explosive mines using various mapping strategies [9]. In this study, we used metal oxide chemical sensors and compared autonomous and controlled flight detection paths with ethanol as a surrogate contaminant. Another study investigated the feasibility of autonomous UAS-based sensors for monitoring carbon capture and storage facilities, especially CO_2 leaks [10]. They evaluated his two sampling strategies. The first is based on a predefined UAS path, the second on a so-called "adaptive sampling" path. The term is increasingly used in the literature to describe autonomous surveillance that is modified as sampling progresses based on artificial intelligence algorithms. Essentially, the device changes its destination based on what it detects. This could be an area of innovation in the ongoing modernization of environmental monitoring and exposure assessment. The same research team also publishes details of an algorithm developed to implement adaptive sampling [11].

Emergency Response

Emergency response (including disaster and humanitarian response) is another area where UAS is rapidly being deployed. Many hygienists are employed as members of response teams or provide expert advice to support such units. The use of robots in emergency response is nothing new. For example, commercial ground robots have long been used by state and local law enforcement agencies to detect explosive devices. A forward-looking 1993 article proposed a chemical and radiological contaminant detection UAS equipped with day and night optical sensors for emergency and disaster response purposes [12]. All of the aforementioned UAS capabilities can be applied to chemical, biological, or radiological detection for screening potentially hazardous environments, or emergency response involving gas, vapor, and aerosol collection devices. Small aerial platforms can be equipped with visible and infrared video transmission to locate ruptured chemical containers or leaking infrastructure (pipes, tanks) or used for search and rescue purposes. A recent publication comprehensively examined the impact of robotics (including UAS) in 31 disasters and accidents from 2001 to 2013 [13]. As industrial hygiene practices evolve into the future, more and more interdisciplinary practitioners are working in safety, environmental management, and other related fields. The field of emergency response is expected to be an area where industrial hygiene will continue to contribute. Remote sensing is also used in epidemiology and infectious disease research. This area would complement the use of UAS for environmental data collection. A recent review and critical discussion of the potential of UAS in epidemiology highlights several strengths and weaknesses of this approach [14]. Environmental factors and other spatial variables suitable for UAS detection that are also determinants of infectious disease transmission are important data sources for risk mapping and analysis. Examples include land-use change, animal reservoir tracking, and hydrological monitoring (such as mosquito reservoirs). Using remote sensing data to study patterns of infectious diseases is nothing new. Malaria is an example where dereferenced satellite data can provide information to predict or explain transmission [15]. Another example is the use of the UAS platform to study spatial determinants of tuberculosis in Spain [16]. It is important to note that, although not as directly applicable to occupational health practice as other applications highlighted in this article, UAS techniques are expected to increase the creation of advanced dereferenced variables is in order to help. UAS is also evaluated for occupational safety applications. One example is using UAS to raise awareness of the occurrence of hazardous situations and worker compliance with safety requirements. The research explored what kinds of interfaces and information would be useful for monitoring construction work simulated using visual feeds from mobile UAS platforms. Indeed, it is hypothesized that the device should act as a "safety officer's backup drone" to facilitate frequent and prompt workplace inspections [17].

Conclusion

UAS is evolving rapidly. As industrial hygiene evolves into its future state, new technologies must be evaluated and considered as part of this evolution to remain relevant. This paper reviews UAS applications in the closely related occupational health literature.

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