Chapter 12
UAVs and Their Use in Servicing the Community

George Eftychidis, Ilias Gkotsis, Panayiotis Kolios, and Costas Peleties

Introduction

Unmanned Aircraft Systems are small aerial vehicles that can be flown by a pilot via a ground control system, or autonomously through use of an on-board computer, communication links and additional equipment that is necessary to operate safely. All these components together are jointly referred to as Unmanned Aircraft Systems (UAS). The term UAS is the official term used by the U.S. Federal Aviation Administration to describe such type of aircrafts. Unmanned defines that they fly with no human pilot on board, the term aircraft is used to comply with airworthiness and airspace regulations, and the term systems is used to emphasize the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft (Austin 2010). Other terms are also widely used to refer to these systems, such as Drones (Dynamic Remotely Operated Navigation Equipment), RPVs (Remotely Piloted Vehicles) and RPAS (Remotely Piloted Aircraft Systems) (Federal Aviation Administration).

The use of UAS has shown to be extremely beneficial in many situations and their popularity is increasing in a very fast pace, due to their great advantages over manned aircrafts. For example, UAS have lower cost of acquisition, operation

G. Eftychidis · I. Gkotsis (✉)
Centre for Security Studies, Athens, Greece
e-mail: g.eftychidis@kemea-research.gr; i.gkotsis@kemea-research.gr

P. Kolios
KIOS Research Center, University of Cyprus, Nicosia, Cyprus
e-mail: pkolios@ucy.ac.cy

C. Peleties
Cyprus Civil Defence, Nicosia, Cyprus

G. Leventakis, M. R. Haberfeld (eds.), *Community-Oriented Policing and Technological Innovations*, SpringerBriefs in Criminology,
https://doi.org/10.1007/978-3-319-89294-8_12

and maintenance, have longer operational endurance, need reduced pilot skills and can be operated with minimum human intervention and, depending on the system, they can operate even for hours under difficult conditions, without loss of concentration and fatigue. Moreover, UAS can be deployed in a variety of terrains and harsh environments, can access hazardous sites and contaminated spaces which are dangerous for flight crews onboard, and can perform visual or thermal imaging of an affected area (Deliverable 61.2 Position Paper).

Undoubtedly, all these features can prove extremely beneficial to civil protection missions (covering both prevention and preparedness), having though an impact on the performance of the UAS in terms of operational times and overall time management. In frame of PREDICATE project, we seek to integrate UAS capabilities to the specific civil protection needs aiming to increase operational effectiveness and decrease operational costs; while decreasing the response time required in disaster prevention and emergency response missions. It is evident that, the sooner a victim of an unlawful act or a missing person during search and rescue is located by law enforcement or civil protection services, the sooner protection and medical aid will be offered and the better the chances of release and survival. Furthermore, AS can support first responder operations and may increase situational awareness of civil protection agencies.

UAS vary greatly in size, flying capability, capacity and methods of control. Nowadays, UAS are used in many parts of Europe to monitor roads, railway systems and infrastructure, to survey agricultural production, to enhance the capabilities of commercial photography, to support wide area mapping and surveillance, to check on wind turbines, electricity pylons, dams and other elements and networks of critical infrastructures. In Fig. 12.1 below, the major categories of UAS civilian application fields are depicted. The capabilities of UAS pave their way to developing civilian applications associated to Community policing within the category of Homeland Security.

Needs Assessment

UAS and in particular rotorcrafts can offer many beneficial support services to civil protection and community policing activities in a variety of ways. Broadly speaking, these services can be classified in two categories, based on their relative purpose of use. They can either deliver help (helper) or provide observation/information (informer/observer). A helper UAS can be used to support civil protection response operations by shipping important dispensable equipment payloads quickly and effectively (i.e. shipping equipment such as a life vest, a defibrillator, a first-aid kit, a thermal blanket, water and food, etc.). An observer UAS can be used to maximize situational awareness and support the personnel of civil protection organizations and community policing organizations in deciding or planning their actions during field operations (i.e. monitor the evolution of field operations or state of unlawful acts,

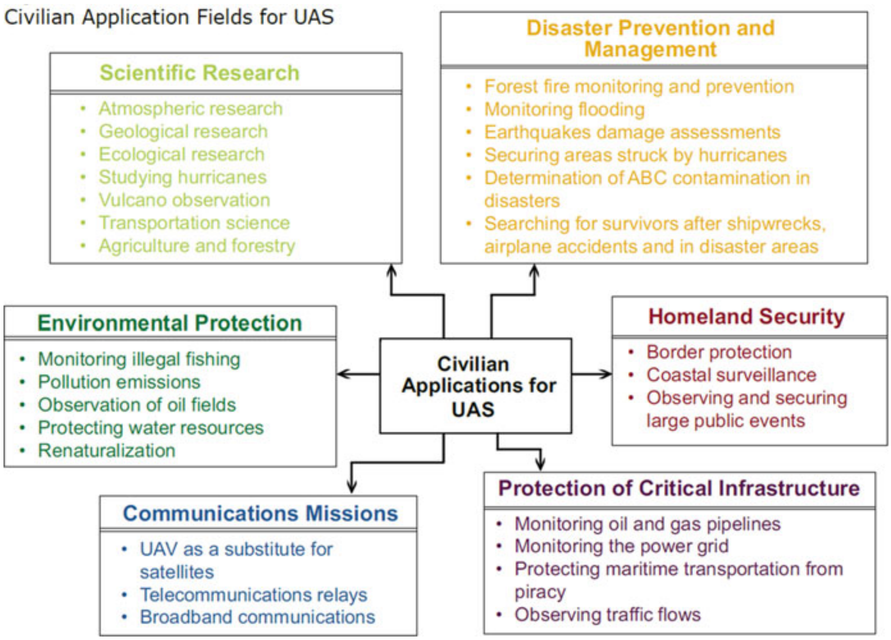


Fig. 12.1 Civilian applications for UAS (diagram by Therese Skrzypietz) (Skrzypietz 2012).

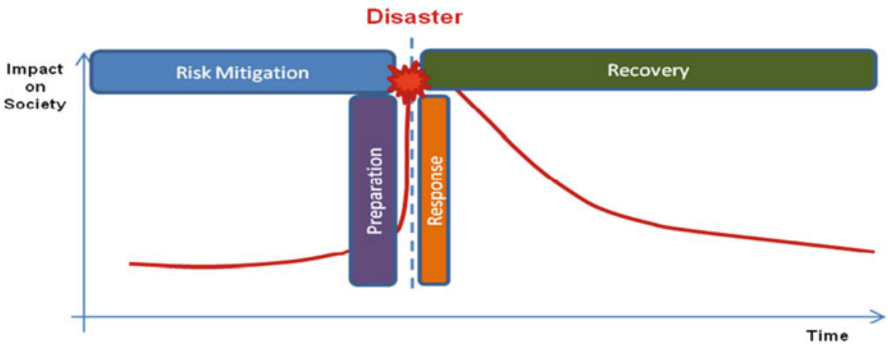


Fig. 12.2 Timeline of effects of a disaster (Deliverable 61.2 Position Paper)

identify threats or evaluate particular situations). The presence or appearance of a UAS may have also deterrent effects in the evolution of an illegal action.

In case of disasters, the public sector is often paralyzed due to eventual damages to infrastructures and disruption of critical services. Figure 12.2 illustrates a natural disaster timeline, with its changing impacts, over four stages: (Risk Mitigation, Preparation, Response, and Recovery). The area beneath the red time-line represents the impact on society, and includes: casualties, negative impact on livelihoods, and, depending on the socio-economic resilience capacity, regression in development.

Time is a crucial factor during emergencies and any unexpected situation. Hence rapidly available and highly deployable equipment is directly linked with response efficiency and mission performance. In that respect, UAS platforms provide an increase in operational effectiveness; while at the same time they decrease operational costs and operational response time. The public emergency services and law enforcement agencies shall potentially use the UAS technology in a variety of ways, depending on the phase of the operations, the level of risk or incident and the type of UAS being used (European Emergency Number Association – EENA 112 2016).

Civil Protection Operational Needs

The needs of civil protection operations have been discussed and elaborated in frame of PREDICATE project with representatives of emergency organizations and law enforcement agencies in order to determine and organize the relevant requirements aiming to address the respective needs. The information was enriched through an extensive literature review, properly prepared questionnaires, physical meetings and personal interviews with relevant experts and representatives of public agencies in Greece and Cyprus. Based on the feedback received during the aforementioned knowledge elicitation activity, the civil protection operations that can be supported, exploiting the UAS capabilities are arranged into four main groups as follows:

- The Reconnaissance And Mapping (RAM) group, refers to the use of UAS platforms and their respective payloads in order to identify and locate vulnerabilities, hazards, and threats that may evolve to natural/man-made/technological emergencies (Se et al. 2009). In addition, RAM is related with the detection and assessment of changes over large Regions of Interest (RoI) and the mapping of such changes to inform prevention plans. The RAM group of operations can be associated with the management of risks and disasters at all levels of the command chain, supporting public actors involved in civil protection tasks with consistent surveillance of large areas, timely risk identification and informed decision making on a concrete situation. The Monitoring and Tracking (MAT) group of operations, refers to the process of persistent surveillance of Areas of Interest (areas smaller than RoIs), stricken by specific emergencies (American Red Cross and Measure 2015). In such situations Search and Rescue (SaR), live saving and evacuation are the primary tasks for the civil protection personnel. MAT is a dynamic process at the operational and tactical level that offers valuable input for deciding response actions and first responders' operations as well as for leveraging situation awareness in crisis management by enriching situational crisis picture. In terms of community policing tasks this type of operations can be combined with monitoring of events in open public spaces involving large crowds, confirmation of unlawful activity in public safety situations etc.
- The group of Temporary Utility Infrastructure (TUI) operations is relative to the task of offering an alternative utility infrastructure, using UAS. Examples of TUI

operations include primarily telecommunication services (Li et al. 2016) e.g. UAS acting as a relay radio communication node, for illuminating dark areas during the night (Direct Line for Business 2017), as notice boards to display inform and replaying of acoustic messages. Multiple drones may be deployed in swarms, e.g., to map out and track pollution or to make up a grid network and relay the data over large distances (White et al. 2008).

- Delivery of Help-Aid (DOH), refers to the process of delivering or releasing (after adjusting custom made equipment, such us buckets, claws, etc.) urgent medical and other supplies to those in need, including: first-aid kits (QuiQui-automated drone delivery of pharmacy items), tools, bottles of water, blood, defibrillators, medications or other healthcare items (Scott and Scott 2017). Delivery method can use automated ground station, parachute, rope dropping, ground landing etc. Thus, despite issues related to privacy, security, safety and regulation need to be addressed, UAS can provide beneficial and ubiquitous support to civil protection, law enforcement and healthcare emergencies.

Community Policing Operational Needs

In accordance to the civil protection operational needs and extended to community policing purposes, there are many applications for the employment of unmanned systems for law enforcement. UAS are able to enhance situational awareness and force protection of officers in the field. Examples include over-watch of vehicle checkpoint and search, situational awareness during hostage situations (close look through windows without risk), traffic monitoring, neighbourhood watch, petty crime response, suspect monitoring, patrolling, incident reconstruction, assistance in vehicle apprehension, crowd monitoring and control (using loudspeakers), disaster response and management, wide area detection of drug making facilities, drug crop detection, distributed video to ground patrols and HQ facilities simultaneously (Fig. 12.3).

UAS have the potential to improve both community and officer safety, while decreasing the cost of improved operations. Some indicative cases are the following (Valdovinos et al. 2016):

- Search and Rescue Operations: a UAS is able to maneuver in relatively small and difficult-to-access areas in order to locate individuals with special needs or disabilities.
- Protecting Officer Safety: Some departments use UAS to get a better look at suspicious packages or locate hidden (and possibly dangerous) suspects while reducing risk to officers.
- Helping Police to respond to criminal actions: Rapid assessment of field conditions and situational awareness that can support intervention and planning.
- Accident and Crime Scene Investigations: An aerial survey by a UAS, particularly one equipped with GIS mapping software, can save hours in follow-up

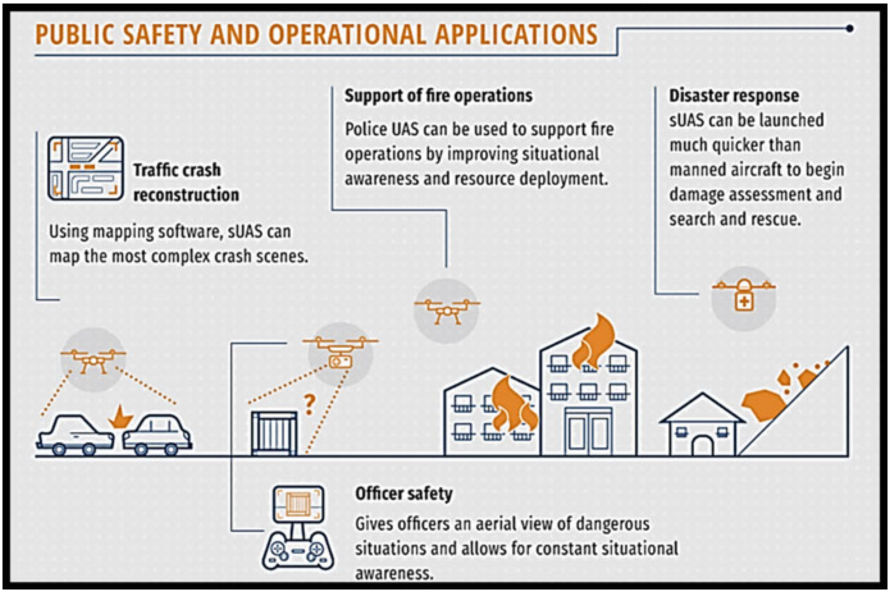


Fig. 12.3 Public safety and civilian applications of UAS

investigations. This can speed up accident and crime scene investigation and report preparation and may reduce incidental traffic associated with a scene investigation.

- Disaster Management: UAS can survey damage in flooded or inaccessible areas quickly, saving responders vital time and protecting their safety.
- Perimeter Security: UAS can provide views of hard-to-access areas, improving officer and public safety. This can be crucial in securing areas before public events as well as in border protection.
- Active Pursuit Support: Focus group members noted that using UAS to follow fleeing suspects, particularly when they are on foot, protects officer safety, and could also reduce the danger to the public.
- Monitor waste disposal and other environmental crimes: Activation of UAS following citizens' complaints.
- Support and Coordination with Fire/EMS and Other Government Agencies: Firefighter safety could be greatly improved by the use of a UAS to view roof damage during a fire. Additionally, public works, community development, parks and recreation, environmental work (such as mosquito control), transportation (like mapping evacuation routes), planning, and many other public responsibilities could benefit from implementation of UAS technology.

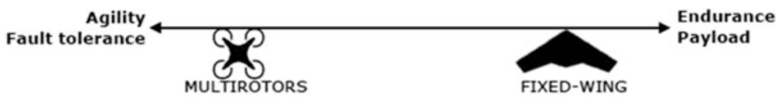
It has to be noticed that, in context of community policing, the operator of UAS can be a private pilot, member of a local community, or Police department linked to organized communities of citizens. In all cases the legal restrictions and constraints for using UAS in urban environment should be considered. In case of PREDICATE, the cooperation with Cyprus Civil Defence included the option of civil protection volunteers as community actors who are authorized to use UAS for operational purposes, including situational awareness and search and rescue.

UAS Capabilities and Operational Requirements

UAS Component Categories and Types

The category and type of available components are the factors that define the operational capabilities of an assembled UAS platform. These capabilities include the air-cruise speed, the altitude and autonomy of the flight, the deploy ability, the performance to environmental conditions, hovering, manoeuvrability, range and endurance, communications range and the size of the platform. It is thus important for UAS users to know which are the categories and the types of available components that they can consider for designing a system, which can address their respective operational needs. The PREDICATE project considers both fixed-wing UAV and rotor crafts (VTOL). Fixed-wing are more efficient regarding endurance and payload while rotor crafts are comparatively more agile and fault tolerant. An overview of the respective performance and specifications of currently available in the market UAS is shown in Fig. 12.4.

Community policing solutions need to consider rather Small UAS and rotor crafts than fixed-wing UAS.



	MULTIROTORS	FIXED-WING
POWER SOURCE	Electric	Electric / Combustion
ENDURANCE	10′ to 50′	45′ to 10+ h
PAYLOAD	up to 15 Kg	0,5 Kg to 50+ Kg
GROUND SPEED	0 (hovering) to 75 km/h	45 km/h to 200+ km/h
ALTITUDE (ceiling)	Up to 3000 m	Up to 5000+ m
SIZE	6 cm to 1,6 m (frame diameter)	1 m to 20+ m (wingspan)

Fig. 12.4 Average commercial UAS specs & performance (European Emergency Number Association – EENA 112 2016)

Table 12.1 PREDICATE needs' assessment matrix for civil protection operations

		Operational need				
		Reconnaissance and mapping (RAM)	Monitoring and tracking (MAT)	Temporary utility infrastructure (TUI)	Delivery of help-aid (DOH)	Overall rating score
UAS capabilities	Carry heavy payload	3	2	5	4	3
	Deploy ability	4	5	5	5	5
	Ease-of-use	5	5	5	5	5
	High airspeed	3	3	1	2	2
	High altitude	3	1	2	1	2
	Hovering	2	2	5	5	3
	Long endurance	4	5	5	5	5
	Long range	3	3	2	3	3
	Maneuverability	3	3	3	3	3

Operational Requirements

A number of technical specifications is required by UAS in order to address the needs of civil protection operations. Nine UAS capabilities have been defined in PREDICATE in order to organize and formalize the ability of the system to perform particular missions and support specific type of operations. These capabilities according to their ratings are depicted in Table 12.1.

High deploy-ability is essential, since response operations require prompt reaction and minimal pre-flight preparation. Thus, UAS platforms should have quick and adaptive deployment ability to ensure they can be deployed quickly even in challenging terrain (e.g. ruined buildings, burned areas, tight spaces).

One particular advantage of the microdrones UAS is the ease with which they can be used. It takes only a short time to learn how to fly and steer these aerial platforms (either in manual or automatic mode), thereby saving on costly training programs. This is crucial for civil protection organizations, the personnel of which are usually volunteers with no previous aviation background or knowledge. Although UAS pilot training for civil protection operations is obligatory the easiness of use is important for introducing UAS in operational tasks and for increasing the efficiency of the operations. Easiness of use in context of civil protection operations is directly related with the hovering ability of UAS and in particular of rotorcrafts. Hovering allows the operator to monitor an event and take unique viewing angles easy and effectively, while the UAS will stay in a specific position as much is required. Endurance is another technical specification which is quite important for civil protection operations. It is obvious that longer endurance provides higher performance as well as lower costs in terms of extra recharging/replacement components. Other UAS capabilities such as long-range flight, manoeuvrability and increased payload capacity[1] have been considered as features of medium importance in civil protection operations. Carrying a heavy payload could be beneficial for some operations, especially when delivering equipment. High speed and high-altitude requirements are not considered important for civil protection UAS missions. In context of PREDICATE, a number of DJI UAS solutions (Matrice 100, Matrice 600 and S1000) was used, which have payload capacity between 3 and 7 kgs, flight time (with payload) between 15′ and 40′ and control range spanning up to 5 km. A number of these UAS was used by the Cyprus Civil Defence for validating the performance of PREDICATE system for operational purposes.

Mission Planning

Visual Data Gathering

Cameras are the primary instruments used on-board of UAS for supporting disaster prevention and perform emergency response missions. They are usually optical sensors operating on the visible light spectrum or infrared, operating in low-light conditions and detecting emitted heat. Visual cameras can directly provide information from the incident field or a region of interest in the form of real-time images and video streams. The procedure of visual data collection is vital in criticality assessment, search and rescue, and monitoring type of missions. Key to visual data collection is the ability of discriminating between objects of interest, where the task is to locate all instances of an object of interest in the captured imagery data.

In order to perform accurate visual analysis (i.e. identifying all objects/areas of interest correctly, without false positive/negative detections), the camera resolution has to be adequate in order to apply Johnson's criteria for defining the number of picture elements (pixels) required to discriminate an object on an image, based on three main levels with more than 50% probability of success (Waharte and Trigoni 2010; Kopeika 1998; TREC 2016). The three levels of discrimination are detection, recognition and identification as shown in Fig. 12.5, which illustrates the relative results achieved in terms of picture elements.

The distance of the camera sensor from the target affects the image resolution and therefore the flight altitude of a UAS carrying the camera is also affected. This means that in order to ensure higher resolution the UAS should fly in lower altitudes. However, flying at lower altitudes will have an impact on the flight performance, since the ground FOV of the camera will become narrower, which fact will lead to longer flight times for the same ROI. The discrimination level should provide enough information for the particular mission while maintaining a feasible and

[1]A payload is the cargo or equipment a UAS carries that is not required for flight, control and navigation. Payload is a percentage of the total take-off weight of the vehicle.

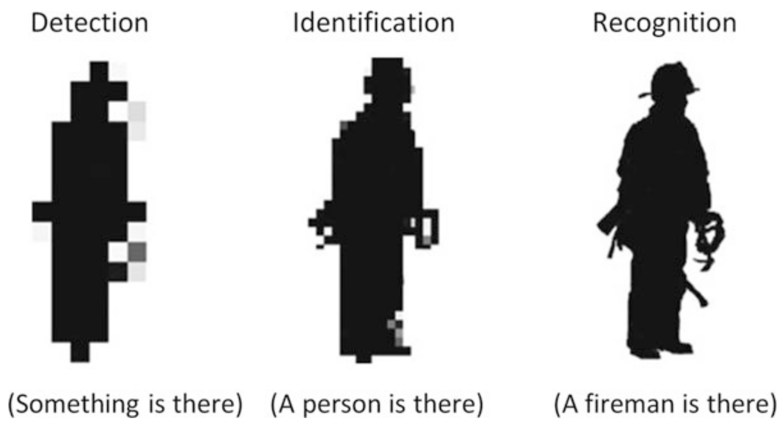


Fig. 12.5 Johnson's criteria discrimination levels (UVSS – United Vision Security Systems 2016)

useful flight plan, eliminating eventual false positives/negatives (UAV Vision 2016). For civil protection, target (object) recognition and tracking is considered the most important task.

Heat sources such as humans, animals, cars etc. can be detected and recognized using infrared cameras. In the respective images, hot objects are coloured white while less warm or cold objects are coloured darker or black. The imagerycollectedcanbeprocessedlocallybyacomputersystemon-boardthe UAS in order to enhance the image, detect and recognize specific objects; or it can be sent to remote control centres for post-processing.

Path Planning

Path planning is the final outcome of PREDICATE project, which provides an up-loadable flight plan to the UAS, based on the mission data calculated using the relative user inputs. It is assumed that for any type of mission, the region of interest that will be scanned is known a priori and segmented into a number of (N) tiles, which the UAS has to sweep, covering all segments before completing its mission. The operational time is governed primarily by the selection of the platform and the payload that will be used.

For the path planning purposes, a tool (Fig. 12.6) has been developed during PREDICATE, specifically for Android devices, providing an easy and organized graphical interface and advanced automated capacities for the end users, such as automatic flight, object tracking, picture stitching and several other capabilities.

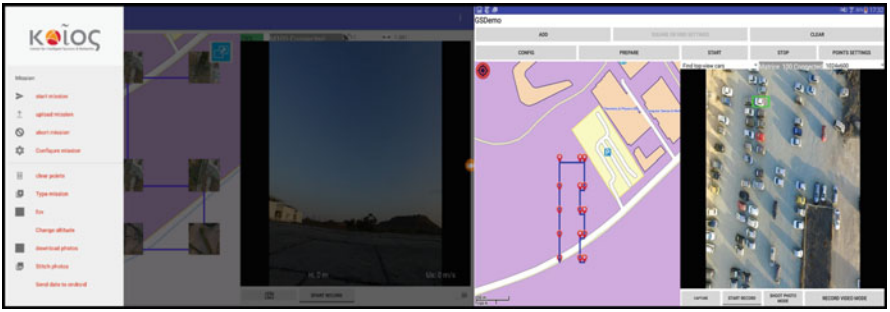


Fig. 12.6 PREDICATE mission planning toolkit

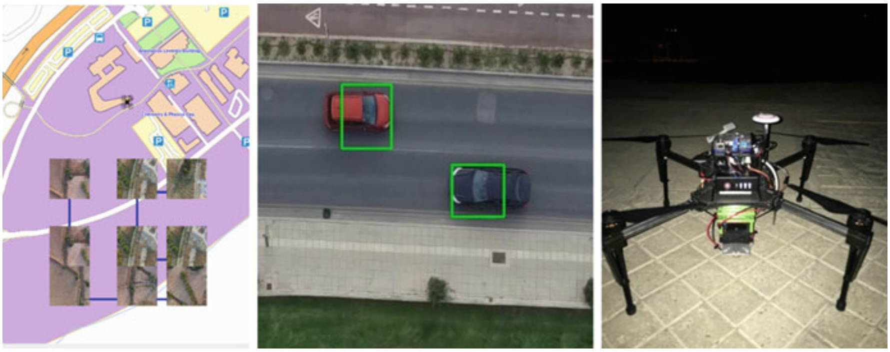


Fig. 12.7 Mapping and reconnaissance (left), monitoring and tracking (center) and temporary utility infrastructure (right) operations

Proof of Concept

As stated above, UAS can be of benefit for a number of emergency management and public safety applications. This has been validated and demonstrated through several field tests, exercises and activities where PREDICATE participated officially.[2] These events provided the opportunity to test the performance of the system in a variety of mission types as regards mapping, monitoring and infrastructure provision during emergencies (Fig. 12.7). The integration of PREDICATE functionality in community policing tasks has been tested in context of the demonstrations performed during the NGCP International conference on community policing held in Heraklion, Crete (Gr) in October 2017.[3] In this case, PREDICATE mission was linked to the back-end system of INSPEC^{2}T[4] and fed with the coordinates of the

[2] http://www.kios.ucy.ac.cy/predicate/index.php/photos/category/34

[3] http://ngcpconference.com/

[4] http://www.inspec2t-project.eu/

incident site to monitor. The PREDICATE UAS received the coordinates of Points of Interest from the INSPEC^{2}T system, plan the respective path and automatically take-off and fly to the site providing the control center with real time images and video streaming from the incident place.

Conclusions

This paper provides an update on the results of the PREDICATE project of DG ECHO and focuses to the possible extension of the use of UAS for improving public safety based on the strengthening of community policing capabilities. As described in the above sections, one of the major outcomes of the project is a mission and path planning utility, which can be uploaded by community policing control centers to a variety of UAS and allow them to perform mission specific flights over specific sites of interest. Using the developments of PREDICATE and the appropriate payloads the UAS can be used for scanning the region for search and rescue purposes, aiming to detect, recognize and identify missing persons and abandoned objects, persons in trouble due to criminal activity or entrapped people.

Such tools (as of PREDICATE) and UAS (especially small ones such as quadcopters) can be a great asset either for civil protection or law enforcement agencies, while serving the community. The aforementioned capabilities can provide improved operational preparedness, reduced response time and increased information and data flow from the incident scene, combined also with the ability of automatic mission deployment. The burst of the UAS market and their use by volunteers and hobbyists can be exploited in context of community policing for strengthening the efficiency of law enforcement in a continuously threatened European society.

It must be considered though by the operating authorities, that procedural justice, transparency, and accountability should be maintained, and that they are responsible of balancing the benefits of such technologies with the preservation of community privacy, safety, and other concerns.

Acknowledgments This work has been partially funded from the European Union's Humanitarian Aid and Civil Protection project "PREDICATE" under grant agreement ECHO/SUB/2015/713851/PREV29.

References

American Red Cross and Measure. (2015). *Drones for disaster response and relief operations*. https://www.issuelab.org/resources/21683/21683.pdf

Austin, R. (2010). *Unmanned aircraft systems: UAVS design, development and deployment*. Chichester: Wiley.

Deliverable 61.2 Position Paper. The future of UAVs for civil security applications, AIRBEAM Project (261769).
Direct Line for Business. (2017, March). https://www.directline.com/lib/campaign/fleetlights/pdf/fleetlights_tech_manual.pdf
European Emergency Number Association – EENA 112. (2016). *EENA operations document – RPAS and the emergency services*. www.eena.org/download.asp?item_id=153
Federal Aviation Administration. *Frequently asked questions/help*. https://www.faa.gov/uas/faqs/. Accessed 10 Apr 2016.
Kopeika, N. S. (1998). *A system engineering approach to imaging*. Bellingham: SPIE Optical Engineering Press.
Li, B., Jiang, Y., Sun, J., Cai, L., & Wen, C.-Y. (2016). Development and testing of a two-UAV communication relay system. *Sensors, 16*, 1696.
QuiQui-automated drone delivery of pharmacy items. http://quiqui.me/
Scott, J., & Scott, C. (2017). Drone delivery models for healthcare. In *Proceedings of the 50th Hawaii International Conference on System Sciences, HICSS*.
Se, S., Firoozfam, P., Goldstein, N., Wu, L., Dutkiewicz, M., et al. (2009). Automated UAV-based mapping for airborne reconnaissance and video exploitation. In *Proceedings of SPIE 7307, Airborne Intelligence, Surveillance, Reconnaissance (ISR) Systems and Applications VI*, 73070M.
Skrzypietz, T. (2012, February). *Unmanned aircraft systems for civilian mission*. Brandenburg Institute for Society and Security (BIGS) Policy Paper.
TREC. (2016). *Johnson's criteria for pixel resolution: Four levels of discrimination*. http://www.trec.com/johnsoncriteria.html. Accessed 16 Nov 2016.
UAV Vision. (2016). *A practical explanation of the Johnson criteria*. http://www.uavvision.com/news/practical-explanation-johnson-criteria. Accessed 12 May 2016.
UVSS – United Vision Security Systems. (2016). *We specialize in long range camera*. http://ev3000.com/uvss-llc/Home.html. Accessed 16 Nov 2016.
Valdovinos, M., Specht, J., & Zeunik, J. (2016). *Law enforcement & Unmanned Aircraft Systems (UAS): Guidelines to enhance community trust*. Washington, DC: Office of Community Oriented Policing Services.
Waharte, S., & Trigoni, N. (2010, September). Supporting search and rescue operations with UAVs. In *2010 International Conference on Emerging Security Technologies* (pp. 6–7). Canterbury.
White, B. A., Tsourdos, A., Ashokaraj, I., Subchan, S., & Zbikowski, R. (2008). Contaminant cloud boundary monitoring using network of UAV sensors. *IEEE Sensors Journal, 8*, 1681–1692.