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USE OF REMOTELY PILOTED AIRCRAFT SYSTEMS TO EVALUATE THE EFFECTS OF TRANSPORT COLLISION

Summary. The evaluation of the effects of transport collision often takes the form of ground reconnaissance. Undoubtedly, remotely piloted aircraft systems (RPAS) can support and help the police, firefighters, security agents and paramedics in the event of a transport collision.

Although there is a scarce amount of literature concerning the use of RPAS in crisis management, it is important to pay more attention to the benefits of this technology. The article describes the danger of collisions, as well as discusses the possibility of using RPAS, their functionality and potential utility. Sensors installed on RPAS can rapidly identify the place of the accident, the number of casualties, the type of damaged vehicles or the type of contamination.

Keywords: transport, remotely piloted aircraft systems, RPAS, search and rescue, crisis management.

1. INTRODUCTION

The civilizational development of our age has caused an increase in road, rail and air traffic. Despite a considerable increase in the outlays for railway and road infrastructure

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safety, the occurrence and risk of transport collisions have not been entirely eliminated to date. A transport collision is defined as a collision between a vehicle operating inland or sea or air traffic with another vehicle or fixed obstacle, which mostly results in property damage, as well as causing a potential hazard to human life. Such events may include vehicle damage, blocked roads, sinking of ships and leaks from bowsers. An evaluation of the circumstances of the event is based on the accounts of witnesses or participants, while the dispatcher or traffic manager who receives a traffic event report is obliged to notify the appropriate medical, technical, chemical or ecological services [5]. It is important that the information provided to the emergency services reflects the actual circumstances to the furthest extent possible, due to the need to prepare and dispatch an adequate number of personnel and equipment to carry out the rescue operation. An evaluation of the effects of collision is usually performed via a ground investigation, which implies significant limitations in terms of determining the area coverage of the accident or the field conditions, for instance.

The proposed solution to improve the capabilities for evaluating the effects of transport collisions is the use of remotely piloted aircraft. Optoelectronic heads employed in a remotely piloted aircraft feed a video signal to flight control in real time. This allows for an analysis of the situation on a current basis, accurate localization of the event, and assessment of the scale of the accident and the number of casualties, as well as selecting and engaging the necessary rescue units. Remotely piloted airships equipped with measuring instruments or detectors are able to analyse the contamination of toxic gases and determine the hazard level in the case of hazardous substance leaks, for example.

While the main field of application of remotely piloted aircraft is currently in the context of military activity, it is advisable to adapt this technology to public order applications, and crisis management in particular. This use of new and dynamically developing technology is becoming increasingly popular around the world.

2. ENVIRONMENTAL HAZARDS RESULTING FROM TRANSPORT COLLISIONS

The most dangerous branch of transport is land transportation, including road and rail traffic [13]. It is this area of transportation where inter-vehicle collisions or collisions with fixed obstacles are the most frequent. The main effects include vehicle damage, property damage, hazards to human life and road blockages (Fig. 1.)

a) b)

Fig. 1. Effects of land-based road traffic collision in: a) collision between a bus and a car carrier in Stare Jeżewo and b) collision between a transporter and a truck in Nowe Miasto [8]

Land collisions may also include collisions of vehicles carrying hazardous materials. According to the statistics for the last decade, over 200 million tonnes of goods are transported by rail transportation annually, with 21 million tonnes of them containing hazardous materials [6, 7]. Road traffic, on the other hand, conveys over 1,500 million tonnes of cargo, with 10% containing hazardous substances [9, 10]. These values include about 170 million tonnes of explosive, inflammable, toxic, aggressive, infectious and radioactive materials, which are dangerous to humans, animals and the environment. The hazardous materials listed above are transported for the purpose of securing and maintaining industrial production in various branches, including paint and lacquer production, artificial fertilizer production, and industrial metallurgy and rubber production. It may be safely assumed that the level of hazardous substance transportation will not be declining any time soon. Meanwhile, collision events involving vehicles transporting hazardous substances pose a danger to local communities and the environment, but the effects of these substances could be very severe and extensive. Accident scenarios include leaks of substances from transporting tanks, releases of toxic substances into the environment, the ignition of fumes and the explosion of cisterns. Recent examples of dangerous collisions include a collision between a train and a cistern in Nowa Sól (Fig. 2a), and a collision of cisterns on a siding in Gutkowo, near Olsztyn (Fig. 2b) [12].

a) b)

Fig. 2. Ground traffic collisions: a) collision between a train and cistern in Nowa Sól and b) a collision of cisterns in Gutkowo, near Olsztyn [12]

Collisions of sea ships or with another ship or rocks, or situations of running aground, cause life-threatening hazards to the personnel and passengers involved. Such accidents may also result in the pollution of the marine environment by oil or fuel. The most frequent sea accidents involve tankers transporting oil. Oil leaks are particularly difficult to remove: the oil floats on water and endangers the local marine ecosystem, causing the death of birds, fish and other smaller organisms. The intense mixing of oil with sea water results in a significant increase in pollution, taking the form of a floating spill patch.

Airborne transportation vehicles, despite enjoying the reputation of being the safest means of transport, are also subject to various faults, which may lead to a traffic catastrophe. The resulting damage suffered by an airplane mainly depends on its travelling speed and size. Collisions of airborne transporting vehicles with birds or machines may have catastrophic consequences, resulting in wreckage or human remains scattered on the ground, often over an extensive area.

3. POSSIBLE USE OF REMOTELY PILOTED AIRCRAFT FOR EVALUATING TRANSPORTING VEHICLE COLLISION EFFECTS

Any rescue team, despite having the necessary training and knowledge, is subject to the risk of the loss of health or life while carrying out a rescue operation. The danger may be significantly reduced or completely eliminated by employing remotely piloted aircraft for this purpose. Remotely piloted platforms, equipped with optoelectronic heads, allow for an evaluation to be performed in real time, with an image being fed to a ground control station. This solution should permit the current analysis of the situation and the engagement of the necessary rescue units. The use of daylight cameras will facilitate the evaluation of the technical condition of cisterns or tanks damaged in the collision, as well as perform a preliminary risk assessment. Moreover, the cameras are capable of imaging the topographic structure of nearby land. The system should be able to estimate the number of dead or injured, or persons subjected to the risk of intoxication, scalding, poisoning or other undesirable effects. An aerial view will significantly facilitate rescue operation planning and enable the quickest route as close to the accident as possible to be chosen (Fig. 3).

Fig. 3. Highway accident and railway accident observed with the use of remotely piloted aircraft [3]

The platforms, equipped with chemical contamination detectors or pyrometers, may be dispatched into areas of low levels of accessibility or high levels of hazard to support rescue units. This allows for a reduction in the exposure of rescue personnel to dangerous conditions, while enabling them to stay within a safe distance from the sources of emission while collecting the required test sample. Remotely piloted aircraft may also be used to assess the effects of leaks of oil, fuel, machine fluid or other transported chemicals, which constitute a severe hazard to the marine and land environment. An aerial observation of the spread of oil, or other spill in the water, means that the speed of the distribution of the hazard can be determined.

Firefighting teams are engaged in rescue operations whenever toxic substances leak from their transportation tanks. The full basic rescue operation capability within the district area should be reached within a maximum of 15 min, while full specialist rescue operation capabilities should be reached within a maximum of 30 min for the most rigorous readiness levels. Regarding the specialist scope, rescue operations particularly include identifying hazardous chemical substances, measuring and analysing hazardous samples in solid, liquid and gaseous form, verifying the threat, and evacuating humans from the hazard area.

Remotely piloted chemical and biological reconnaissance aircraft could be employed as permanent equipment for rescue units, e.g., on a district level. This would significantly speed up the identification and reconnaissance of emergency situations, along with the preliminary evaluation of hazards on site.

4. FEATURES OF REMOTELY PILOTED AIRCRAFTS

RPAS are based on unmanned aircraft (platforms), as well as on-ground flight control systems. Remotely piloted aircraft are mobile air objects used to carry task equipment, which may perform flights with the operator maintaining eye contact with the platform in remote control (RC) mode or automatic control mode, i.e., without the operator eye contact with the platform. In the automatic control mode, the remotely piloted aircraft is capable of making an automatic flight with the use of a GPS signal (multipoint navigation) by changing navigation points and flight conditions during the flight. The saved route points may be edited during the flight through radio communication with the platform. A platform can either have an airframe or a multirotor design, while a platform of adequate structure is dispatched depending on the mission to be completed. Airplane-type platforms feature a long flying range, allowing for the continuous delivery of information to the ground control station in real time. Multirotor-type platforms have a smaller range, but their design allows for a vertical start and landing, as well as hovering above an area or observation point. The ground control station constitutes an integral part of the system and is necessary for operating the airborne platform, as its purpose is to control the platform while performing tasks in various missions in real time, receiving the signal transmitted from the platform, and decrypting these data, in addition to producing the graphical presentation of piloting and navigating parameters and data imaging, and displaying a map reflecting the flight route that is planned and the one currently followed (Fig. 4).

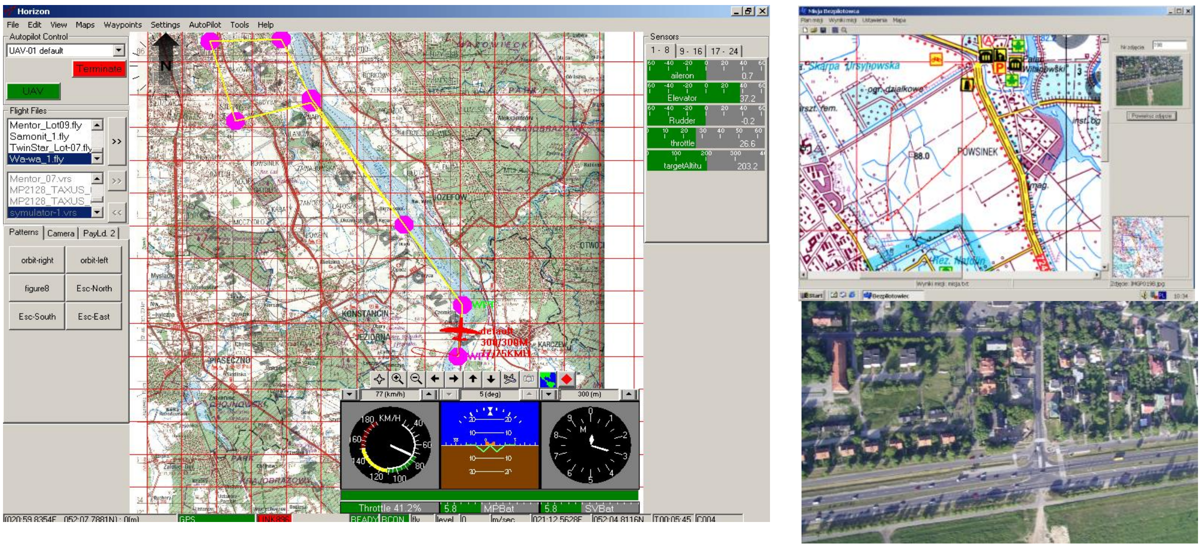

Fig. 4. Map image and video transmission image on the flight control system monitor

The main task of RPAS used for evaluating the effects of transport collisions is to observe the area where the collision took place. Photogrammetrical images and data may be collected with the use of cameras, optoelectronic heads, infrared heads, synthetic aperture radars, and real-time information transmission systems used in the unmanned platforms. Observation sensors are built into the heads installed on the remotely piloted airborne platform (Fig. 5.).

Specialist remotely piloted airborne platforms allow for the rapid taking of photographs within the visible spectrum, as well as in infrared (Figs. 6-7). The photographs shown in Figure 6 were taken from an altitude of about 300 m, with the photograph on the right depicting a man leaning off the starboard of a fish cutter. The photograph shown in Figure 7 was taken from an altitude of more than 1,000 m.

a) b)

Fig. 5. Heads with observation sensors installed on remotely piloted airborne platforms

Fig. 6. Photographs taken from a remotely piloted aircraft

Fig. 7. Photograph taken from a remotely piloted aircraft at an altitude of more than 1,000 m

The optoelectronic heads employed in the system allow for the selection of various types of digital cameras with different resolutions; the most common set, however, is the combination of a daylight camera, thermal vision and a laser rangefinder. The object identification capability is dependent on the image resolution, which is defined by the size of its single "pixel" (not strictly dependent on the focal distance of the lens). General reconnaissance allows the presence of objects with a characteristic shape and distinctive colour to be identified, whereas detailed reconnaissance allows for the special features of objects to be identified. Table 1 presents the maximum reconnaissance altitudes for lenses with different focal lengths, while Figure 8 presents images obtained from an observation at a 45° angle.

Tab. 1

Estimated values of camera-to-object distance for specific reconnaissance

Object	General reconnaissance		Detailed reconnaissance	
	Focal length: 8 mm	Focal length: 12 mm	Focal length: 8 mm	Focal length: 12 mm
Single person	78 ÷ 103 m	144 ÷ 191 m	26 ÷ 31 m	48 ÷ 64 m
Passenger car	207 m	384 m	104 m	192 m
Truck	310 m	576 m	186 m	346 m
Building	517 m	960 m	207 m	384 m

Fig. 8. Images obtained from observing the ground at a 45° angle

Table 2 presents the reconnaissance area coverage for lenses with different focal lengths and at different altitudes.

Tab. 2

Reconnaissance area coverage for lenses with different focal lengths

Altitude	Focal length		
	3.6 mm	8 mm	12 mm
50 m	128 x 94 m	45 x 39 m	28 x 26 m
100 m	256 x 188 m	90 x 78 m	56 x 52 m
200 m	512 x 376 m	180 x 156 m	112 x 104 m
300 m	768 x 564 m	270 x 234 m	168 x 156 m
500 m	1280 x 940 m	450 x 390 m	280 x 260 m

Figure 9 presents angular observation parameters, Figure 10 presents the reconnaissance strips for fixed-angle observations, and Figure 11 presents reconnaissance strips for variable-angle observations.

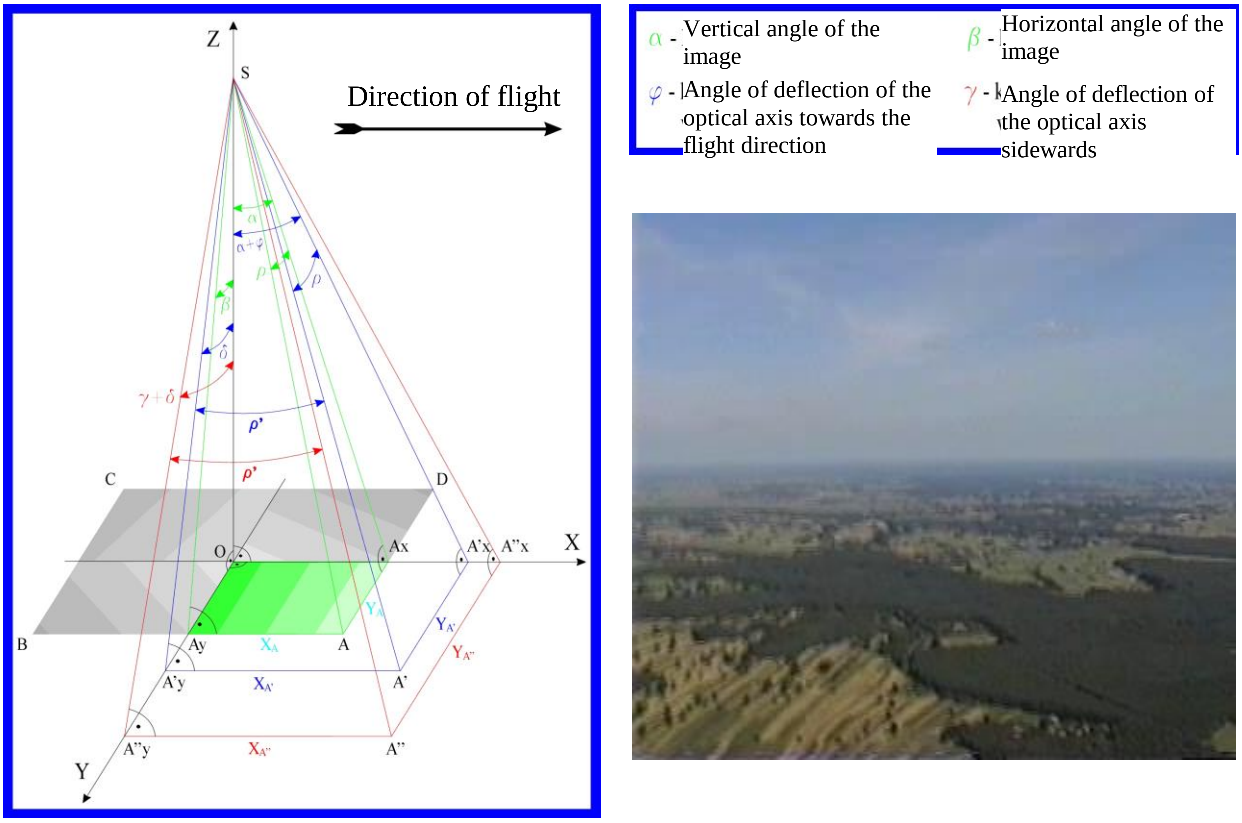

Fig. 9. Angular observation parameters

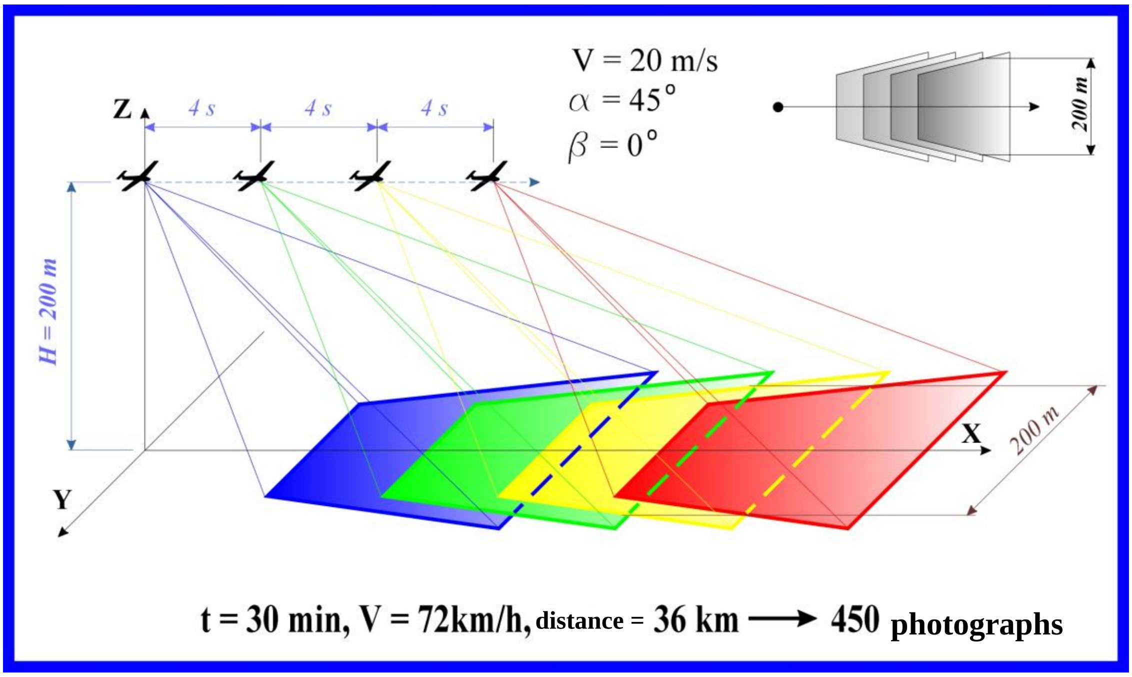

Fig. 10. Reconnaissance strip for fixed-angle reconnaissance

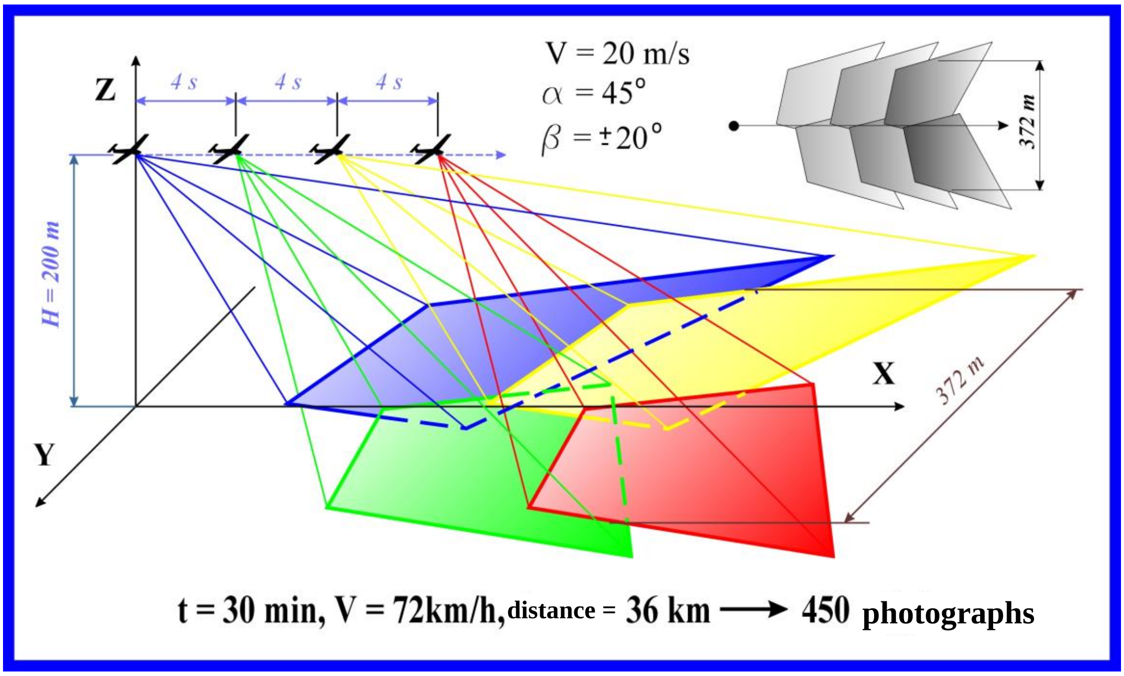

Fig. 11. Reconnaissance strip for variable-angle reconnaissance

Remotely piloted airborne platforms used for evaluating the effects of traffic collisions may be equipped with optional reconnaissance sensors or temperature, radiation and hazardous substance sensors. Instruments installed in the remotely piloted aircraft used for chemical and biological reconnaissance should facilitate the collection of test samples, without exposing rescue teams to life- or health-threatening hazards. Apart from the sample collection features, the system also enables the detection of gas compounds, including H_2S,

CH_4, CO_2 and SO_2, as well as the detection of volatile organic compounds through the use of a gasometric instrument (Fig. 13). Position, altitude, temperature, humidity and chemical compound concentration parameters, registered by the system, allow for a contamination map to be drawn in real time (Fig. 12) [1].

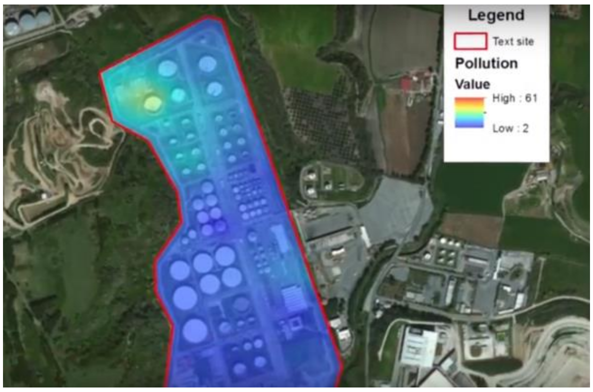

Fig. 12. Contamination emission map [1]

Fig. 13. Scentroid DR 1000, Flying Laboratory [1]

Fig. 14. Remotely piloted platform with built-in AED [2]

Fig. 15. Pars platform with built-in lifebuoy [4]

Adding minor rescue equipment to the platforms should increase the chances of the quicker convalescence of injured persons, while remotely piloted platforms equipped with first-aid kits should be able to supply dressing materials to persons providing first aid to casualties. The use of an automated external defibrillator (AED) for performing safe defibrillation in cardiorespiratory arrest situations would also prove beneficial (Fig. 14). Such a solution was developed by the Belgian engineer, Alec Momont, who constructed a remotely piloted aircraft with built-in AED. As GPS navigation is able to locate the person reporting the event (using a GPS phone), the target can be reached within 3 min. The platform is equipped with a real-time transmission system, feeding the image to the rescue dispatcher's screen. An added facility would be to equip the remotely piloted aircraft with a voice communication system. The dispatcher could then provide instructions to the rescuing person through built-in speakers, while, at the same time, observing the injured person [2].

Apart from this solution, aircraft could be equipped with lifebuoys, which would increase the chances of survival for sea castaways by keeping them afloat on the water's surface until the arrival of rescue teams. The Iranian company RTS Lab has designed the Pars platform, which is used for rescuing drowning persons. This remotely piloted aircraft, which can reach the target much faster than any water rescue teams, is able to drop the attached lifebuoy near the drowning person. Another innovative idea has been to create a water platform for the remote-controlled Pars with solar panels attached to it, allowing the vehicle to charge its batteries between rescue operations. Furthermore, the platform is designed for charging more than one remotely piloted aircraft (Fig. 15).

5. CONCLUSION

The tasks performed by remotely piloted aircraft, with the purpose of evaluating the effects of transport collisions, facilitate the delivery of information on the occurrence of hazards in the monitored area more quickly and accurately. Messages delivered to the operator-dispatcher allow for adequate rescue units to be despatched and shortening their time of arrival at the collision area. Real-time data transmission enables the coordination of actions by rescue teams and the selection of necessary means of aid to be used during the operation. Apart from cameras, biological and chemical or radioactive contamination detectors limit direct exposure to the hazardous substances in question. An undoubted benefit of RPAS is their modular design, which allows for the respective system to be appropriately configured for the airborne operation carried out. Additionally, these vehicles may be used to deliver a first-aid kid or AED in rescue areas with limited accessibility. The continued development of remotely piloted flying systems should further improve the way in which crises are managed.

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