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# POSSIBLE AREAS OF APPLICATION OF DRONES IN WASTE MANAGEMENT DURING RAIL ACCIDENTS AND DISASTERS

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## ABSTRACT

In this article the most modern versions of unmanned aerial vehicles (drones) will be presented from the aspect of safer identification of dangerous effluent materials during rail accidents and catastrophes. These technologies are crucial to minimize the pollution of dangerous waste generated during accidents or catastrophes. Doing this, exploration of further opportunities of waste management – satisfying the conditions of the highest level of environmental safety – is necessary, as well as to find new methods to handle waste in time securely and professionally. Exploration of unprecedented solutions during rail- and road accidents or catastrophes is also reasonable. Relevancy of application of drones is particular as long as the approachability of the affected area is difficult or impossible. During the neutralization of explosive, hazardous or toxic materials the risk of life could be eliminated using drones equipped with the most modern technologies.

## KEYWORDS

drones, environmental safety, dangerous wastes, minimizing damages, rail accidents

## CLASSIFICATION

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APA: 4070, 4090
JEL: H12, Q53

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## INTRODUCTION

In order to permanently reduct wastes into the economical and social turnovers, it is necessary to reveal factors affecting engineering safety, to determine the elements of engineering safety in waste management, furthermore, the employability of these solutions.

Engineering safety is a totality of technical and technological methods and procedures, which aims to secure the existence or the functioning of somebody or something [1].

During waste management this goal could be achieved by the appliance and utilization of engineering sciences. Doing this, every single element could be an influential factor, which holds the shaping, installation, maintenance or the creation of conditions of the engineering safety.

From all of these, the most important element is the human factor. This could be manifested during vehicular catastrophes and accidents coming from malpractice or negligence, causing serious damages.

It is very important to highlight and emphasize the role of hydrocarbons polluting the soil and aquatic life. These materials are mostly emerging in the wake of disasters and they often not burn out. We also have to mention other types of special industrial or delivered liquids. By this time, polluted area must be cleaned from these liquids and materials, which have been transformed into dangerous waste [2].

## SECURITY OF RAIL TRANSPORTS

Transportation is probably as old as humanity, but the level and importance of this activity has never been so determinate as today.

The most decisive way of forwarding is the rail transport. Air conveyance is fast but expensive. Waterage and railway transport is too bound, depending on the riverbed several factors or the quality of the railroad. Rail transport is the most secure solution, because the track of the cargo could be supervised or optimized rapidly [3].

The cargo must be secured, because the cargo itself could be endangered, or it may pose a threat to the environment. In light of this, protection and defense is the key to keep the cargo safe. Guarding is a permanent counteraction responding to a presumed threat on the cargo. The guard so an insurance one attaching to a hypothetical, supposed activity, the protection it began though, a related averting task ensued with an event concerned. It can be expected that large amount of waste is generated during rail disasters. Decontamination and disposal of such waste – polluting soil or water – is an urgent objective, as well as the elimination of the pollution and the rehabilitation of the affected area.

## RFID IDENTIFICATION OF WASTES COMING FROM ACCIDENTS AND DISASTERS

In case of waste management, our personal behavior and the rules of traffic must be extended in order to manage an accident or a catastrophe, to reduce the effects of hazardous materials and to hold polluting effects. These steps and know-how would be similar to the well known first aid exam, obligatory for all drivers. One of the possible solution to treat a damaged tanker is the appliance of the Vetter-pillows. These pillows are easy to deploy even by laymen [4].

Radio Frequency Identification (RFID) provides reading of the information carrier chip of the vehicle from safe distance by radio waves during disasters and accidents. This method also works at great speed of the vehicle.

During catastrophes and accidents the vehicle often suffers so severe damage that UN numbers and other information of the cargo become unreadable. The information carrier unit is also vulnerable; in this case, reading is also impossible. A rapidly employed drone would be capable to read a properly installed chip, in order to rapidly identify dangerous goods. Following this, obtained information must be transmitted to the units participating in recovery actions. Possessing the necessary information, these units could prepare the appropriate tools of decontamination, protective clothing, etc. Shaping of the strategy of neutralization is also possible before taking actions at the location of the disaster.

Significance of this combined method is extraordinary, if the location of the disaster or accident is out of the way or impossible to approach. In case of poisoning, contamination or explosion the RFID system could help to save those who involved in the rescue process. The recommended procedure may significantly decreases pollution of hazardous wastes, because effluent, non-burning hazardous materials become hazardous waste by touching the ground. The affected area of the rail and the environment also become contaminated, because of time factor and the fast spreading of the pollution. We would like to highlight that groundwater could be also polluted when hydrocarbons diffuse into the soil [5].

## WITH DRONES AGAINST WASTE

The drone is a small, propeller driven unmanned aerial vehicle, available for multiple useful tasks. Drones' applicability could be demonstrated by their employment in American metropolises, where illegal waste dumping world was reduced, following the appearance of these aerial vehicles. This problem is also cardinal, where illegal waste dumping is a common phenomenon along the railways, inhabited regions, parking places and green areas.

Over the recent years, many research groups are working in order to exploit the potential advantages of quadrotor rotorcrafts as UMAVs of future. This article is addressed to problems of controller performances evaluation and analysis. The main benefits of this research concern with achievement of a controller architecture that should enable quadrotor high dynamic performances, robustness to external perturbations as well as satisfactory trajectory tracking precision [6].

Autonomous quad-rotor helicopters increasingly attract the attention of potential researchers. A wide area of robotics research is dedicated to aerial platforms. The quad-rotor architecture has low dimensions, good manoeuvrability, simple mechanics and payload capability. The electrically powered four-rotor quadrotor helicopter architecture has been chosen for this research [7].

A basic principle can be that whenever a traditional aircraft can prove to be useful, drone can be a benefit, too. Obviously, not all traditional aircraft uses can be substituted, but the author believes that the rate of potential applications of drone is on the rise due to technological development. Based on experience, the spread of drone is expected to reduce the costs of aerial applications, so by following the previous train of thought, we can conclude that drone could also be used in cases where traditional aerial reconnaissance was not previously considered owing to its high costs although its effectiveness was never doubted [8].

Application of drones could be more useful at the prevention of rail accidents and catastrophes. On the other hand, appliance of UAS/UAV is more suitable in practice to identify dangerous rail cargo.

Stating the eruption in the center of the disaster's time scale any activity, so logically also all UAS applications supporting disaster management can be thematically separated like it. Before the eruption as a pre-disaster activity UAS application can support the prevention or

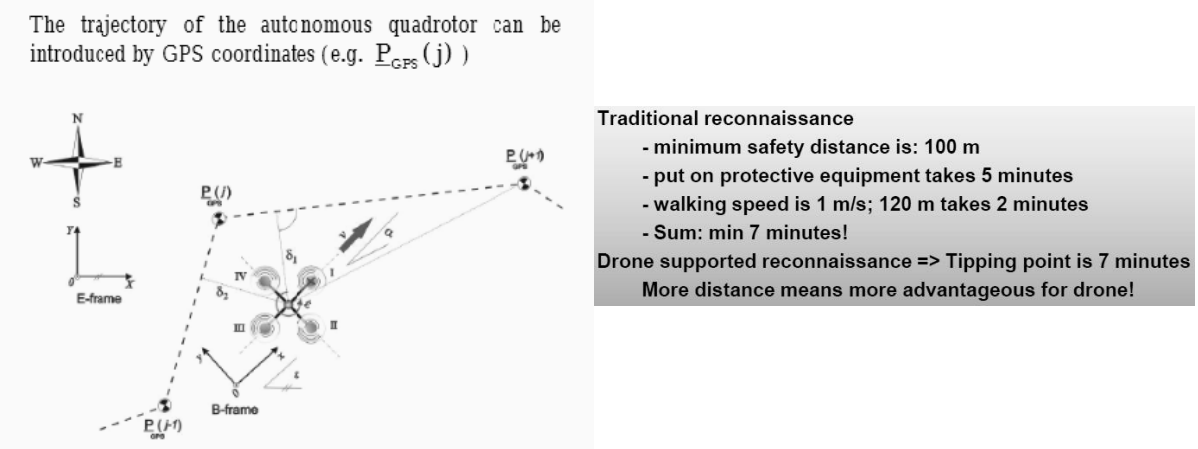


**Figure 1.** Drones is related to the transport of dangerous merchandises accidents the opportunities of a happening application [9].

be able to supply the early detection. In case of man-made disasters like a chemical accident during illegal transport, the UAS railway observation belongs to prevention, following a toxic smoke spreading belongs to early detection, while avoiding the escalated forest fire by UAS flight patrol can belong to both prevention and early detection [10].

The popularity of drones constantly increases among hobby aviators and companies as well. More and more areas are going to use of these devices for different purposes. At the CES 2015 in Las Vegas, only 4 manufacturers were presents, while this year, 27 appeared. The market potentials are clearly shown by the fact that, more than 100 000 units were sold in 2013 in the USA, while in 2015, more than a million units were sold, thereby creating a 1,7 billion dollar industry. The drones of sales will exceed 3,7 millions. The sales forecasts for drones 2013 between 2017 are shown in Figure 2 [11].

## OPTIONS OF APPLICATION OF DRONES

There are many way to scale different disasters. Disasters can be scaled from limited to escalated, by the effected area or population, from the eruption to slowly spreading by the time it develops, or in many other ways depending on the condition we take into account. This article uses namely some disasters such as floods, earthquakes, nuclear accidents and forest fires, however demonstratively expresses that topic is so huge, all presented work is just touching the surface [12].

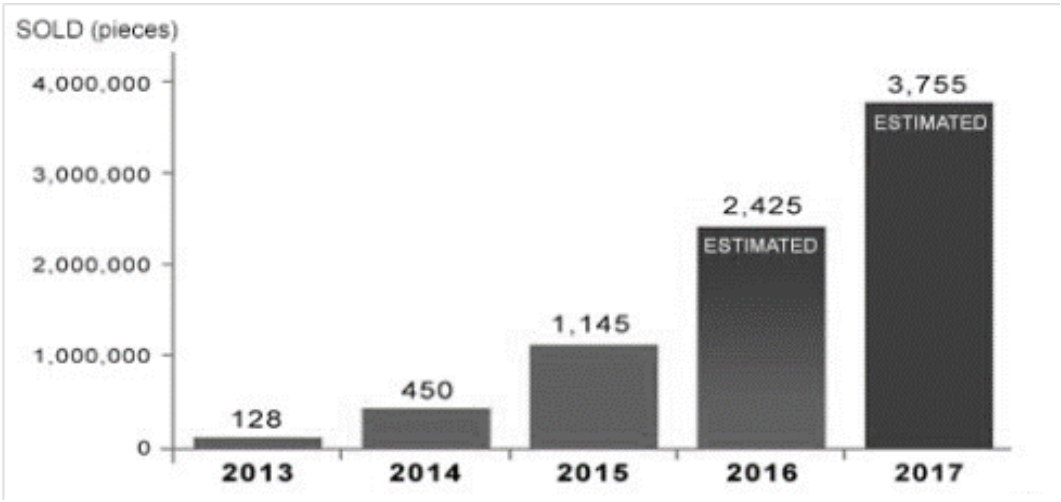


**Figure 2.** Progress in the sale of drones between 2013 and 2017 in America [13].

The main advantage of rapid mapping systems based on drones is to acquire swiftly sensory data on the disaster area where ones can hardly access. For this reason, there have been many studies on the application of dron systems to the disaster management.

It is difficult to access information about the transportation of dangerous goods, and, in case of an accident, it is necessary to conduct a collective analysis of data stored in different systems in order to be able to carefully assess the situation. Consequently, it would be necessary to ensure the accurate tracking of vehicles transporting dangerous goods in railway transport, too. There is no uniform monitoring and tracking system for railway vehicles in Europe. In Hungary, tracking is restricted to the locomotives of railway companies. Nevertheless, there are international examples for the unique identification of railway wagons. The railway systems of the United States have a strong tradition in this field.

In the United States 1,7 million types of hazardous substances are transported by railway each year. Dow Chemical has already started to use the RFID system, in order to help to identify railway wagons carrying hazardous chemicals. 26 000 railway wagons in North America transports about 650 types of TIH (toxic inhalation hazard) chemicals [14].

Along the railways of American metropolises illegal waste disposal was decreased, owing to the engagement of drones. Illegal waste disposal is also a serious problem in Hungary, especially in Budapest, because homeless people – permanently living at the railway areas – accumulate lots of waste. In smart cities, this kind of waste is unhealthful.

The complexity of these opportunities is very large. In light of this, I list only the most interesting ones, in connection with rail traffic. UAVs, having been initially designed for military use have found their way into the civilian arena. While the developed world uses UAVs for various applications; the developing countries benefit tremendously. This is due to their general lack of resources, remote rural locations and prevalence of various kinds of catastrophes. UAVs provide an effective, fast and less expensive solution to save more lives and the environment in developing countries. Although there are still challenges in the use of drones, they are outweighed by benefits [15].

The safety-technology purposes of drones should be distinguished from the use for hobby purposes, as they have unquestionable benefits in such application. Similarly to this topic, drones have already been used in Hungary during a flood event. Their use helped to determine the extension of the flooded area, the situation of possible critical points and the accessibility of escape routes. In case of chemical accidents, a gas detector could be mounted on the drone, which can measure the concentration of the gas escaped into the air, this way ensuring that faster and more precise measures could be taken to protect the inhabitants. There have been examples for such application in disaster management, which means that these devices are able to perform such tasks.

Our experiment was carried out in a railway environment to examine the operating of the RFID reader near a large mass of metal. On the first occasion, measurements were performed without a drone, holding the reader in hand in different positions. During the research, the commercially available drones will be equipped with the following elements: a high-resolution camera, a thermal camera, a communication module, an RFID reader and an air composition sensor. We are planning to use the drones during the transportation of hazardous substances for the identification of wastes in case of an accident or disaster. Their use in such an incident can have significant benefits in comparison with the present practice.

Former experiments proved that only high-end drones are capable of carrying a load of 1-2,2 kg by air. Such aerial vehicles of higher capacity (for example: 13 kg) are also available commercially, so these can be used to carry the implemented devices during the experiment.

According to our plans, the extra accessories of the drone will not weigh more than 4-5 kg including the batteries which ensure the long flying time. Our measurements show that the drone will be able to perform the identification of hazardous substances from a distance up to 80 m depending on the circumstances found at the site of the accident.

## RADIOFREQUENCY IDENTIFICATION AND COMMUNICATION

RFID technology is one form of the Automatic Identification Systems. Its basic idea is that the object for identification is equipped with an element (transponder or tag) which is capable of data storage. The microcontroller and the antenna together is called RFID *transponder*, RFID *tag* or RFID hard tag. The information necessary for identification and other data are stored in the memory of the microcontroller.

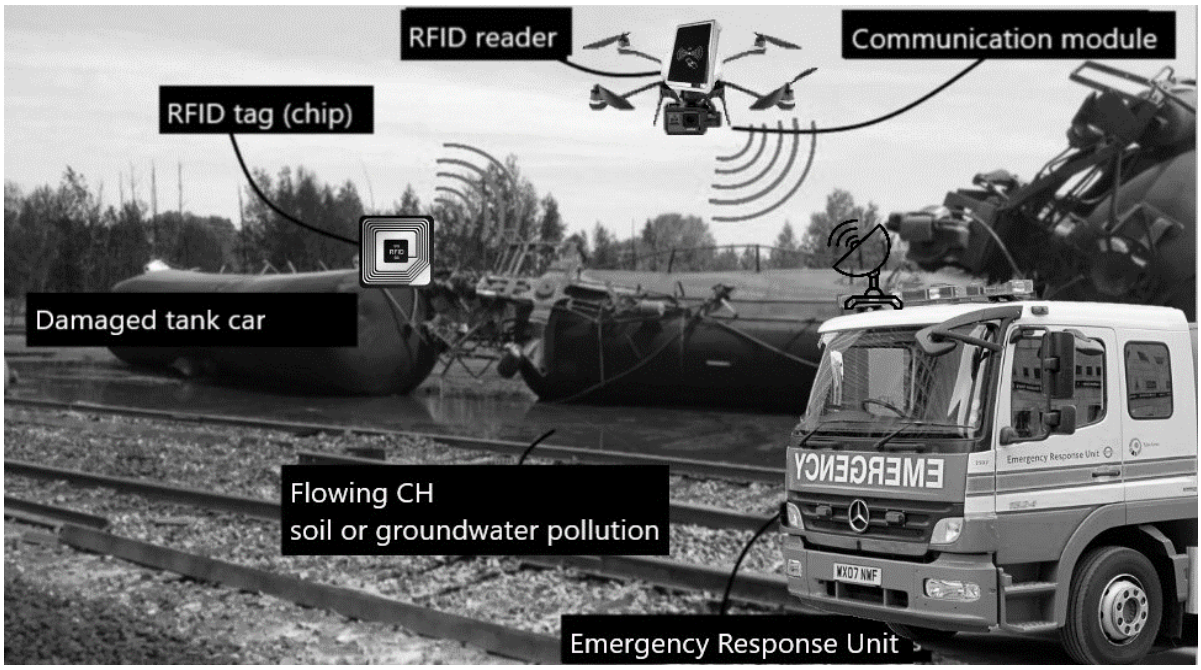


**Figure 3.** Conceptual draft by the author.

1 litre of gas oil can pollute 1 million litres of water. Therefore, in case of the release of 60 000 litres of gas oil, 60 billion litres of water could become unfit to drink.

This, besides causing significant harm to the environment, would have serious effect on public and personal safety, and the remediation process would impose an immense financial burden on society, as it could last for decades. As the above examples show, in the event of such accidents, the transportation infrastructure can also be seriously damaged [16].

During rail accidents and catastrophes, hydrocarbon pollution is very likely, as shown in the pictures above. Railways are mostly running close to natural waters, as a result, identification of the type and extension of pollution is possible rapidly, using the presented methods. The RFID system, mounted on the vehicle, stores the data required to idetify the transported material(s). In normal or havaria-mode the carry-on device or the drone itself is able to read the data stored in the RFID-part. Another part of the system is the communication module placed on the drone. This module is responsible for maintaining the contact between the reading device and the operator. Apart from the reading process, guidance of the drone is implemented via another communication channel. In most cases, navigation happens by GPS coordinates automatically.

The radio module is a small device, it consists only the most essential basic elements: an Atmell (ARDUINO) microcontroller and a radio IC. The radio IC devices are able to operate

on 433 MHz frequency band. The radio module requires low energy only. The 433 MHz frequency band is an ISM band, which is free to use in Hungary with strict adherence to the rules regarding the performance of the broadcast. These modules' transmission power is 100 mW, therefore it seems to be a good choice for this purpose. When selecting the drone itself, you should pay attention to the fact that most drones use the 433 MHz frequency band to forward telemetry data, so interference may occur, if our device operates in the same band.

The module is factory-equipped with an antenna, allowing to operate from 300-400 meters. A larger antenna would provide a wider action radius, for example, a Yagi antenna (the Yagi is easy to prepare in this band and it has a comfortable size). With such a range it can provide 55 kb/s data transfer rate. Data transfer should be chosen to FSK. Completion of the system requires two modules, one of them includes the programmable microcontroller. This component calibrates the radio IC's to the required frequency, sets data transfer speed and error codes. Therefore the microcontroller reads the data of the RFID through the interface, then forwards information to the radio IC in order to emit it. This signal would be received by the device of the operator, indicating the requested information automatically. Thereby we receive the crucial information from the RFID-part of the vehicle. Moreover we should take into consideration that these frequency bands are free, available to other users also. Drones also use the 433 MHz band mostly, so interference may occur. Ideal frequency should be chosen carefully. The system should be planned, constructed, tested and measured in detail.

### LOCAL RECONNAISSANCE WITH THE NEWEST TECHNICAL DEVICES IN WASTE MANAGEMENT DURING RAIL ACCIDENTS

Nowadays a lot of drones are used for several purposes all over the world. As a result, wide scale civil use preceded legal regulation of the utilization of these devices, but the analysis of the related problems, furthermore, the lessons learned are also necessary to develop safe and regulated use of airspace by these vehicles worldwide. In Hungary, the next step may be taken towards the introduction of the recommended RFID-DRONE-VIRTUAL REALITY system after the establishment of the relevant legal regulation, in order to apply these solutions during the identification and disposal of hazardous wastes and items, furthermore, in case of rail accidents and disasters.

## FINDINGS

How to make life on Earth safer, sustainable and disaster-free? The less energy you have to use, the less waste you have to produce! We must strive towards closed production and consumption cycles, so economic processes need to function in a circular way. Simplified natural laws must be interpreted quantitatively, and this requires serious engineering knowledge to be brought back to these laws, incorporating the parameters that will allow us to create brilliant engineering and technical security solutions, to remedy the problems of our age.

Currently, recycling (circular economy) is still managing the increasing accumulation of waste, with many years of delay, as a result, we need more sophisticated computing solutions, the use of quantum computers in order to process billions of parameters of our industrial life, to make it more bearable and livable.

Based on our proposed solution, i.e. Radio Frequency Identification by drones would make transport vehicles' identification much more, easier during railway accidents and catastrophes, thereby decreasing possibility of waste generation. Mini-drones may approach locations of accidents and catastrophes very fast in difficult circumstances, too. Transport regulation and railway area-management should be analyzed and examined from the aspect of waste-management also, in order to take adequate arrangements. In case of emergency or catastrophe the most effective methods are needed to prevent dangerous materials from diffusion safely.

High security RFID reading, identification of dangerous goods, fast forwarding of information would be an inestimable help for the people taking part in actions of recovery. Another important aspect is the life-saving, the transmission of information for the environmental and other emergency units, in order to start decontamination and restoration of the area.

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