RDrone
Feasibility Analysis

1. Introduction

The raport contains results of the technical feasibility analysis of RDrone product – the rescue drone equipped with radar for sensing the disaster survivors. The analysis included: specification of intended use and functional requirements, analysis of the state of knowledge and solutions available in the market, initial project risk assessment and regulatory aspects. Based on performed research a technical solution concept was prepared.

The report was prepared for demonstrational and self-improvement purposes.

Cracow, DD-MM-YYYY

2. Intended use

The RDrone is a drone intended for surveillance of the disaster zones and detecting the survivors both on the surface and those trapped underneath debris. The system consists of the drone itself, control station and accompanying software and accessories. RDrone is intended for use by emergency units – appropriately trained professionals in the environment after natural disasters or war zones.

2.1. Functional requirements

Functional requirements were prioritized into three categories:

Must have – the essential requirements allowing the product to achieve its basic goals.

Should have – the requirements addressing important, but not essential aspects of the product, lack of their implementation will decrease the final value of the product.

Nice to have – the requirements increasing the final value of the product, but not deeply connected to the desired principle of work.

Must have:

1. Detection agent allowing for movement through and scanning of the disaster zone.
2. Detection of survivors:
    a. on the surface,
    b. beneath the rubble for 10 meters deep.
3. Manual control.
4. Wireless communication.
5. Continuous work for min. 2 hours.
6. Compatibility with procedures used in disaster zones.
7. Control range for up to 1 km.

Should have:

1. Detection of survivors beneath the rubble for 20 meters deep.
2. Automated detection and counting survivors in specified areas.
3. Live-streaming video from the agent.
4. Continuous work for min. 5 hours.
5. GPS navigation.
6. Control range for up to 5 km.
7. Protection against adverse weather (both control and detection agent).

Nice to have:

1. Communication and data export with the rescue teams.
2. Automated scanning movement through the designated sector.
3. Control range for up to 10 km.

3. State of knowledge

Natural disasters protocol

- the definition of disaster? – for description of the environment
- the emergency units action protocols
- the equipment used

The disasters can be differentiated from emergencies and catastrophes as[1]:

- Emergency – an event that may be managed without the need of added response measures or changes to procedure.
- Disaster – an event involving more groups than emergency, requiring involved parties to relinquish usual autonomy and freedom to special response measures, changing the usual performance measures and requires closer operations between public and private organizations.
- Catastrophe – an event that destroys most of a community, prevents local officials from performing their duties, causes most community functions to cease and prevents adjacent communities from providing aid.

In other words, disasters are serious disruptions to the functioning of a community that exceed its capacity to cope using its own resources[2] . They can be classified into three types[3]:

1. Natural – resulting from natural forces such as floods, earthquakes, tsunami, volcanic activity etc.
2. Manmade – resulting from human decision, includes: plant and factory failures, explosions, wars, riots, terrorist attacks etc.
3. Hybrid – resulting both from natural and manmade causes like unleashing the forces of nature as a result of technical failure or sabotage.

Beside the original cause of the disasters the subsequent disasters can be distinguished as a result of the previous disaster (such as chemical pollution followed by drought).

The total number of disasters in the world (excluding manmade disasters) seems to be increasing[4]. Based on the Emergency Events Database (EM-DAT) in the years 1900 – 2005 the number has increased from 93 to 4 850 for analyzed periods of 10 years. The disaster in the

[1] Eshghi, K., & Larson, R. C. (2008). Disasters: lessons from the past 105 years. *Disaster Prevention and Management: An International Journal*, *17*(1), 62-82.
[2] The International Federation of Red Cross and Red Crescent Societies: https://www.ifrc.org/our-work/disasters-climate-and-crises/what-disaster
[3] Shaluf, I. M. (2007). An overview on disasters. *Disaster Prevention and Management: An International Journal*, *16*(5), 687-703.
[4] Eshghi, K., & Larson, R. C. *op. cit.*

database is defined as an event causing widespread destruction and fulfilling at least two of three criteria: ten or more people reported killed, 100 or more people reported affected or a call for international assistance or a declaration of a state of emergency from a government. The detailed trends are shown in Figure X.

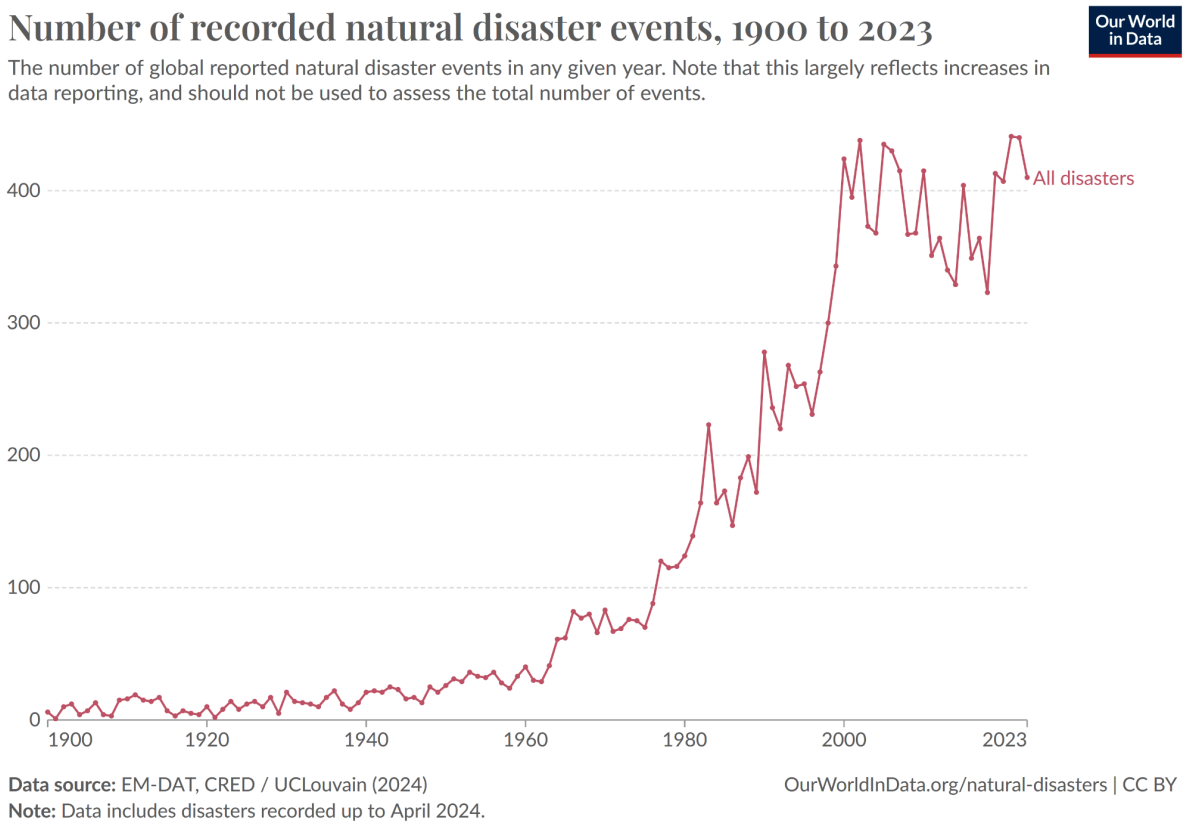

Fig. X. Number of recorded natural disasters in 1900 – 2023[5]

Eshghi et al.[6] points out that the increasing number of the disasters can be explained by developing more accurate detection technology, communications and media. This however does not explain the increase between 1990 – 1999 and 2000 – 2005 periods. Another possible explanation is increase of the human population and growth in the areas more vulnerable to hazards. Those claims seem to be supported by further analysis shown in

[5] "Data Page: Number of recorded natural disaster events", part of the following publication: Hannah Ritchie and Pablo Rosado (2022) - "Natural Disasters". Data adapted from EM-DAT, CRED / UCLouvain. Retrieved from https://ourworldindata.org/grapher/number-of-natural-disaster-events [online resource]
[6] Eshghi, K., & Larson, R. C. *op. cit.*

Alimonti et al.[7] pointing out the declining trend later to 2022 and attributes the increase to the better reporting, refuting the UNDRR report[8] about the upcoming increase of natural disasters, caused by global warming.

Despite the increased number of people affected, according to the *Ourworldindata*[9] service the number of deaths in the last century has drastically dropped to about 40 000 deaths. The decadal average of deaths from disasters is shown in Figure X.

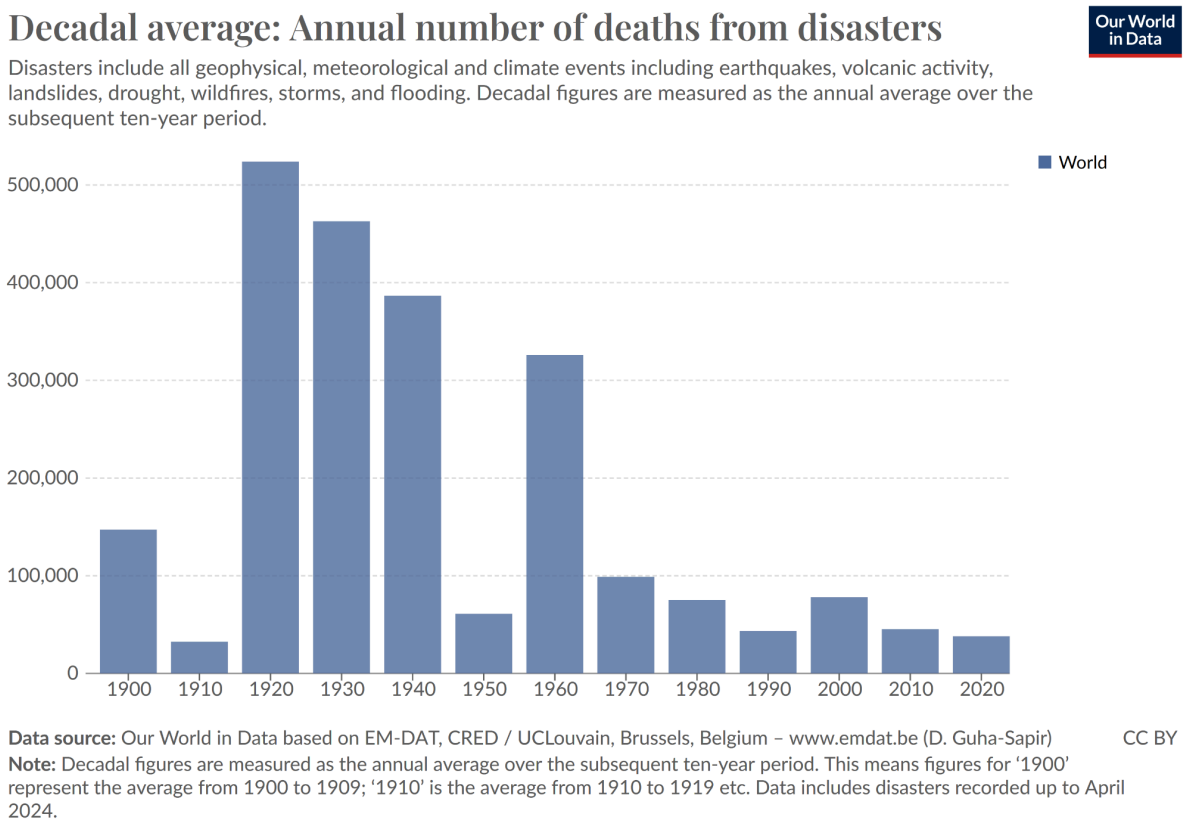

Fig. X. Number of recorded deaths from natural disasters in following decades since 1900[10]

[7] Alimonti, G., & Mariani, L. (2023). Is the number of global natural disasters increasing?. *Environmental Hazards*, 1-17.

[8] The human cost of disasters: an overview of the last 20 years (2000-2019): https://www.undrr.org/publication/human-cost-disasters-overview-last-20-years-2000-2019

[9] Hannah Ritchie and Pablo Rosado (2022) - "Natural Disasters" Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/natural-disasters' [Online Resource]

[10] Hannah Ritchie and Pablo Rosado, *op. cit.*

Survivors detection

- surface detection methods
- rubble detection methods

State of knowledge summary

4. Market research

Life detection equipment

- probably some probes or radars for rubble
- radars for warfare, through-wall detection

Life detection systems

- probably some drones with cameras and thermal imaging
- maybe warfare drones with radars?

Market research summary

5. Risk analysis

Users and survivors health and safety

- missing the survivor – low detection accuracy
- loss of control over UAV – training required, backup procedures, backup connectivity,
-

System’s effectiveness

- false positives of detection – wasting resources
- insufficient battery
- inappropriate use – training required

6. Regulatory aspects

Market introduction

- is it MDR? or appropriate aerial regulations? or both?

Standards and legal requirements

- regulations
- applicable standards (harmonized would be best)
- flight permission

Accredited tests

- if applicable
- RED tests will be for sure
-

7. Technical solution concept

System architecture

Detection agent

- vehicle platform, requriements - UAV
- maybe some ready UAV with enabled modifications???

Sensory detection units

- proposed algorithm
- exemplary sensors

Vehicle control units

- like accelerometers, motors etc.

Power management

- brief estimations of required power
-

MCU

- examples of MCU's
- recommended one

Connectivity units

- satellite module
-

Control station

Movement control

- mcu and
- joystick or what is required to steer

Connectivity

- the same as in detection agent

- probably some serious antenna

User interface

- screen
- example of existing user interfaces

Industrial design

- examples of drones
- examples of controllers
    - recommended design
-

Efficiency and safety verification

- validation procedure?

8. Conclusions