AIRSPACE AND POSSIBLE USAGE OF NEW TECHNOLOGIES DURING MITIGATION OF LARGE DISASTER ON THE EXAMPLE OF THE ASSISTANCE PROJECT. OVERVIEW.

Maciej ZAWISTOWSKI
Radosław FELLNER
Piotr SADOWSKI

ABSTRACT: With current, sudden climate changes, an increase in the frequency of various natural disasters can be observed which affects populated, urban areas. This may cause the need to increase the number of rescuers so that they can respond appropriately to various disasters or the need to use new technologies that will help in efficient and safe disaster management, especially in difficult terrain. This article focuses on the second approach pointing to the most important advantages and possibilities offered by new technologies during disaster mitigation such as:

- Measurement of air pollution using an unmanned aerial vehicle (UAV),
- Measurement of life parameters of rescuers,
- Checking the location of rescuer and visualization on the map for better action management and situational awareness.

The above-mentioned aspects have an impact on the organization of the airspace and air traffic management. Attention should be given to the necessity of coordinate flights of unmanned aerial vehicles with manned aviation (extinguishing operations, flights with the SAR status).
KEYWORDS: Unmanned Aerial Vehicle, UAV, Search And Rescue, SAR, Virtual Reality, VR, Wearable devices, Robots, Rescue services, First Responders
SŁOWA KLUCZOWE: Bezzałogowe Statki Powietrzne, BSP, poszukiwanie i ratownictwo, P&R, wirtualna rzeczywistość, VR, urządzenia ubieralne, roboty, służby ratownicze, ratownicy

1. *Introduction*

The use of new technologies will not replace a qualified rescuer, however after tailored training, it can significantly improve its performance while taking care of and improving its safety. This subject is dealt with by the project funded by the Horizon 2020 program called ASSISTANCE. During its implementation, three different usage scenarios were selected: earthquake, industrial accident and terrorist attack, under which drones (UAVs), wearable devices and robots will be used. Besides this during this project a training grid based on Virtual / Mixed / Alternate Reality will be establish. Ultimately, the project effects are aimed at increasing the situational awareness of rescuers and improving their safety. The article presents the possibilities of using the above technologies by various groups of rescuers, improving their capabilities, safety and situational awareness.

Moreover, the obtained so far results and opportunities of new technologies will be embedded in the context of ensuring safety in the airspace during rescue operations. It is worth to indicate the fact that the use of virtual reality during rescue coordination exercises means a new perspective in the pursuit of ensuring flight safety. Firstly, officers can train in virtual reality in the field of navigational preparation for flight, flight procedures, and flight execution without putting at risk other users of the airspace. Secondly, VR makes it possible to practice coordination of activities between different types of services involved in rescue operations, as well as coordination of flights with air traffic services. This makes it possible not only to identify gaps and barriers but also to create new aviation procedures to be used in reality (during real operations), increasing the safety of flights.

2. *New technologies for rescuers*

2.1 Unmanned Aerial Vechicle UAV

There are now more and more UAVs in the sky. The development of this technology is extremely fast, which is manifested in ever newer constructions. More and more advanced constructions with a wide spectrum of possibilities have resulted in the start of their use in emergency services. It should be noted that more and more often UAV is only a supporting structure for specialized cameras and sensors. The real benefits of using UAVs during a rescue operation are the appropriate and fast processing of large amounts of data and their appropriate presentation so that they are easily accessible and understood by the person coordinating the rescue operation. Examples of equipment mounted on UAVs can be the whole range of sensors such as RGB cameras, infrared cameras, sensors measuring air pollution, etc. What is more, during rescue mission, UAV have to deal with difficult terrain, be able to fly close to buildings (houses, storehouses, stadiums), constructions (towers, antennas, bridges) and trees. So it must be equipped with sense and avoid technologies. One of the basic UAVs applications is quick control of the incident area through cameras. For example thermal cameras in the event of fires are a great tool for checking the situation inside a fire. This is extremely important in the exact location of its forest, which allows, for example, better and more effective directing of extinguishing streams. A good example of this could be the fire at Notre Dame Cathedral. In addition, after extinguishing the fire, the drones were used to pre-check the condition of the structure, which allowed minimizing the risk for firefighters [1, 2].

In the case of searches, drones can search a larger area in a shorter time than the search team, and its advantages generally increase with the difficulty of the area in which the search takes place [3, [4], [5]]. There are many different cases of usage drones for search operation, but one of the more medial was the use of drone during search for a missing British on Broad Peak in Karakoram[6]. In this case, UAV was used in two ways. First, the operator came over to the British and

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1. DJI drones helped track and stop the Notre Dame fire. [Online: https://www.theverge.com/2019/4/16/18410723/notre-dame-fire-dji-drones-tracking-stopped-thermal-cameras], accessed on 10 July 2020
2. Drones Helped Save Notre-Dame Cathedral: an interview with Beniot Guillot at Artedrones. [Online: https://www.directionsmag.com/article/9306], accessed on 10 July 2020
3. Jurecka M., Niedzielski T. “Searching for lost persons in the wilderness Review of applied methods” *Scientific dissertations of Institute of Geography and Regional development of Wroclaw University* 2020, no 47;
4. Półka, M., Ptak, S., Kuziora, Ł., Kuczyńska, A. “The use of unmanned aerial vehicles by urban search and rescue groups”. *Drones: Applications* 2018, pp.83;
5. Surmann, H., Worst, R., Buschmann, T., Leinweber, A., Schmitz, A., Senkowski, G., Goddemeier, N. “Integration of UAVs in Urban Search and Rescue Missions” *IEEE International Symposium on Safety, Security, and Rescue Robotics (SSRR),* 2019, pp. 203-209.
6. McRae J. N., Gay C. J., Nielsen B. M., Hunt A, P. “Using an Unmanned Aircraft System (Drone) to Conduct a Complex High Altitude Search and Rescue Operation: A Case Study” *Wilderness & Environmental Medicine*, Volume 30, 2019, pp. 287-290

took a picture with GPS coordinates. Then, after passing the information, the drone aimed the rescue group at the person sought.

In addition to searching for people, drones are great for creating disaster maps which are more detailed than make by satellite. This can be extremely important in the event of extensive disasters such as earthquake, where at the beginning we do not have information about damaged infrastructure.

Figure 1. Comparison of the quality of satellite images (left), and made using an unmanned vehicle (right side) on the example of Tanzania [7]

Based on the detailed map, the commander can choose the appropriate route, avoiding the barrier problem[7] and thus reach the victims faster. In addition, accurate drone maps can be a great tool to choose the right places for e.g. a field hospital or command post.

Another very common problem that occurs when dealing with large-scale disasters such as an earthquake or flood is damaged telecommunications infrastructure. Communication problems among various emergency services can cause complications and unnecessary prolongation of actions, reducing the efficiency of rescuers and problems with their management. This problem is also solved within the ASSISTANCE project by using a swarm of drones. A swarm of drones equipped with special devices will create an Ad-Hoc network in the disaster area, allowing services to communicate with each other and with the coordinator of the rescue operation [8]. In addition, drones in this application can serve as cameras, allowing the coordinator to observe area of the disaster. Fast information transfer supported by monitoring from UAVs will allow faster response and gain valuable time.

Drones can be used as a tool for air contamination reconnaissance. The ASSISTANCE project provides for drone usage to detect toxics substances in the air. Project will use dedicated gas and particular meter sensors combined with data transmission and collection system. The system aim is to provide full range of air pollution data with auto map generators using GIS technology. Such systems can provide live situation awareness and can support operational decision making.

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7. Feltynowski M., Langner M. "The Role of EASeR Project in Enhancing Search and Rescue Teams Performance", *Safety & Fire Technology*, Volume 53, 2019, pp.130-143

8. Tahir, A., Böling, J., Haghbayan, M. H., Toivonen, H. T., Plosila, J. "Swarms of unmanned aerial vehicles—A survey" *Journal of Industrial Information Integration*, Volume 16, 2019

Another wide UAVs usage is to provide wireless connectivity. One of the way is to provide mobile network connectivity, another wireless WiFi network solutions [9].

Mobile networks are well suited to support low-altitude drone communication and to be integrated with drone traffic management systems and also can enhance the safety and security of drone operations. The licensed mobile spectrum serves as the foundation for mobile networks to provide wide-area, high-quality and secure connection that can enable cost-efficient drone operations beyond visual line-of-sight range. Current mobile networks are capable of serving drones in the low-altitude airspace. Specific performance enhancements can optimize LTE/5G connectivity toward more effective and efficient connectivity for connected drones while maintaining the performance of mobile devices on the ground [10].

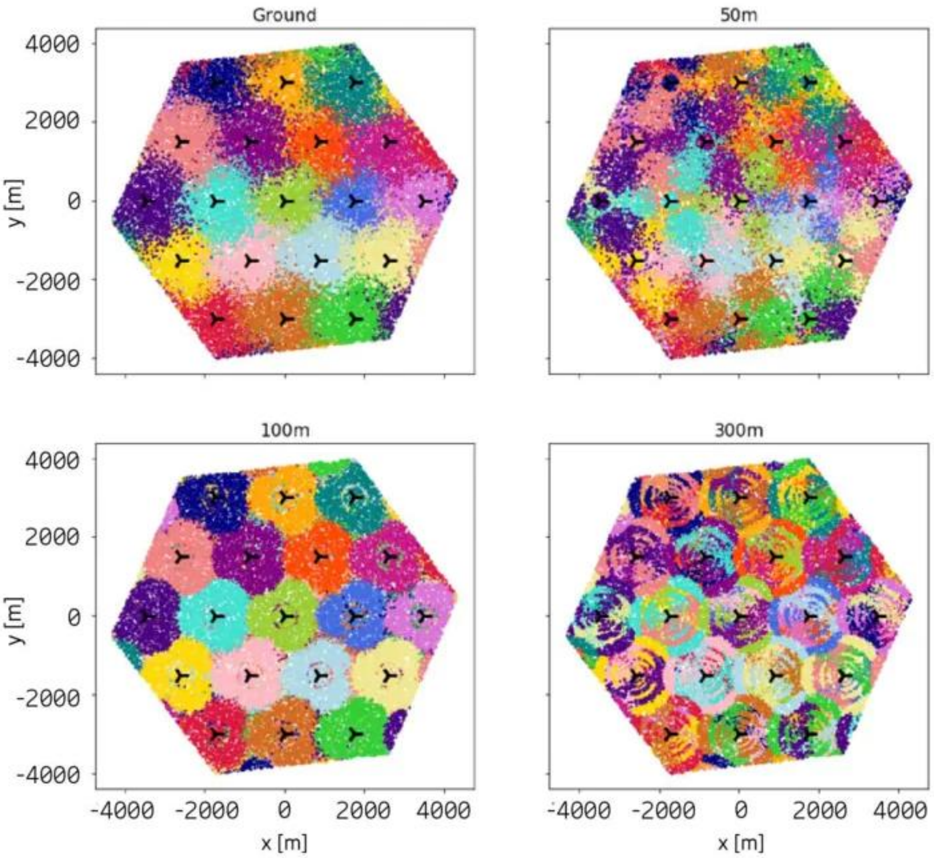

Figure 2. Cell association patterns at a different altitudes [11]

The major components of the flying wireless (WiFi) networks are the UAVs carrying the wireless nodes. The flying nodes should stay stable in the air, multirotors using position hold flight mode are perfect network nodes. The process of network architecture formation can be automated using automatic

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9. Shakhatreh, H., Sawalmeh, A. H., Al-Fuqaha, A., Dou, Z., Almaita, E., Khalil, I., Guizani, M. “Unmanned aerial vehicles (UAVs): A survey on civil applications and key research challenges” *IEEE Access*, Volume 7,pp. 48572-48634, 2019

10. Mehallegue, N., Djellab, M., & Loukhaoukha, K. “Efficient Use of UAVs for Public Safety in Disaster and Crisis Management”, *Wireless Personal Communications*, 2020, pp.1-12

11. Ericson Website. [Online: https://www.ericsson.com/], accessed on 10 July 2020

route and waypoint preparation. Before take-off each drone can be attached with proper configured network equipment providing adequate radio signal strength and range. It is possible to support fully automated UAV nodes replacement according to defined battery flight length parameters.

WiFi signal coverage provided by UAVs presents following table [12] (¡Error! No se encuentra el origen de la referencia.):

Table 1. WiFi signal coverage provided by UAV's

Standard	Rate [Mbps]	Radius [m]
2.4GHz 802.11b	11	6719
2.4GHz 802.11g	54	950
2.4GHz 802.11n	144	754

Disaster area wireless network can be generated in very simple way using UAV technology.

2.2 Wearable device

Thanks to the miniaturization of today's sensors, wearable technology has evolved considerably. This can be seen primarily with the growing number of models generally available on the market. These are mainly intelligent wearable headbands, although other constructions appear. Such devices enable the measurement of the most important human parameters, such as temperature, heart rate or oxygenation, which may indicate, for example, increased lifeguard effort. In addition, mounted so-called motion and location sensors can indicate a rescuer who for some reason lost consciousness and should be assisted. Wearable technology is any type of technology that can be worn or built into present uniforms or protective clothing for the purpose of collecting data that can be transmitted and monitored that will provide useful information that will enhance human safety [13]. Wearable uniform devices can be divided into four main groups:

- health status sensors [14];
- chemical and external temperature sensors [15, 16];

12. Guillen-Perez A., Sanchez-Iborra R., Cano M-D., Sanchez-Aarnoutse J. C., Garcia-Haro J. “WiFi networks on drones” *ITU Kaleidoscope: ICTs for a Sustainable World (ITU WT)* 2016, pp. 1-8.
13. Franklin, J., Howell, G., Ledgerwood, S., Griffith, J. “Security Analysis of First Responder Mobile and Wearable Devices” *National Institute of Standards and Technology Interagency Report 8196,* 2020, .
14. Mukhopadhyay, S. C. “Wearable sensors for human activity monitoring: A review” *IEEE sensors journal* 2014, Volume 15(3), pp. 1321-1330.
15. Barfidokht, A., Mishra, R. K., Seenivasan, R., Liu, S., Hubble, L. J., Wang, J., & Hall, D. A. “Wearable electrochemical glove-based sensor for rapid and on-site detection of fentanyl” *Sensors and Actuators B. Chemical,* 2019, Volume 296.
16. Hubble, L. J., & Wang, J. “Sensing at your fingertips: glove-based wearable chemical sensors” *Electroanalysis* 2019, Volume 31(3), pp. 428-436.

- CBRN sensors [17, 18];
- personal microprocessor unit and wireless communication module [19].

Health status sensors are introduced to monitor human health status. It is intended to monitor electrocardiogram (ECG) to detect early signs of cardiac events following for example firefighting or training exercises. Other reason is to estimate body temperature to reduce the risk of heat-related injuries and fatalities.

Chemical and external temperature sensors are used to monitor environment. They are used to collect data of air contamination or dangerous gasses emission.

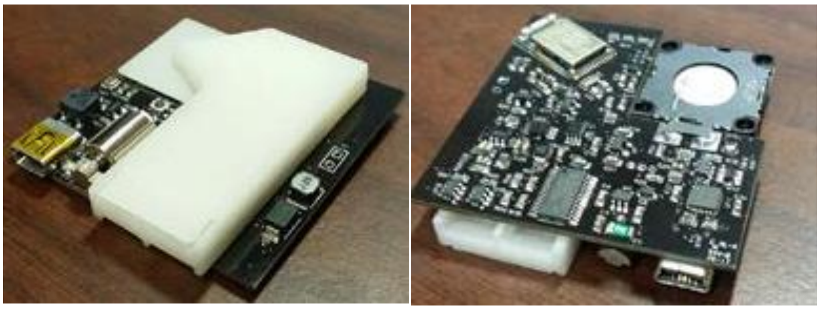

Figure 3. Wearable chemical sensor prototype (H_2S, NH_3) (own materials)

Picture above (

Figure 3) presents wearable chemical badge sensor prototype, fabricated during SBIR Phase I [20], successfully demonstrated detection of H_2S and NH_3 in the presence of other contaminants.

The sensor was able to identify and predict toxic industrial chemicals concentration within 20 seconds with an accuracy of ±2 ppm. The manufactures DHS Science and Technology Directorate and TDA Research, Inc. also carried out a detailed design of the sensor badge, generated 3-D models and assessed the techno-economic merits of a four-six gas sensor.

CBRN sensors provides data according to Chemical, Biological, Radiological or Nuclear factors exposure. These sensors are a multi-probe survey meters designed for operation in contaminated environment. Their sensibility has been specifically adapted to use with CBRN protective clothing.

Personal microprocessor unit and wireless communication module aims to collect all wearable sensors data and communicate with system core to provide complete data view to monitoring operator. There are two main sensor communication possibilities: LMR (Land Mobile Radio) technology and cellular technology. LMR mode allows for communication from one user directly to

17. Sempionatto, J. R., Mishra, R. K., Martín, A., Tang, G., Nakagawa, T., Lu, X., Wang, J. "Wearable ring-based sensing platform for detecting chemical threats" *ACS sensors*, Volume 2(10) , 2017, pp. 1531-1538.
18. Al-Zinati, M., Al-Thebyan, Q., & Jararweh, Y. "An agent based model for health surveillance systems and early biological threat detection" *In 2018 IEEE 6th International Conference on Future Internet of Things and Cloud (FiCloud)* 2018, pp. 55-62.
19. Fletcher, R. R., Dobson, K., Goodwin, M. S., Eydgahi, H., Wilder-Smith, O., Fernholz, D., Picard, R. W. "iCalm: Wearable sensor and network architecture for wirelessly communicating and logging autonomic activity" *IEEE transactions on information technology in biomedicine*, Volume 14(2) , 2010, pp. 215-223. ;
20. SBIR STTR America's Seed Fund. [Online: https://www.sbir.gov/ab out/about-sbir], accessed on 10 July 2020

another user or group of users without the aid of any outside network. This is common with larger incidents where many public safety users are in close proximity and would be impeding incident and agency operations by using the repeater system infrastructure [13]. Conventional LMR systems operate similarly to direct mode but use repeating infrastructure to increase the range to a much larger area. Cellular mobile devices are commonly used in public safety scenarios [21, [22]]. They may be issued as a dedicated enterprise. These devices may ship with mobile applications specifically written for the search and rescue services.

Designed wearable devices system solutions are scalable, allows to add or remove wearable devices on the fly as response to an incident characteristic. The systems are independent of radio repeaters or internet connectivity and can work in the most hostile environments including heavy structures or remote wilderness. The same technology can be used for emergency management system. Smart roads with embedded sensors could tell the first responders about the best rescue route, or heat sensors embedded in buildings could help firefighters track the progression of fire room by room and indicate the safest path to avoid air contamination and fog. Mobile and wearable devices will become ideal options for first responders (firefighters, law enforcement and EMS). These devices will provide many benefits to first responders, such as quality communication on a dedicated network and the ability to send vital information necessary to achieve success during an emergency incident [13].

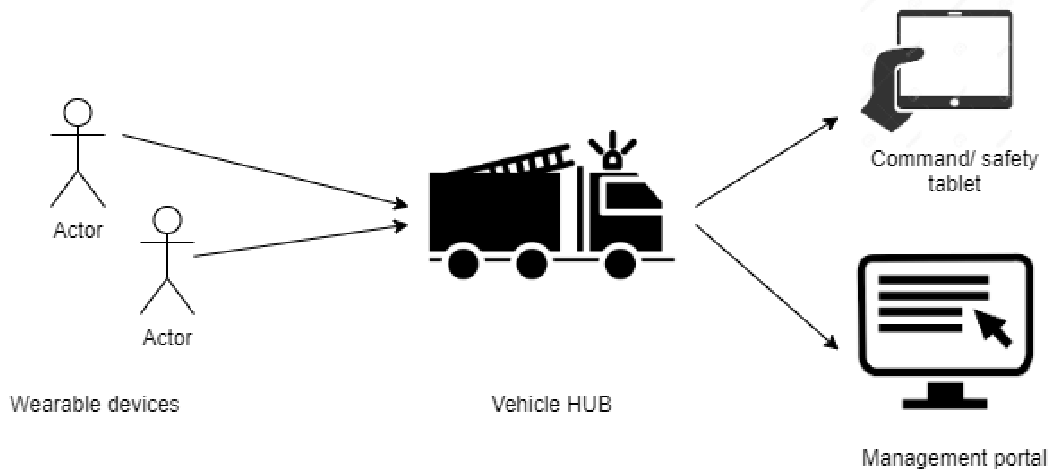

Figure 4. Wearable devices system architecture (own materials)

Wearable devices combined with tailored platform for data presentation will be used as part of the ASSISTANCE project to increase rescuer safety. The use of sensors that allow measuring such parameters as location, ambient temperature, rescuer temperature, wireless cameras and wireless communication is being considered.

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21. Hildmann, H., Kovacs, E. "Using Unmanned Aerial Vehicles (UAVs) as Mobile Sensing Platforms (MSPs) for Disaster Response, Civil Security and Public Safety" *Drones* 2019, Volume 3(3), pp. 59.
22. Jagannath, A., Jagannath, J., Sheaffer, B., Drozd, A. "Developing a low cost, portable jammer detection and localization device for first responders". *In 2019 16th IEEE Annual Consumer Communications & Networking Conference (CCNC)* 2019, pp. 1-4.

2.3 Robots

The use of robots, in this list, is the oldest technology considered in rescue, but due to technological progress still being developed in terms of performance, equipment or capabilities of the manipulators installed. Robots in rescue operations allow, inter alia, to perform tasks in an environment harmful to the rescuer. An example of such use may be e.g. the use of a robot during the Fukishima disaster removal in 2011. The sensorized and radiation-protected Monirobo (Figure 5) robots provided information on the state of the structure and the consequences of failure in places where the level of radioactive radiation did not allow the introduction of people [23, 24].

Figure 5. A Monirobo- Japanese vehicle to assist in the recovery of Fukushima nuclear power plant failures [25]

This case also indicates the need to secure this type of vehicle against CBRN threats. Earlier attempts to use this technology, e.g. in Chernobyl [26], proved unsuccessful. On the one hand, it resulted from difficulties in moving around the rubble and on the other due to the destructive impact of radiation on electronics. There was an attempt to use the robots to clear the damage reactor's chamber roof out of radioactive graphite in Chernobyl. First the officials decided to use Russian lunar landers, called Lunokhod, and a borrowed police robot. Next attempt was to use Joker. Joker was one of the robots, that was originally from West Germany, and was set to the rooftop to remove the highly radioactive rubble. Due to high level of gamma radiation exposure all of them failed.

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23. Drones for Disaster Response and Relief Operations. [Online: https://www.issuelab.org/resources/21683/21683.pdf] , accessed on 10 July 2020
24. Monirobo measures radiation following nuclear crisis at Japan's Fukushima Daiichi power plant. [Online: https://www.engadget.com/2011-03-23-monirobo-measures-radiation-following-nuclear-crisis-at-japans.html] accessed on 10 July 2020
25. Feltynowski M., Zawistowski M. "Opportunities related to the use of unmanned platforms in emergency services" *Safety & Fire Technique* 2018, pp.126-136
26. Rescue operation after the Chernobyl disaster. [Online: http://czarnobyl1986.info/akcja.html], accessed on 10 July 2020

Currently, after more than 30 years, the progress of robots has significantly improved. In addition to the above-mentioned use of robots, they can significantly improve the transport capabilities of a single rescuer. An example of such a robot could be a four-legged walking robot called Spot. It allows rescuer to carry loads up to 23kg for up to 45 minutes. The design of the robot modeled on the construction of animals makes the robot very stable and allows to work in difficult field conditions. The ASSISTANCE project will also use a robot provided by the Polish PIAP institute. The GRYF construction (Figure 6) was chosen for the project. This riding platform has a weight of about 40kg, is easy to maneuver, has an accurate manipulator and relatively large space for additional load or sensors. An additional advantage of the robot is its easy reconfiguration and adjustment to the tasks it is going to perform.

Figure 6. View of GRYF robot provided form PIAP [27]

GRYF (Figure 6) produced by polish PIAP is a terrain reconnaissance robot. It is also used to perform reconnaissance actions in hard reach spaces. The main arm is able to lift up to 15kg and has 5 degrees of freedom. GRYF has modular construction that allow to remove its components to adapt robot to operate in tight spaces. Is has ability to overcome uneven terrain and obstacles up to 45 degrees. Is has a good maneuverability due to low weight that makes it easy to transport or carry. Modular construction allows for quick and easy change of additional equipment. It can operate at night due to IR cameras installed.

GRYF technical datasheet is shown below (Table 2.).

Table 1. GRYF technical parameters [27]

Dimensions (length x width x height) [cm]	90 x 59 x 51
Total weight [kg]	38
Max speed [km/h]	8
RC range and video transmission [m]	800

27. PIAP GRYF. [Online: https://www.antyterroryzm.com/portfolio-posts/piap-gryf/], accessed on 10 July 2020

Arm max lift capacity (fully extended) [kg]	15 (5)
Arm range [cm]	190
Operating time [h]	2
Number of cameras	4

Another example of search and rescue robot is developed by German Research Center for Artificial Intelligence Coyote III (Figure 7) - initially build for space exploration tasks, it has shown its multipurpose character in many different scenarios [28]. The rover captivates with high mobility and flexibility, to cope all kinds of situations.

Other than space, Coyote III can also be deployed for search and rescue (SAR) tasks on Earth. Using the camera and laser scanner, the operator gets a clear overview of the surrounding and can safely operate the rover. With a modular system architecture, various sensor and payload modules can be attached to the rover. This allows to help the rescue teams in all kinds of situations and increase the safety of their work. Coyote III provides even the possibility to operate fully autonomous and explore extensive areas.

In addition to mapping and visual awareness, the detection and mapping of hazardous materials is an important part of SAR applications. To demonstrate this capabilities, a representative environmental sensor unit was designed and integrated into a modular payload item. The sensor module is equipped with different gas sensors as well as temperature and humidity sensors.

The environment sensor package can detect gas contamination, and help to find gas leaks. This can warn the rescue forces about dangerous areas, for example with high sludge or carbonic oxide gas pollution. During its traverse, the rover automatically generates a surrounding map and highlights the detected gas concentration.

28. Sonsalla, R. U., Akpo, J. B., Kirchner, F. “Coyote III: Development of a modular and highly mobile micro rover” *In Proc. of the 13th Symp. on Advanced Space Technologies in Robotics and Automation (ASTRA-2015)* 2015

Figure 7. Coyote III with fully integrated rover system-bus [29]

Coyote III technical datasheet is shown below (¡Error! No se encuentra el origen de la referencia.):

Table 2. Coyote III technical [29]

Dimensions (length x width x height) [cm]	99 x 58 x 38
Total weight [kg]	12.5
Max speed [m/s]	1.3
Power supply	LiPo primary battery: 44.4 V; 4.5 Ah
Sensors	- Laser range finder: Hokuyo UST-20LX - Camera: Basler Ace (2048 x 2048 px, 25fps) - IMU: Xsens MTi-300 AHRS
Actuation/ Engine:	4-wheel drive: Robodrive ILM 50x08 BLDC-motor with Harmonic Drive gearing (80:1) for hybrid legged-wheels (5 legs)

2.4 Data aggregation platform

A very large amount of data without proper interpretation and visualization can overwhelm more than one person coordinating activities. To do this, you need a tool that allows you to quickly analyze and easily display the most important information. A special platform will be a very important part of the ASSISTANCE project. Its main task will be to collect data received from UAVs, wearable devices or robots, their appropriate treatment and visualization of these results in a manner adapted to the needs of the coordinator of the rescue operation. The platform will increase the safety of rescuers by informing the coordinator when e.g. a sudden change in some parameters of the rescuer such as temperature or heart rate. In addition, the platform will allow the coordinator to better carry out tasks by providing him with data such as the location of individual rescuers and equipment, their condition and the information they provide. The ASSISTANCE project will adapt the platform based on the solution provided by the Valencia University of Technology called SIMACET-FFT [30] (Figure 8).

29. Coyote III - Robot Systems. [Online: https://robotik.dfki-bremen.de/en/research/robot-systems/coyote-iii.html], (Picture by: Tobias Stark, DFKI GmbH), accessed on 10 July 2020

30. Esteve M., Pérez-Llopis I., Hernández-Blanco L., Climente A., Palau C. E., "SIMACET-FFT: Spanish Army friendly force tracking system", *MILCOM 2009 - 2009 IEEE Military*

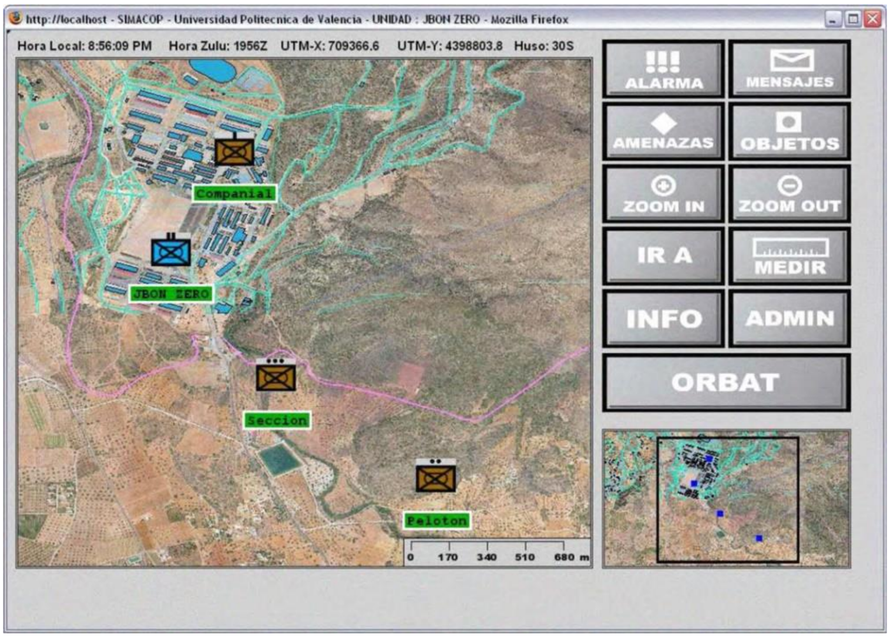

Figure 8. SIMACET-FFT system example exercise screenshot [30]

SIMACET-FFT is an information system providing greater visibility of assets such as service men, troops, vehicles, etc. It is design to help access to information for decision makers in rear-areas, and a trustworthy communication link all action involved units.

SIMACET-FFT allows to obtain the common operation picture at platoon and squad level, virtually locating friend, neutral and enemy units over an operations theatre cartographic database with the suitable scalability at each level. It facilitates command and control decisions to platoon and squad level, from one or from many tactical command and control locations, forward or rear and allows self-synchronization among platoons, shared awareness based providing acquired individualized data from troop units, which act as sensors and actors simultaneously.

SIMACET-FFT provides new features for the most different tactical situations. So as the capability of integrating sensors, video and telemetry, allow the development of the newest advanced network enabled capability concept tool.

Specifying the above elements, new technologies for rescuers is needed in order to capture the full picture of the landscape of activities on the ground during accidents and disasters. As it turns out, the human factor requires proper preparation to handle the new technology. The specificity of accidents determines their impact on the airspace. Actions on the ground require consideration of other airspace users - fire-fighting aircraft or rescue helicopters. It is, therefore, necessary to develop procedures for reporting flights or booking zones, coordinating manned and unmanned flights, transferring reports, exchanging information between services, rules for image and data transmission. Here a VR and AR may help to solve the problem. It must be remembered that implementation requires training.

2.5 Training with the use of virtual and augmented reality

Even the best and most modern technologies without proper training are not useful for rescuers. Current training courses use real training grounds and are associated with significant use of resources and costs. In addition, it is difficult to train a person to work in various conditions such as rain, frost, fire, etc. In order to reduce these inconveniences, the ASSISTANCE project is creating a training network using virtual and augmented reality. The virtual reality training network that is being created covers four countries (Poland, Spain, the Netherlands and Turkey) and is designed to enable training and exchange of experiences for rescuers from different countries who have access to appropriate equipment. The use of virtual and augmented reality has a special application in the era of various types of pandemics, allowing the rescuers to exercise and develop without the need to endanger their health and life. However, it should be noted that despite the increasing realism of the simulations created, virtual and augmented reality will not fully replace field tests, but they are a great alternative to various types of initial training, such as first aid and activities in various weather conditions (e.g. fog, rain, snow etc.). Example view of virtual scenario is shown below (Figure 9.):

Figure 9. An exemplary view of a road accident scenario in bad weather conditions using the VR network used in the ASSITANCE project (own materials)

3. *Discussion*

Supporting rescuers and their safety should be very important in the context of coping with major disasters. Currently, new technologies can significantly improve this security, while adding additional capabilities and data, allowing for better coordination of activities, greater knowledge about the location of rescuers and their condition and enabling communication. The use of new technologies such as UAVs, wearable devices or robots can be used as great data sources about the disaster itself and about the rescuers. However, it should be noted that excess data can cause problems for the coordinator of the rescue action. That is why the platform collecting, processing and visualizing the received data is very important when using various new technologies. Additionally use of virtual and augmented reality technology gives additional training possibilities for use of new technology, in a safety for first responders and cheap way. This technology can be used many times in various weather conditions, etc. Moreover, each attempt can be recorded and then carefully analyzed by evaluator together with the participant.

When it comes to airspace issue, as it results from the current research work, VR systems and environments must take into account the possibility of creating and testing the procedures for transferring reports, information, establishing reserved airspace elements (ad-hoc created restricted area - "R"), stations for coordinating manned and unmanned flights.

4. *Summary*

The further development of new technologies is very important and necessary for rescuers, especially in connection with climate change and various disasters that are increasingly occurring in the world. On the one hand, these technologies should allow for better and faster rescue actions and their monitoring, and on the other, they should protect the health and lives of the rescuers themselves. The technologies mentioned in the article may allow, among others:

- Location of rescuers,
- Examination of their physical condition,
- Better coordination of activities, e.g. during site searches,
- Maintaining wireless transmission for various services,
- A detailed on-site vision.

It should be emphasized that VR and AR create an interesting prospect for increasing the level of safety in the airspace. Thanks to this technology, it is possible to train in the field of procedures, information exchange, as well as to create and test new coordination procedures.

The use of new technologies should be preceded by training and training in its use. Only in this way will rescuers be able to take full advantage of their potential. For initial training, it is worth using virtual and augmented reality, which will allow you to quickly and cheaply carry out many tests in various conditions. The use of the ASSISTANCE project has very attractive themes, and its effects will definitely increase the safety of rescuers when dealing with extensive disasters.

5. *Podsumowanie*

Dalszy rozwój nowych technologii jest bardzo ważny i niezbędny dla ratowników, zwłaszcza w związku ze zmianami klimatycznymi i różnymi katastrofami, które coraz częściej pojawiają się na świecie. Technologie te z jednej strony powinny pozwalać na lepsze i szybsze akcje ratownicze oraz ich monitorowanie, z drugiej powinny chronić zdrowie i życie samych ratowników. Wspomniane w artykule technologie mogą umożliwić m.in .:

- Lokalizacja ratowników,
- Badanie kondycji fizycznej,
- Lepsza koordynacja działań, np. podczas przeszukiwania witryn,
- Utrzymanie transmisji bezprzewodowej dla różnych usług,
- Szczegółowa wizja na miejscu.

Należy podkreslić, że VR i AR stwarzają interesującą perspektywę do podniesienia poziomu bezpieczeństwa w przestrzeni powietrznej. Dzięki tej technologii możliwe jest szkolenie z zakresu procedur, wymiany informacji, a także tworzenie i testowanie nowych procedur koordynacyjnych.

Stosowanie nowych technologii powinno być poprzedzone przeszkoleniem i szkoleniem z ich obsługi. Tylko w ten sposób ratownicy będą mogli w pełni wykorzystać swój potencjał. Do szkolenia wstępnego warto skorzystać z wirtualnej i rozszerzonej rzeczywistości, która pozwoli szybko i tanio przeprowadzić wiele testów w różnych warunkach. Zastosowanie projektu

ASSISTANCE ma bardzo atrakcyjne tematy, a jego efekty zdecydowanie zwiększą bezpieczeństwo ratowników podczas rozległych katastrof.

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