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CONCEPT OF THE MOBILE MONITORING SYSTEM

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Abstract. In connection with the spread of viral diseases caused by COVID-19, its high dynamics and the formation of infection outbreaks were observed. The experience from the first wave of the pandemic showed that, although state-wide measures are effective, they have a significant economic impact and more effective solutions are therefore necessary. In the activities aimed at combating the pandemic caused by COVID-19, one of the most effective means is the isolation of sick patients and the most vulnerable population groups, where the level of risk is the highest. No universally applicable technical solutions which are available on the commercial market would assist in population isolation, in case of protection and monitoring. Creating a mobile monitoring system to protect isolated and at-risk population groups against the spread of viral diseases is highly relevant within Slovakia and with great potential for applicability abroad. This article is focused on the project description that was approved in connection with the protection against the spread of COVID-19, the definition of its main goals, methodology, activities, and benefits.

Keywords: COVID-19; monitoring; isolation; protection

1. INTRODUCTION

The proposed project falls under the intelligent specialization Transport means for the 21st century and is focused on the research and development of a mobile monitoring system. The goal of the project is to create and test a portable monitoring system designed to protect isolated groups of the population from the spread of viral diseases or, conversely, to protect the people from an isolated group identified as a source of risk, including the design, development, and verification of behaviour models of individuals and entities.

The applicant for the project is the Technical University of Kosice, which ranks among the leading Slovak research universities and covers a wide range of educational needs not only for the region of Eastern Slovakia but also in the Central European area. The Lešť Training Centre is a partner in the project. The primary purpose of the establishment of the Lešť Training Centre is to fulfil tasks related to the security and defence of the state, the implementation of health care, medical safety, and special training, especially of the special units of the Slovak Armed Forces, research, and development tasks according to requirements.

In connection with the spread of viral diseases caused by COVID-19, the high dynamics of the spread of the disease and the formation of outbreaks of infection, which may not be identified early enough, have been demonstrated. The experience from the first wave of the pandemic showed that, although state-wide measures are effective, they have a significant economic impact, which is why the EU approaches the solution at the regional or local level. In the activities aimed at combating the pandemic caused by COVID-19, one of the most effective means is the isolation of sick patients and the isolation of the most vulnerable population groups, where the level of risk is the highest.

Currently, in Slovakia, the topic of isolation of individuals dominates, for which effective technical or other measures. But the problem is not only the isolation of individuals but also the isolation of entire communities. Despite high civil awareness, the overall situation in the isolation of communities is primarily influenced by individuals' behaviour and the crowd's psychology. In recent months, the media in Slovakia also addressed the problem of ensuring the isolation of areas by the Slovak security

forces from the point of view of the protection of human rights and the bad influence of the presence of a relatively large deployment of security forces on people's psyche.

Therefore, even in this area, the state in such a situation needs to have its technical solution, people ready to deal with such a situation and be self-sufficient. No universally applicable technical solutions available on the commercial market would assist the force and security forces in securing premises, or they largely replaced them.

Creating a mobile monitoring system to protect isolated and at-risk population groups against the spread of viral diseases is therefore highly relevant not only within Slovakia but also with great potential for applicability abroad. The originality of the solution is demonstrable in the use of non-trivial types of sensors for a given security application in connection with the system's independence from the infrastructure.

2. THEORETICAL BACKGROUND

Monitoring of the protected areas and surroundings at a regional and local level is critical given their exposure to anthropogenic pressures, including those associated with climatic change [1]. But an application for monitoring a region of protection is complicated, covers several areas and may have different purposes [2]. Although monitoring has commonly revolved around field data, remote sensing can play a crucial role in establishing baselines of habitats and associated diversity and quantifying failures, degradation or recovery related to specific events or processes. In the past, biodiversity and protected area monitoring were attacked for being insufficiently appropriate to the conditions of managers and useless in integrating information into decision-making [3].

Nowadays, systems and techniques intended to protect isolated population groups and monitoring of areas have their significant justification, and it is necessary to concentrate on them. Considerable threats from the security side are marked differences in options to try attacks from intruders. Today's technologies make circumstances easier for terrorist attacks, theft attempts, sabotage, or other attacks to destroy or damage protected objects or individuals. Many violations have even started to use unmanned aerial vehicles (UAV) for these purposes, which have the technical abilities to carry out many types of illegal activities quickly [4]. Conversely, unmanned aerial vehicles (UAVs) are becoming used instead of helicopters to help search for vulnerable missing persons, target criminals in crime hotspots, and provide high-quality data for documentation and reconstruction. The most significant advantage of drone designs is that they vary in shape, size, flight range and operating flight altitude, so they have been developed to provide multidimensional abilities across a wide range of civil and military applications [5]. A UAV relies on different sensors to locate and calculate its flight attitude [6], and it is possible to use them to protect isolated groups of the population or to protect and monitoring a protected area.

Accurately assessing the status of threatened and endangered populations is vital to detect population drops that further endanger the people and to demonstrate the effectiveness of protection actions. Monitoring to detect status differences is frequently identified in recovery plans. Unfortunately, seeing changes in status with generally used monitoring strategies such as monitoring species quantity and statistical tests for population trends can be challenging [7]. Similarly, monitoring of the protected areas or other essential areas can be demanding in terms of technology, conditions, and in some cases, the subsequent evaluation of the area's condition.

New possibilities and methods are therefore required. In addition, the current times and population are being tested by multiple new challenges that are often unprecedented, such as the ongoing COVID-19 pandemic. To date, the world has suffered from this pandemic in terms of human lives lost, economic and financial repercussions and raised poverty. The pandemic had and still has an impact on all areas of human life: transport, tourism, economy, international trade, education, culture, and sport. It also has an adverse effect on people's mental health, isolated groups of people, relationships, and social well-being. This is also why, in the case of such a large-scale intervention, it is necessary to react differently in the future. It is also required to better prepare for such situations, which many experts assume to be a normal part of life [8]. The potential applications of UAVs offer

the possibility to collect complex information in real-time at a reasonably low cost. Within transmissible disease epidemiology and public health research, UAVs can deliver spatially and temporally precise data essential to comprehending the connections between disease transmission and environmental factors. Plus, using UAVs bypasses many limitations associated with satellite data e.g., long repeat times, cloud contamination, low spatial resolution. Nevertheless, using UAVs for field research limits their use to specific applications and settings [9]. As a great example of applying UAVs, it is possible to mention social distancing, which was proved to be an effective non-pharmaceutical measure to slow down the spread of COVID-19. As UAV is a flexible mobile platform, it is an optimistic option to use UAVs for social distance monitoring [10].

3. PROJECT GOALS AND METHODOLOGY

The project's primary goal is to create and subsequently test a mobile monitoring system designed to protect isolated groups. Protection is meant mainly in the context of the current situation related to the COVID-19 pandemic, which has affected the entire world to such a large extent. It represents an unprecedented threat from which lessons can be learned, and it is necessary to respond differently in the future. With the proposed monitoring system, it is possible to protect isolated groups of the population from spreading viral diseases (coronavirus, different variants, etc.). It is also possible to ensure the protection of the population against an isolated group identified as a source of risk. The project's focus is also the design, development, and verification of behaviour models of individuals and entities. The system will be built from:

- mobile sensor elements,
- a mobile monitoring station and
- a cloud data system.

These elements will make it possible to ensure the identification of potential threats and the necessary degree of protection.

Mobile sensory elements will be installed in the form of separate free-standing devices, which will be distributed in the area to create a sensory network.

In addition to the design of the integrated system, the project also aims to test it in the field, considering potentially influencing factors such as:

- weather conditions,
- dustiness,
- vibrations, or
- the presence of animals.

The goal is to create a mobile monitoring sensor system for the protection of isolated and at-risk population groups against the spread of viral diseases, which will not depend on local electricity distribution, which will not visually change the character of the defined area, and therefore will not cause an additional psychological burden for any of the protected parties.

The project will be executed through two research and development activities.

The goal of the first activity will be to develop a mobile monitoring sensor unit. The system will be mobile and independent of ground infrastructure, bringing more benefits when using it. Individual components will be independent of external power and communication galvanic inputs. The research will also include creating 3D models and virtualization using a virtual reality workplace and optimizing the localization of mobile sensory elements in the area of interest. As part of the activity, data obtained during testing, verification and validation of the mobile sensory system will also be processed and evaluated. To verify the system, it is necessary to collect and implement additional information about the activities taking place in the surrounding area and about meteorological, topographical, and other physical effects of the environment, which can have a fundamental impact on the operation of the mobile monitoring system. This information will be obtained in cooperation with the project partner.

The first activity will be implemented in five main milestones (Table 1). The first milestone (M1.1) deals with the design of the sensory, communication and power supply equipment of the sensory unit. The second milestone (M1.2) aims to create a prototype of the sensory unit. The output of the third milestone (M1.3) will be a report from the testing of the sensor unit prototype. The fourth milestone (M1.4) will focus on the mobile sensor system prototype, and the final milestone (M1.5) will test the mobile sensor system.

Table 1 Description of the first activity and its milestones

First activity: development of a mobile monitoring sensor element		
Milestone	**Duration (in months)**	**Output**
M1.1	3	Design of sensory, communication and power supply equipment of a sensory unit
M1.2	3 – 12	Sensory unit prototype
M1.3	12 – 15	Sensor unit prototype testing report
M1.4	15 – 25	Prototype of a mobile sensor system
M1.5	25 – 39	Mobile sensory system testing report

The expected results of the research activity will be applications for intellectual property rights, two patent applications and publication outputs, with an emphasis on conference outputs and journal contributions indexed in the Web of Science Core Collection, Current Contents Connect and Scopus databases.

The second research and development activity will be carried out with an emphasis on research into the incorporation of unmanned aerial vehicles (UAVs) in the reserved and restricted area protection system. The activity aims to design, develop, and verify different behaviour models of individuals and entities.

Plus, the activity focuses on creating and developing a mobile monitoring system to protect isolated population groups from spreading viral diseases and verification and testing in the OneSAF constructive simulation environment. An integral part of the activity will be integrating UAVs into the data collection system to increase the effectiveness and efficiency of monitoring.

Additionally, the use of UAVs ensures a dedicated area for the protection of at-risk population groups. Based on input data from all camera systems, "heat maps" will be developed as part of the activity, which, using advanced models of predictive analysis, will serve as input attributes for the development of individual SMART-FENCE units as part of the first activity. The partner's monitoring and sensory unit outputs will simultaneously function as reference inputs for the mobile security monitoring system during all phases of its validation and testing.

By linking the individual activities of the project in this way, an effective mechanism will be created to optimize the effectiveness of the mobile sensory units of the system concerning the actual geographical features of the terrain.

The activity will be implemented through four main milestones (Table 2). The first milestone (M2.1) will focus on developing behaviour models of isolated individuals and entities. As part of the second milestone (M2.2), a prediction model of the behaviour of isolated individuals and entities will be developed. In the third milestone (M2.3), the integration of an unmanned aerial vehicle (UAV) into the system of protection of risk and isolated groups against the spread of viral diseases will be ensured. And through the last milestone (M2.4), testing and validation of laboratory research results in the training area's real conditions will be proposed.

Table 2 Description of the second activity and its milestones

Second activity: design, development, and verification of different behaviour models of individuals and entities.		
Milestone	**Duration (in months)**	**Output**
M2.1	3	Developed behaviour models of isolated individuals and entities
M2.2	3 – 12	Developed prediction model of the behaviour of isolated individuals and entities
M2.3	12 – 18	Integration of an unmanned vehicle into the system of protection of risk and isolated groups against the spread of viral diseases
M2.4	18 – 30	Integration of an unmanned vehicle into the system of protection of risk and isolated groups against the spread of viral diseases

4. PROJECT BENEFITS AND SOLUTIONS

Solving the problem through the project will significantly contribute to preventing the spread of viral diseases or protecting risk groups of the population. It will be ensured by the cooperation of critical teams for individual activities. From the point of view of the development of scientific and research activity, the successful solution of the project activities will contribute to the further development of research excellence oriented to means of transport for the 21st century in the conditions of the Slovak Republic, but also of the EU.

The nature of the scientific research activity creates a realistic possibility of transferring the knowledge acquired in the past period and developed within the project activities to support the excellence of research teams on an international scale through cooperation with researchers with many years of experience in the field of training security and defence forces not only of our state.

At the same time, the project follows on from several research and development activities that were implemented in the past and were part of the solution of several projects. The project's solution uses the existing infrastructure and on, instrumentation and laboratory equipment relevant for the individual domains of the smart specialization of RIS3 SK. The current instrumentation is a suitable basis for successfully resolving all milestones planned for individual activities and sub-activities in the project. Still, it is necessary to supplement it with unique laboratory and instrumentation more precisely defined in the project budget.

The project is divided into two activities (1 for the applicant and 1 for the partner), which are interconnected and complement each other. Everyone is responsible for their activity, both professionally and organizationally and managerially. A multi-project approach is proposed for senior project management, where each activity represents a complementary project with its own management. The TUKE applicant guarantees top integrated project management, and from the point of view of project management, the Faculty of Aeronautics is in the project coordinator position.

The proposed solution of the monitoring system for securing areas of interest is original, especially from the point of view of its mobility, as current studies show that the localization and subsequent isolation of outbreaks of infection plays a crucial role in the fight against viral diseases. Another aspect is that the current pandemic is particularly dangerous for certain groups of the population, especially seniors or people with severe or chronic conditions. And the protection of at-risk population groups is also one of the factors proving the topicality of the problem solved at the international, even global level.

Applicability in practice and on an international scale will be ensured by the transfer of knowledge and technologies by the partner organization's staff, which is a renowned training organization for the training of security and defence forces not only from Slovakia but also from abroad.

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