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AVIGILON COMPACT CAMERA'S TEST FOR INTEGRATED SAFETY SYSTEM WITHIN AIRPORT SECURITY

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Abstract:

The article presents an experimental exploration of the selected technical features of the Avigilon 2.0C-H4A-BO1-IR Compact Zoom Camera with IR Adaptive Illumination. The article describes the purpose, procedure, and results of the motion detection verification, as well as the identification of motion detection errors, using Avigilon's investigated camera, to the distance of guaranteed recognition capability in specific daylight conditions that determines video analysis. This article constitutes the first part of the internal research activity of the Department of Flight Preparation - pre-research, for the design of an integrated mobile airport security system. For safety reasons, the testing was performed near the airport and not at the airport. The test sample was obtained by using the Avigilon 2.0C-H4A-BO1-IR camera located 8 meters above the ground level in the direction of the selected perimeter of the "protected area" for the experiment. The movement in the space was made by people and the passage of motor vehicles at a distance that was less than the distance guaranteed by the camera's recognition capability in the specific daylight conditions. The movement of persons and motor vehicles was generally performed perpendicular to the position of the camera, left to right, and/or back. The speed of movement of people was, as a rule, an average walking speed of 1m/s, the motor vehicles ranging up to 40km /h. Identification of motion detection errors is important for corrections of the prepared information model of security risk assessment of a protected object based on the fuzzy logic to support the airport security management decisions, as well as for finding a technical solution to eliminate these camera vulnerabilities, or selecting and testing another camera for our mobile technology platform. The results advance our theoretical knowledge and have a praxeological significance for the creation of a technological demonstrator and subsequently a prototype of a smart mobile airport security system. Institutions responsible for the protection of state borders, the fight against illegal migration, smuggling of goods, etc. are also interested in mobile security solutions.

Keywords: *compact camera, integrated airport security, system, experiment*

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1. Introduction

Based on the definition of state security in the Constitutional Act of the Slovak Republic no. 227/2002 Collection of Laws we can identify the following protected interests: ensuring the sovereignty, territorial integrity and the inviolability of state borders; protection of the lives and human health; property protection; the protection of fundamental human rights and freedoms, the protection of economic interests and the environment. An important part of the protected interests is also the critical infrastructure in which the "Transport" sector plays a key role. To protect interests, we create social and complex technical systems for working in the digital and real-world space.

In the technogenic security sector, we are exploring

- safety and the human factor in technical and technological processes,
- Critical Infrastructure Protection / Critical Infrastructure sectors and subsectors,
- information protection, cyberspace protection, cybercrime,
- security challenges of science and technology development for an individual level of security
- citizen safety, protected rights and interests, and protection of the population, etc. (Kelemen, 2017).

Real-time protection of interests and predictions are possible if they are linked to a real-time data provider using modern information and communication technologies, including the camera systems, image analysis tools, sensors, etc. We find inspirational applications at work as on the analysis of spatiotemporal data to predict traffic conditions (Kyriakou et al., 2019), an integrated approach to information analysis (Semenov et al., 2019) or on the analysis of the traffic stream distribution, etc. (Ambroziak et al., 2014). The description of the current state of knowledge presented in world literature in relation to the research area presented in article on the selected tools for the object or critical infrastructure protection and critical infrastructure failure and risks we can also study generally in the agenda of the European Data protection Supervisor before the user acceptance test, in the image quality testing (IEC, 2015), or in the work on the specification of operating systems of Internet of Things cameras (Palmer, 2017), on safety and security issues in technical infrastructures (Rehak et al., 2020), on the technology agenda within the critical infrastructure and integrated protection (Vidrikova et al., 2017). We can be inspired by the work of CCTV System Performance Specifications (Young, 2015), on discussion of the requirements and applications of the Airport Security Program (Price, Forrest, 2016), or discussion on perimeter security and lists and defines several types of barriers (Purpura, 2017). After system studies, we find an examination of the specific properties of sensors on owing to a lack of computational resources, lightweight and computationally efficient face recognition algorithms are required (Lee et al., 2020), also the many fusion methods for information acquired from sensors (cameras) that have been proposed in the literature for activity recognition (Aguileta et al., 2019), etc.

For the Transport sector/subsector Air transport is a lasting issue of ensuring the safety of air traffic, the protection of persons and property, which affects the air transport and shipping processes. Creating the integrated security systems for airports is one of the available and effective tools to handle the certain risks of the required state. Engineers and researchers are challenged to research, and to develop an innovate relevant technology, collect, process, and visualize data to ensure the security of protected interest as in another works (Szabo et al., 2019) and (Tobisová et al., 2017). The camera systems are such effective tools whose technical parameters and intelligent capabilities are subject to investigation and verification.

The purpose of the pre-research is to support the decision-making process of the end user on the selection of sensors (cameras) for the mobile airport security project for helicopters, based on experimental verification of digital cameras from pre-selection, in accordance with input specifications and customer requirements. The Avigilon and Hikvision cameras meet the entry requirements and therefore 2 independent verifications were performed in the standard situation before the verification of the cameras in non-standard situations and before the subsequent verification within the so-called user acceptance test. The article aims to present the selected outputs of the motion detection verification experiment, as well as the identification of motion detection errors using the Avigilon 2.0C-H4A-BO1-IR camera to the distance of the guaranteed recognition ability under the specific daylight conditions that determines the video analysis.

The research methodology of the article was based primarily on quantitative methodology. The nature of the tasks required the implementation of pre-experimental research on the issue, such as case study research design, which takes into account one dependent variable. The evaluation criterion was the number of errors in the detection of objects within the monitored space, in the specified time and monitoring conditions. We assume the thesis that the results of the verified Avigilon camera will not show errors in the detection of persons or in the incomplete display of a person, but will show errors in the detection of vehicles as objects with a higher speed of movement.

For these reasons, the two basic research questions were formulated for the planned pre-experimental research of the issue:

- what is the number of errors in detecting movement of people and vehicles from the test image sample in a defined "protected area" for the electronic monitoring using the Avigilon 2.0C-H4A-BO1-IR camera that we can identify?
- to find out whether an analytical tool (camera, SW) can only register a human being when the whole body is clearly visible or evaluating an object as a human being even when the person's personality is not visible?

2. Research data and description of functional verification

Experimental research is a scientific approach to research, where one or more independent variables are manipulated and applied to one or more dependent variables to measure their effect on the latter (https://www.formpl.us/blog/experimental-research). Causality is the core of the experiment. The researchers observed, described, measured, scaled the results and evaluated the changes according to the digital recording and detection of the phenomenon, the causality of which they monitored during our pre-experimental research.

We have two samples of digital IP cameras (Avigilon, Hikvision), which we expose to simultaneous recording of the same situations, at the same time and in the field of surveillance. They are treated the same. After research, we will find out which camera shows more cases of motion detection error identification. Therefore, we can come to the partial conclusion that which camera shows better parameters in standard situations, in accordance with the customer's input requirements. The standard situation is the movement of people, vehicles and other subjects in the observation area, where the researcher influences the time and space of the camera's surveillance, but not the number of subjects for editing and monitors the consequences. In the following experiment, in non-standard situations, we calculate, examine and compare the achieved results (identify, analyze and evaluate). The non-standard situation will be the movement of persons, vehicles and other entities in the monitored area, where the researcher influences the variables according to different scenarios of the tactical situation and conditions, and monitors their consequences. It will seek to make it more difficult to work with cameras (masked persons, deliberate maneuvers of persons in the field of surveillance, daylight, night light, drones, luggage, animals in space, etc.).

The article presents the results of a case study of the Avigilon 2.0C-H4A-BO1-IR Compact Zoom camera. The second article will present the results of a case study of a Hikvision camera.

Examining the selected technical parameters of the Avigilon 2.0C-H4A-BO1-IR Compact Zoom Camera was a work with a large number of digital data, which was the main material for the experiment. The database has been searched for and processed based on certain rules.

Before designing our experiment, we studied the similar procedures, findings and work of researchers who were somewhat concerned with the camera systems. The expert community confirms the experience that the video motion detection required by us is the basic and prevailing video analysis method in camera systems (Caputo, 2014; Loveček and Reitšpís, 2011; STN, 2013; 2013; STN, 2014). For example, you can track the line crossing, person counting, image motion, object tracking, neural networks, pixel motion detection, or the classic motion detection, etc.

To achieve the goal, camera-based camera assessment (object identification, analysis, and evaluation) was compared with the detection of the analytical SW tool within the following Avigilon 2.0C-H4A-BO1-IR camera experimentation (the experimental limitations):

– selecting a "protected area" perimeter for the experiment,

- realization of the design of the location of the camera,
- realizing the process of "camera learning" in a selected perimeter of the protected area,
- the trial operation of monitoring and recording of motion in the selected "protected area" area for the experiment, approximately within 2 hours,
- "experimental operation" of monitoring and recording of movement in the selected experimental area of the "protected area" for the experiment, approximately 5 hours,
- checking collection, storing records in the archive, within 5 hours,
- identifying and selecting the "experimental sample record" in the selected timeframe from the scanned "protected area",
- performing digital image analysis based on motion detection of persons and vehicles in the selected "experimental sample record",
- verifying the level of success in detecting the movement of persons and motor vehicles,
- identification and number of errors in the detection of movement of persons and motor vehicles, in the selected "experimental sample record",
- verification of digital data from the selected "experimental sample record",
- processing the discussion of the results of the experiment for the Avigilon 2.0C-H4A-BO1-IR camera, as part of the pre-survey.

An experimental sample of the record was selected from the database of digital data obtained during the 3 days of the pre-experiment. The test sample is from the 15th of October 2018, at 12:30-13:30, using the Avigilon 2.0C-H4A-BO1-IR camera located 8 meters above the ground level in the direction of the selected perimeter of the "protected area" for the experiment. The movement in the space was made by people and the passage of motor vehicles at a distance that was less than the distance guaranteed by the camera's recognition capability in the specific daylight conditions. The movement of persons and motor vehicles was generally performed perpendicular to the position of the camera, left to right, and/or back. The speed of movement of people was, as a rule, an average walking speed of 1m/s, the motor vehicles ranging up to 40km /h.

During the pre-experiment, the privacy policy was followed.

3. Results and discussion on Avigilon experiment 1_2018

The pre-experiment database was created from the 3 days from 14th to 16th October 2018. A comparison of the image analysis was performed on the selected test image, dated 15.10.2018, at 12: 30-13: 30.

When comparing the video-analysis, only systems using the so-called "qualified video-analysis, that is, that the system knows with a certain degree of probability that a person is present in the picture, respectively the car. No pixel-based video-analytic functions were also used, which only track the changes of individual pixels in a given image without being able to determine qualitatively what to engage in the records. We do not mean that a simpler, the pixel analysis is not usable, but for our experiment, we have focused on a qualified form of analysis. We left all the systems in the automatic setting, so the values for the sensitivity, the size of the analyzed objects, the speed of movement, and so on, were left to set the system on its own. We have learned from our previous work on resolving crises and protecting critical infrastructure also (Kelemen et al., 2014, 2015).

Camera system Avigilon 2.0C-H4A-BO1-IR

By camera from Avigilon we found that the camera qualified the 63 people out of a total of 75 in the test records. We have manually searched for people who have not marked as a qualified object of interest and have verified why they have not registered there by the system. The result of the analysis is the finding that the 11 people were the case when two or more people crossed each other simultaneously. The probability of object detection has reached 84%.

Motion Detection Analysis - 1

The test records were prepared to demonstrate the capabilities and the current state of the video-analytics tools of the camera. At the top of the picture there is a sidewalk that is interrupted by the standing cars, with the pedestrians passing through the scene alternately showing the whole or only the upper part of the person's body. The purpose of the experiment was to find out if an analytical tool (camera, SW tool) can be registered with a human when the whole body is visible or evaluating the object as a human being even when the body is not visible.

At the bottom of the scene there is a roadside parking where it is possible to track the cars passing by the

car at different speeds and directions. Due to the fact that it is a parking place, it is the only a speed in the range of 0 to 40 km/h. In the test camera, we deliberately used the longer focal length of the lens, that is, the narrower angle of the shot, so that the passing objects, whether the cars or people, were shot at relatively short distances, thereby placing the higher demands on the success and accuracy of the video analytics tool.
In the first test record, one person who was not registered with the camera, it was the case of a cyclist. In this case, the system did not evaluate the object as a person. The reason may be the fact that the cyclist was not visible as a whole, while at the same time it was at another car (but it was qualified). The speed of movement seemed subjective to a qualified label. The car of dark colors is an incomplete image but the camera system detected it (Figure 1.).

Motion Detection Analysis - 2
When detecting the cars as a qualified object, it is rather difficult to determine why the system did not know identified the car of the white color as an object. One of the possible causes may be a fast-moving car that has not been in the field of vision for a long enough time to identify it as a vehicle.
The second reason can be the fact that cars often went so that they were not visible as a whole in the camera's field of view (Figure 2.).

Motion Detection Analysis - 3
The experiment demonstrated the fact that the car, as in the previous situation, it was not entirely in the test record, but the camera system qualified it as a car. We believe that in this case, it is a possible reason that the car was of black color, which could help the camera system to the contrast of object to the recognition (Figure 3.).

Motion Detection Analysis – 4
Experimental records from the Avigilon camera were also tested and compared with the Axxon Next software tool's analysis. Data from the pre-experimental camera research in standard situations were evaluated within the camera software for analytics. Due to the effort of objective evaluation obtained from the monitored area using a selected camera and identification of errors in object detection, we also used an independent situation analysis detection tool Axxon Next from AxxonSoft (AXXON, 2020).
The success rate of the Axxon Next software was lower than the previous Avigilon system. We think the reason may be that we left the system in the default mode, so we left all the values of the analysis at their original values. At these values, Axxon Next was perceptually relatively successful in the identifying of people, with a qualified 80% of the subjects being shot. However, the basic settings were insufficiently set for a qualified car identification, where the software qualified only 32.56% of cars in the records.
It follows from the above that, at the basic setting, the Avigilon system produces better results without the need for additional adjustment of different analysis values, such as external SW. On the other hand, the second comparison system from Axxon Next has to analyze the records before using to create enough time for the "learning" process and set the SW for a specific purpose (Figure 4.)
The results of the pre-experiment, followed by the presentation of selected situations in the test records, are important for the research team's knowledge and the creation of the expert database for the following functional verification of Hikvision camera, for their comparison and formulation of the new project under preparation. The Avigilon 2.0C-H4A-BO1-IR pre-imaging camera could be the part of collecting and researching data of the other selected components for the comprehensive ISS C-4 integrated security system design of mobile helicopter airport.
C-4 allows the Transport sector to centralize the security performed by both the public and private organizations at the airports, railways, road transport, and ports (SC4, 2020).
Discussion on the overall key findings of the Avigilon 2.0C-H4A-BO1-IR camera verification, that relate to established research questions, they have shown that:

- the realization of the process of "learning" the camera in the selected perimeter of the "protected area" for the experiment lasted 2.5 hours,
- the camera required the further manual refinement of the process of "the camera learning" in a selected "protected area" perimeter, by an experienced operator,
- the camera required an additional manual clarification of "the camera learning" from detected own errors in the object detection,
- the design and implementation of Avigilon camera placement should not be perpendicular

to the planned movement of objects (persons and cars) in the protected area due to the increased time for the object detection process,
– in the case of 2 or more persons moving in a space concurrently in a group, they cannot identify the number of persons but they made their detection as 1 object,
– in the case of a person with a baby carriage and a child up to 1 m high, the system detected a child carriage as a car identified the person separately but did not identify the child,
– if the person was behind the car and a person's shadow was visible on the road, the system detected the shadow of the person on the road. This fact is important in the case of the likely detection of a person hidden behind an object,
– the probability of detecting objects using the Avigilon camera reached 84%.

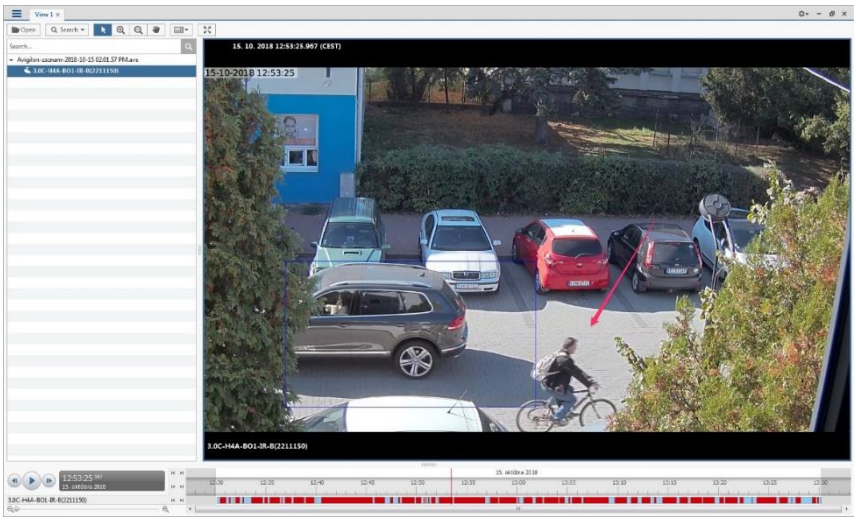

Fig. 1. First test record – The cyclist, unidentified

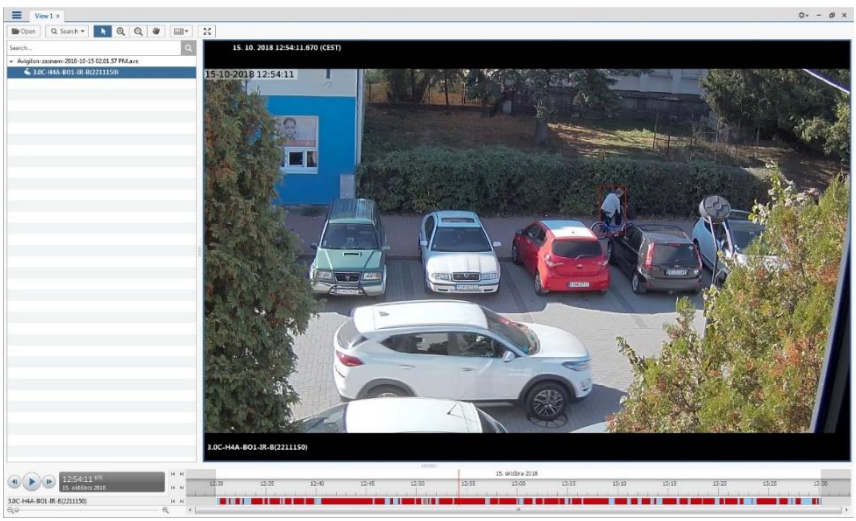

Fig. 2. Second test record - White car, unidentified

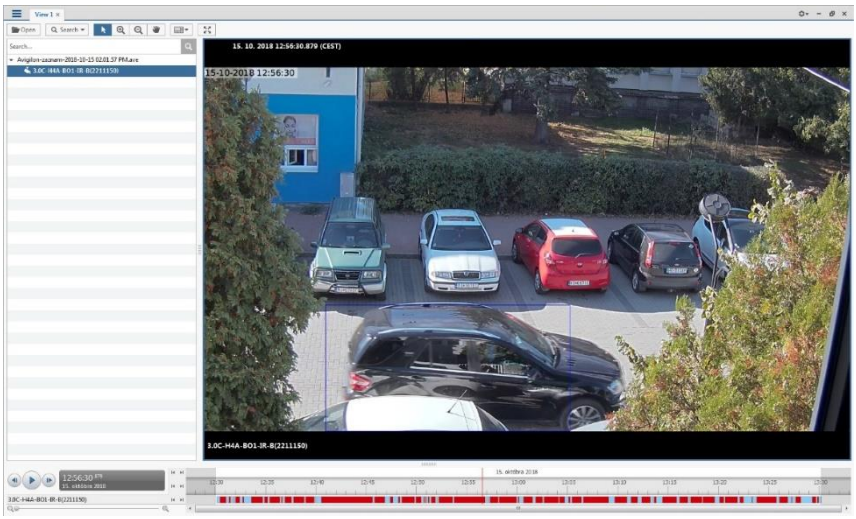

Fig. 3. Third test record - Black car, identified

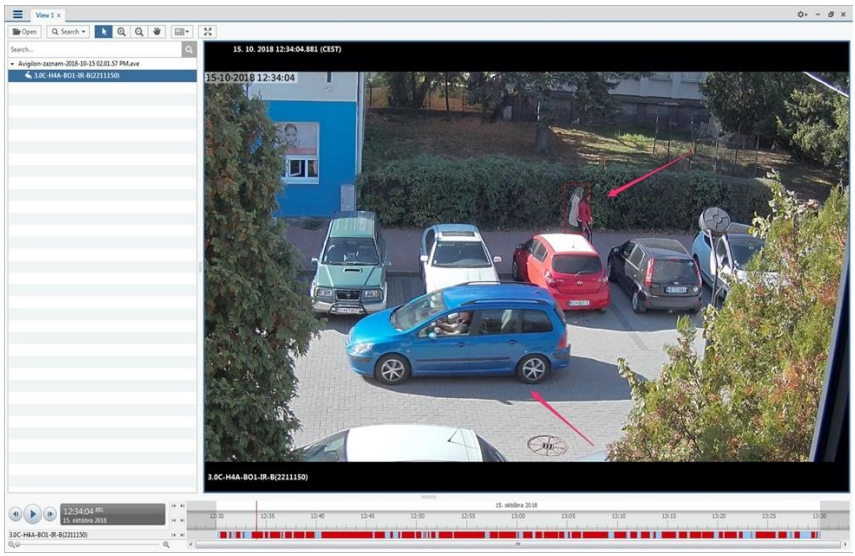

Fig. 4. Fourth test record - Persons identified, auto unidentified

4. Conclusions

Praxeological experience confirms the general recognition that, when evaluating the system, probability equal to 1 (100% detection) could be considered if the camera system is set and working under an ideal detection condition (Nilsson, 2009). Real-life does not provide the optimal conditions, so it is also necessary to experimentally verify this phenomenon.

CCTV manufacturers are looking to build integrated security systems that include their products. An important part of the protected interests is also the critical infrastructure in which „the Transport" sector and „the Air transport subsector" play a key role. For the selection of suitable camera systems and other

components of the integrated security system of the airport, it is necessary to obtain the operational data on the capabilities of the cameras in the practical operation from the manufacturer, by the reference from the current system users or by our testing.

When we polarize our pre-research thesis and examine its validity, whether we consider causality correctly with respect to the results of the pre-experiment of the Avigilon camera: the results of the verified Avigilon camera will show errors in the detection of persons or in the case of incomplete display of a person, but will not show errors in the detection of vehicles as objects with a higher speed of movement, then we state: the results of the verified Avigilon camera show errors in the detection of persons, especially in the case of an incomplete image of a person, but do not show errors in the detection of cars as objects with a higher speed.

According the results we register errors in the detection of people in dark clothes, if they were on a bicycle. We do not detect errors in the detection of persons in light clothing if they were on a bicycle. Detection of people as pedestrians in various clothes was without problems. Contrary to this finding, we register a white (or light blue) car detection error when moving perpendicular to the camera scanning direction, but we do not register a black car detection error when moving perpendicular to the camera scanning direction. We will use this causality and knowledge in the preparation of the continuation of the functional verification of the Avigilon and Hikvision cameras in non-standard tactical situations using the method of creating scenarios with other variables. The ultimate goal is to select and recommend the best sensor (camera) to perform the task in the mobile airport security system.

Our initial research thesis was not confirmed, but proved the interrelationship (causality) for errors in the detection of objects with different color gamut, in the detection of people and other objects, which will significantly affect the creation of scenarios for further functional verification of the camera Avigilon, resp. also Hikvision cameras, in more complex variable conditions for detection. The results of the functional verification of the Avigilon camera in pre-experimental conditions reached a level of 84% certainty and success for object detection.

The pre-experiment data have enabled us to respond to the identified research questions and it will be used in the comparison to the other integrated security system components. The pre-experiment results met our expectations, when the camera was originally set up. To clarify further research on the object detection and to find the optimum camera placement, we plan another Avigilon / Hikvision experiments 2020. Future research work will aim to collect the additional data into the C-4 expert database, with a tactical subject experiment. The objects will intentionally move and steal in a protected area before detecting a skewed camera. Data will be used to perform a comparison with other selected cameras, and so on. Part of C-4's integrated security system of the mobile airport will include the recommendations for the system operators, based on our test results and the error detection in the object detections.

The importance of the first pre-experiment results of the Avigilon camera stems from the following pre-experiment of the Hikvison camera, comparison of their results and recommendation for the end user to the prepared project of a complex design of a mobile airport for helicopter operation with the following partial solutions:

- a lockable mobile hangar,
- the mobile shelter for the helicopter with the technical containers for staff and material,
- the mobile backup power source,
- the innovative mobile transport platform for the small and medium-sized helicopters,
- the portable light technology system for the airport, a heliport, an operating part of the airport,
- the physical and object protection of airport and integrated mobile airport security system,
- the research of the complex communication layer security, secure and controlled WIFI environment, which is the part of the mobile airport infrastructure,
- the design of mobile infrastructure for the airline staff, passengers, cargo, etc.,
- the visualization of the outputs and design of the mobile airport,
- the project documentation for the technical design of devices/products will also be output.

This article constitutes the first part of the research activity of the Department of Flight Preparation as the pre-research, for the design of an integrated mobile airport security system. For safety reasons, the testing was performed near the airport and not at the airport. Identification of motion detection errors is

important for corrections of the prepared information model of security risk assessment of a protected object based on the fuzzy logic to support the airport security management decisions, as well as for finding a technical solution to eliminate these camera vulnerabilities, or selecting and testing another camera for our mobile technology platform. The results advance our theoretical knowledge and have a praxeological significance for the creation of a technological demonstrator and subsequently a prototype of a smart mobile airport security system. Institutions responsible for the protection of state borders, the fight against illegal migration, smuggling of goods, etc. are also interested in mobile security solutions.

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