C-STAR Simulator Teaching Experience

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Abstract – **In the paper hereby, some issues related to training, evaluation, and selection of UAV operators are considered. In particular, the training process is carried out by means of simulator C-STAR, SimLat Ltd, and group of trainees. Each trainee is required to perform exercises at the pilot and the payload station and, eventually, take a test. In this way, the trainees' abilities are estimated and the eligible candidates are selected for further training.**

Experimental data are processed upon candidates' training completion and presented in the paper graphically. Conclusions are made as to what previous experience is preferable and others.

Keywords – **operator, UAV, simulator, training**

I. Introduction

Year after year, a growing number of companies set about developing and building unmanned aerial vehicles (UAV). For example, the number of unmanned airplanes in the US Air Force for the past 10 years has grown 136 times, i.e. from 50 units in 2000 to 6.8 thousand in 2014. In Europe, the belief that armed unmanned complexes may prove to be a good substitute for combat aviation is firm. Russia is trying to catch up with Europe, the United States, and Israel in creating an unmanned aviation, and in the next three years has increased the development of different types unmanned airborne systems.

The number of unmanned aerial systems for civilian use is increasing too. However, development of civil UAVs is delayed due to the potential users being interested in fully-built systems and purchasing related services. What is more, a legislature basis for UAV certification has yet to be developed which is the reason why it is remarkably easy to obstruct the UAV integration into existing air traffic management systems, [1], [2].

Ensuring safety is of paramount importance in preparation and performing flights by UAV. At certain technological level it is possible for the civil air traffic control to monitor the UAV flights. Monitoring might also be carried out by military air traffic services, [3]. One of the main factors for high level of emergency is the human factor. Unfortunately, the majority of "experts" running this type of equipment, do not have relevant qualification which is frequently encountered issue. Obviously, staff training process can have a significant impact on safety. This makes it necessary to develop identical training requirements and programs for UAV operators, as well as reliable training tools depending on the different categories of UAVs.

A basic tool for training is the simulator which is used to provide individual and crew training and improve trainees' expertise.

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II. Materials and Methods

A. Basic description of simulator C-STAR

The training system C-STAR of Israeli firm SimLat, installed at the Department of Aerospace Control Systems, provides an educational tool for pilots and payload operators alike who work within a crew. The training system is a virtual environment which closely resembles a real flight routine. Initially, the simulator is meant to train crews but it is also possible for both pilot and payload operator to carry out flight simulation separately. In this case, it is the instructor who replaces the absent crew member. The working environment is user friendly. The interface is understandable and accessible to everybody who is somewhat skillful in computers.

At the instructor station, the flight scenario and mission control are carried on. During the flight session, various malfunctions might be simulated, such as on-board instruments failure or severe weather. The instructor sets path and behavior pattern of ground, water, and aerial objects, the UAV flight route, flight task type (targets discover and tracking, aerial scan, etc.) and simultaneously logs flight monitoring data. The software tool PANEL facilitates instructor in relation to further data processing by creating charts, graphs and evaluating the trainee.

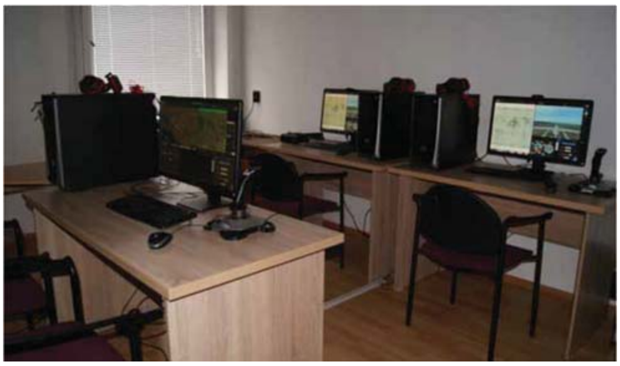

Fig. 1. C-STAR system common view

B. Training process stages

The Space Research and Technology Institute possesses a base version of the training system C-STAR, Fig. 1. It is thoroughly discussed in paper [4]. Crew members were taught in a "Laboratory for Selection, Training, and Control of UAV Operators" by Institute employees who had attended training course arranged by SimLat and been given certificates for instructor proficiency. All flight scenarios used for training process were developed by the researchers at the Institute.

In 2018, employees from Ministry of Interior Affairs and Ministry of Defence attended course at the C-STAR simulator. The course lasted five days and included theoretical study and practical exercises. Trainees were required to take a final exam. All trainees were between 20 and 30 years old. Among them, few had professional pilot experience.

Initially, the trainees were shown basic flight skills at the pilot station. This included take-off, following an initially set flight route, approach for landing with short/long lag, landing. Then all trainees were required to perform exactly the same flight procedures so as to gain some skills. In order to hinder the trainee in addition, the autopilot stabilization ability was occasionally switched off so that Euler angles limitations were no longer available.

The training continued at the payload operator station. It included discovery and tracking of a mobile ground target. The trainee was required to complete this task as quickly as possible. Meanwhile, the airplane was performing automated flight, i.e. no pilot was initially present. According to our experience, this particular flight task seemed more difficult and it took the trainees more efforts to succeed because the target kept on altering its position. The airplane manoeuvring only worsened the situation for it happened to shift the camera FOV.

Fig. 2. Flight task routes

In Fig. 2, the aforementioned task scenario for is depicted. The airplane route is visible, so is the route of the ground mobile target (tank). In the lower right corner, a screenshot taken by the sensor video channel is placed. It depicts the target followed by the onboard sensor after successful lock. The sensor keeps on following the target automatically no matter how intensively the airplane performs a manoeuvre.

Eventually, the trainees were told to form crews and undertook team work at both stations. It should be noted that the stations share same video channel which (in our humble opinion) makes successful task completion by the crew less likely. The SimLat staff however declined our proposal of introducing an alternative video channel.

During the training process, various malfunctions were simulated in addition such as autopilot or cooling system failure, communication link loss, etc. The trainees were also put to a test of bad weather conditions, i.e. turbulence, wind shear.

III. Results

Upon taking the exam, trainees are given a report produced by the PANEL tool. Exemplary reports are shown in Fig. 3-5. The results are average for excellent, acceptable, and unsatisfactory trainee performance. Each chart is divided into two main sections: a flight area map (left half) and a plot sector. The plot contains four curves and multiple grey bars which provide information about trainee’s performance.

Fig. 3. Excellent result achieved by a professional pilot

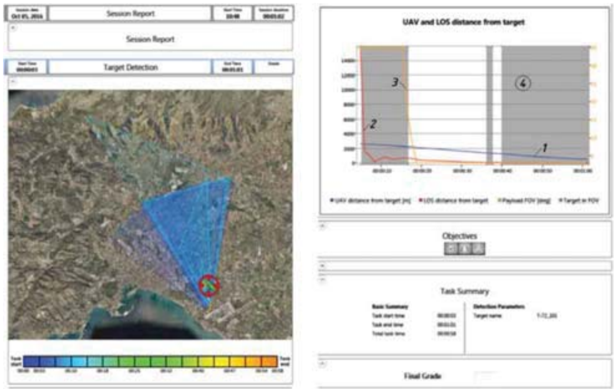

Fig. 4. Acceptable result achieved after initial training

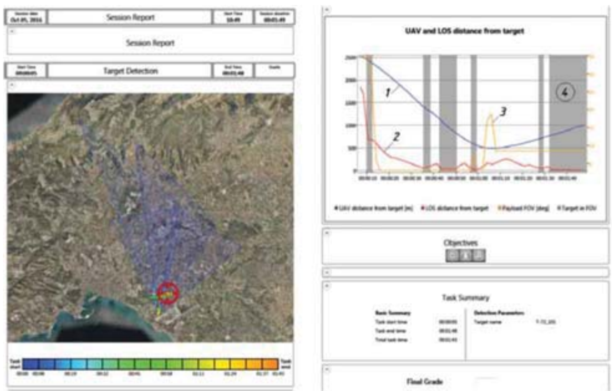

Fig. 5. Unsatisfactory performance

The charts show the payload operator's effectiveness during flight task performance. The curves stand for following:

- Curve 1 – distance between the UAV and the target, m;
- Curve 2 – distance between line of sight and the target, m;
- Curve 3 – onboard sensor field of view, degrees;
- Gray areas 4: target lies within the sensor FOV.

We therefore deduce that successful operators are either skillful in driving vehicles (airplanes in particular) or play computer games on a regular basis.

With the benefit of hindsight, we should have carried out additional research by means of a wider range of trainees in terms of initial experience. The flight sessions should have been extended. It is also advisable to take into account the trainee's opinion about personal performance, i.e. a self-evaluation report.

IV. Further Study

Yet another way of getting a clear, deep, and perhaps sudden understanding of the human-machine interaction in this particular study case is making use of an eye-tracker. Having been installed, such a device presumably provides information about where the trainee's eyes are focused during the flight. This information can be used to gain deep insights into trainees' attention and also design new pilot / operator interface or improve potentially erroneous one.

Fig. 6. Stationary eye tracker and heat map

An exemplary stationary eye tracker is shown in Fig. 6. The heat map (red and green spots) is data visualization technique showing location, order, and time spent looking at different screen locations, [5]. For the flight simulator case, these locations may vary depending upon flight conditions. For instance, the trainee would not be expected to make use of the video channel if visibility is low.

V. Conclusion

The simulator training program is an integral part of the operators' complex training process, which focuses on the practical training. Upon completion of the course, candidates are supposed to have developed habits for quick situational assessment, making choice of control strategies, making optimal solutions in rapidly changing environment. The formation of these qualities and technical culture implies individual approach towards each trainee.

The professional training of UAV operators includes conducting selection of candidates as well as monitoring the acquired habits and knowledge based on simulators and training systems. For applicants who are assessed it should be determined whether they are skillful enough to perform specific work and be keen on performing better on duty.

Program implementation for candidates training (both professionals and amateurs) is focused on training and certification of UAV operators applicable to different spheres, i.e. environmental monitoring, mapping, infrastructure remote inspection, advertising, professional orientation of adolescents and young people. The flight simulator stage is an essential part of the training program which is suitable mainly for beginners. In this regard, experiments conducted in order to study activity of operator working with the C-STAR simulator include:

- Investigating operator's activity during UAV control and performing different types of flight tasks;
- Evaluation of the algorithm for correct data logging by the SimLat's PANEL tool;
- Making comparison between training data obtained by trainees with and without prior experience in UAV control;
- Picking out applicants that meet initially set requirements.

The UAV operator's job is mainly related to cognitive processes in terms of summarizing and analyzing a significant amount of information. Meanwhile, it is necessary for the operator to acquire skills quickly so as to perform complex procedures and actions, make decisions within a limited time interval, and communicate and interact within the crew simultaneously, [6].

Information processing is a basic approach in cognitive psychology. In this case, the human cognitive system is considered a system having devices for inputting, storing, outputting the information considering the bandwidth ability (by analogy to the computer). The methods of cognitive psychology are designed for qualitative and meaningful analysis of such psychological processes, such as motivation, decision making, goal setting, information processing, etc.

At present, UAV control is mainly carried out in semi-automatic mode. Most operations such as following flight path, aerial photography, area scan, ecological monitoring, search and rescue, inspection of power lines, wind turbines, railroads, anti-poaching, etc., are performed in automatic mode, which is the reason why the operator is able to monitor the flight activity having been located at a significant distance from the UAV. Nevertheless, in the final phases of flight, such as take-off and landing, operators are often forced to switch to manual mode. More than 70% of the military UAV losses occur due to subjective errors [7].

Significant difficulties are experienced by the operator during take-off and landing phases. This might be explained by the intuitive operator's response who is not present on board and does not receive visual information. The operator is unable to hear the engines running, sense a load factor during steep decent or climb, use side vision for orientation, etc. Instead, the operator solely observes the situation through the onboard camera. For these reasons, the operator is forced to interpret the flight instruments readings. The task of the operator, who is initially included in the control loop, boils down to detecting and recognizing the ground targets and also tracking the target by means of the onboard sensor. Naturally, the UAV capability and effectiveness are determined to a great extent by operator's ability to process visual information and implement accurate and highly coordinated actions upon target detecting and tracking.

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