JOURNAL OF MECHANICAL AND TRANSPORT ENGINEERING
Vol. 68, No. 4 2016
DOI 10.21008/j.2449-920X.2016.68.4.04

Jerzy MERKISZ*
Marta GALANT*
Michał ZALEWSKI*
(Date of receipt of the article: 08.09.2016, Date of acceptance of the article for publication: 04.11.2016)

RESEARCH ON THE INFLUENCE OF WEATHER CONDITIONS ON THE PILOT'S PSYCHOPHYSICAL CONDITION

The dynamic growth of air transport is associated with an increased amount of used aircraft. This involves with the need to conduct research on issues of safety in air transport. The most common cause of aviation accidents is still the human factor. The paper presents a study of attentional control during the simulator training carried out at the Institute of Internal Combustion Engines and Transport at Poznan University of Technology.

With the use of a technically advanced flight simulator CKAS MotionSim5 and the bioelectrical brain activity monitoring device MindWave produced by NeuroSky it was possible to determine the effect of deterioration of weather conditions on the concentration of the pilot. Studies have shown that for the majority of respondents a sudden change in weather conditions strongly influenced the level of pilot's concentration.

Keywords: air transport safety, flight simulator, pilot's concetration, electroencephalography, Mindwave, CKAS MS5 simulator

1. INTRODUCTION

Excessive operator's cognitive system load may cause deterioration of the perceptual abilities, reaction time and increase the probability of finding an incorrect decision. The same can lead to dangerous situations that may result in eg. accident. Studies of operator's cognitive load can therefore contribute to a safer transportation. The only possible and effective method that avoids these risks is to monitor the operator's load cognitive system.

* Poznan University of Technology, Faculty of Machines and Transport.

Attentional control refers to an individual's capacity to choose what needs to pay attention to and what should be ignore [Astle i Scerif 2009]. Attentional control can be also described as an individual's ability to concentrate.

The studies involving simulators allows to analyze a variety of adverse events whose simulation in real traffic conditions would be impossible or too dangerous. The undoubted advantage of the use of simulators in research is the ability to control as many factors as well as the ability to record a number of variables, including the physiological and psychological parameters of the operator [Jukiewicz et al. 2013, Merkisz et al. 2014, Merkisz et al. 2014]. The use of high quality simulators allows to carry out research which allow to obtain full normalization of test conditions [Niezgoda et al. 2011]. Scenarios repeatability enables you to compare the behavior of different drivers in the same situation or the same driver in various situations, which is not possible in real traffic conditions.

The need to reduce the participation of the human factor in accidents leading to increased interest in simulators both with regard to research and training.

2. RESEARCH METODOLOGY

2.1. The CKAS MotionSim5 simulator

The research was conducted in the laboratory using a flight simulator CKAS MotionSim5 (Fig. 1). It is a system that uses software and hardware that combines the reliability of a modern desktop computer equipment on a custom built motion platform, with a cockpit that provides control devices identical or similar to those found on the real aircraft.

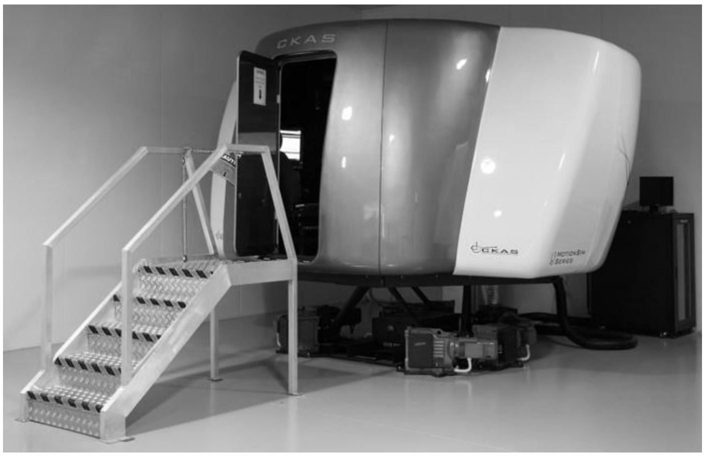

Fig. 1. CKAS MotionSim5 simulator

The CKAS MotionSim5 trainer is designed to simulate four generic types of light aircraft: a piston single-engine aircraft, a piston twin-engine aircraft, a light twin-engine turboprop aircraft and a light jet. It is not intended to simulate a particular aircraft model, but rather to represent a typical aircraft of each class in its handling qualities and features.

The MotionSim5 is a four-seater platform with two sets of flight controls. It requires at least two persons to operate: a pilot and an instructor, seated behind the left pilot seat at the Instructor Station. The Instructor Station provides control over the flight simulator environment such as weather, positioning, malfunctions as well as real-time tracking and flight recording.

The MS5 Visual System provides a wide 200° × 40° viewing angle with high resolution. It consists of three full-HD (1920 × 1080 pixels) front surface DLP (Digital Light Processing) projectors, three high-end PCs for image generation, and the screen. An additional PC is used to drive flight instruments and for general flight simulation.

Movement simulator cab is made possible by the electrical motion system with six degrees of freedom. This makes it possible to obtain high accuracy in performing of movement. The system tilts the hull in every possible direction at an angle of 18° and moves it 150 mm.

The Instructor Station provides control over the flight simulator environment such as weather, positioning, malfunctions as well as real-time tracking and flight recording. Additionally it is possible to take operations from and to almost every airport in the World.

2.2. Device for measuring the bioelectric activity of brain

Investigation of bioelectrical brain activity was performed using a MindWave device, which is manufactured by NeuroSky.

The device consists of eight main parts: ear clip, flexible ear arm, battery area, power switch, adjustable head band, sensor tip, sensor arm and inside thinkgear chipset. Figure 2 presents the device design.

The principle of operation is quite simple. Two dry sensors are used to detect and filter the EEG (electroencephalography) signals. The sensor tip detects electrical signals from the forehead of the brain. At the same time, the sensor pick up ambient noise generated by human muscle, computers, light bulbs, electrical sockets and other electrical devices. The second sensor, ear clip, is a grounds and reference, which allows thinkgear chip to filter out the electrical noise [Jukiewicz, Merkisz i Orszulak 2013, Merkisz i Galant 2015]. The MindWave Mobile safely measures and outputs the EEG power spectrums (alpha waves, beta waves, etc.) [Merkisz i Galant 2015]. In the basic version of the device measures three values: raw EEG signal, the level of concentration and the level of relaxation [Paszkiel 2014, Sałabun 2014].

The device is based on Bluetooth, thereby using it is not limited in any mechanically way. Figure 2 shows the device with the most important parts.

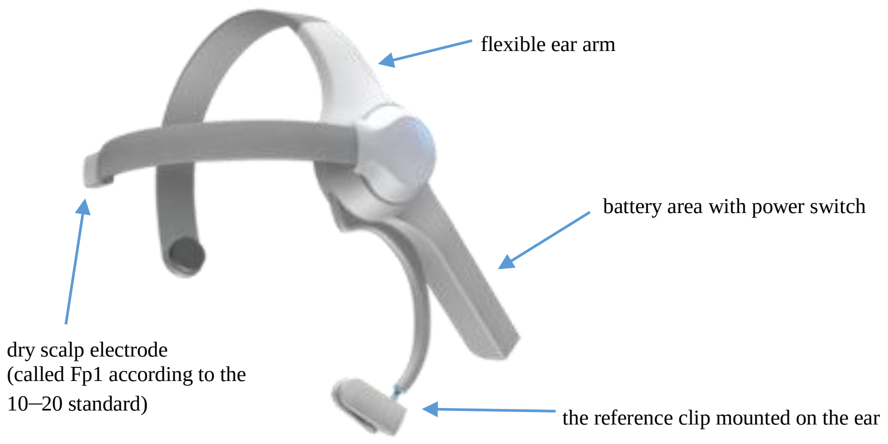

Fig. 2. The MindWave Mobile device

2.3. The course of study

The study involved four adult men. Each has been tested in a way to check whether a change in weather conditions may affect the psychophysical condition of the pilot. The level of concentration of the pilot during full flights between airports in Poznan and Zielona Gora (route about 90 km) was examined.

Studies have been carried out during the day, in the morning. Each of the pilots made three flights. The first flight was a test-flight aimed at familiarization with the operation of the simulator. The second one, was the first test-flight. Its took place under conditions simulating dawn (6:00 am). Weather conditions were not a threat, but it was cloudy. The pilot started from EPZG (Zielona Gora airport) from the runway RWY 06. The flight was headed to the CZE point (Czempiń). In the middle of way between the airport in Zielona Gora and the CZE point instructor gradually changing conditions by setting rainfall. Adverse weather conditions were simulated for about 5 minutes before weather setting gradually returned to the original. Then the pilot approached the landing at the EPPO airport (runway RWY 29 (ILS)).

A third flight was performed at night hours (10:00 pm). The airplane started from Ławica Airport (RWY 29). After take off headed to the airport in Zielona Gora and, by analogy with the first test-flight in middle of way instructor was setting changing weather conditions. Similarly, the change takes about five minutes, and before landing rain was reduced to zero. Landing is performed at the EPZG airport o runway RWY 06. The task to the pilot was to conduct the flight at 5000 ft AGL (Above Ground Level).

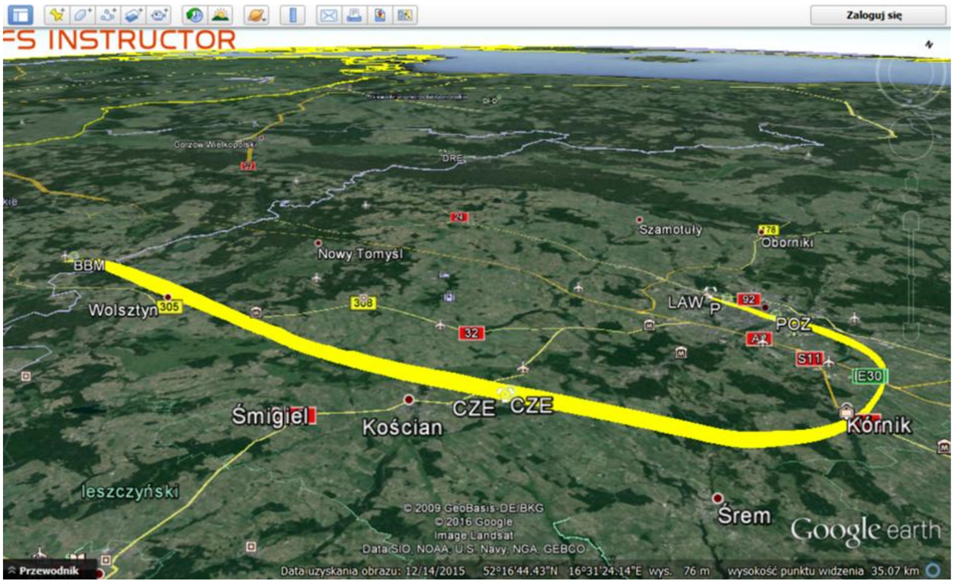

Fig. 3. The view of route used in investigation

3. RESULTS

3.1. Pilot 1

In the first test flight, when there were heavy rain, problems with keeping given to flight level were noted. Whitin few minutes with the most intensive rainfall flight level ranged up to 1000 ft. Beyond time of changes on weather conditions, there was no significant problems. Initially, the pilot flew at too high level, but after he realized that, he tried to correct it. At the graph we can see all the characteristic flight phases (start with climbing, flight, approach and landing). The flight altitude during the first flight is shown in Fig. 4. Red dotted lines marked the points, where the sudden deterioration in weather conditions occurred.

Changes in pilot's concentration during flight were shown in Fig. 5. As previously red dotted lines marked the points, where the sudden deterioration in weather conditions occurred. To determine changes in the level of concentration of the tested moving average method was used (selected period of k = 5). In the first flight, when the changes of weather conditions occurred – the beginning of the rainfall – the concentration level drops very significantly (about 30%). The next decrease level of concentration, which can be observed in the chart were not related to the weather conditions. About 12:04 an engine failure occurred, but the impact of component failure is not evaluated in this paper.

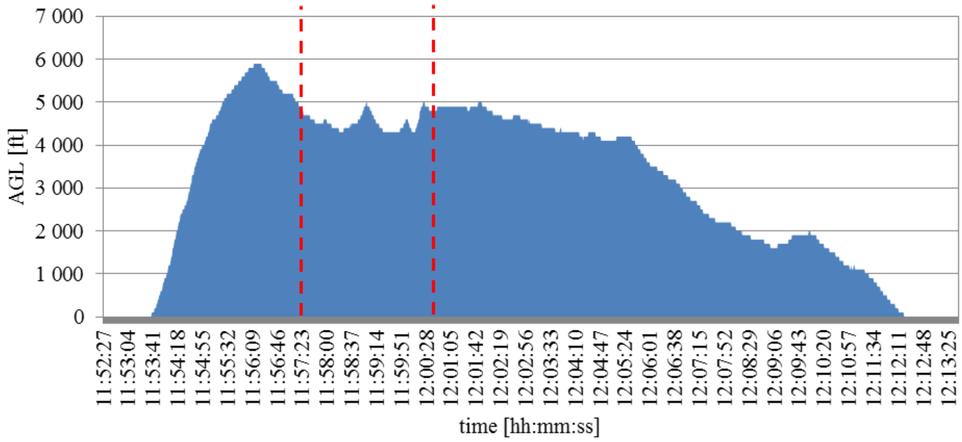

Fig. 4. Flight altitude AGL during the first flight for the tested 1

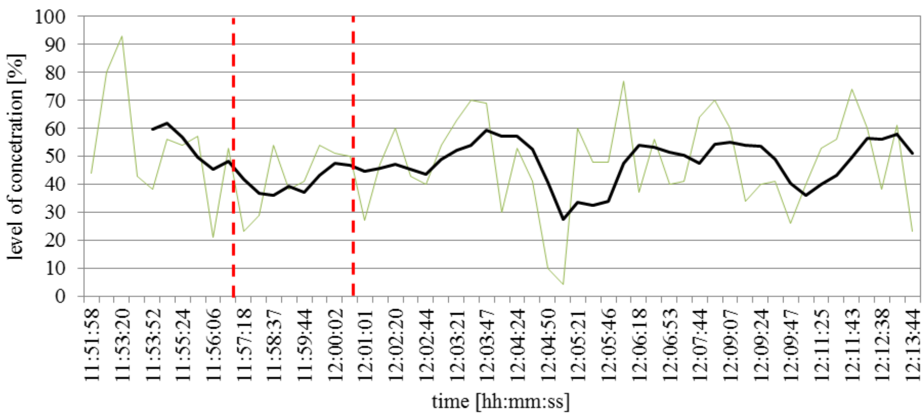

Fig. 5. Level of concentration during the first flight for the tested 1

In the second flight a more stable situation was observed. In the first phase of the flight, there were no significant differences, and the flight level were kept. The occurrence of snow has not changed the situation significantly. This may be caused by the fact that the pilot expected changes in weather conditions. It should be noted, however, that the phase of approach was more rapidly than in the case of the first flight. The flight altitude during the second flight is shown in Fig. 6.

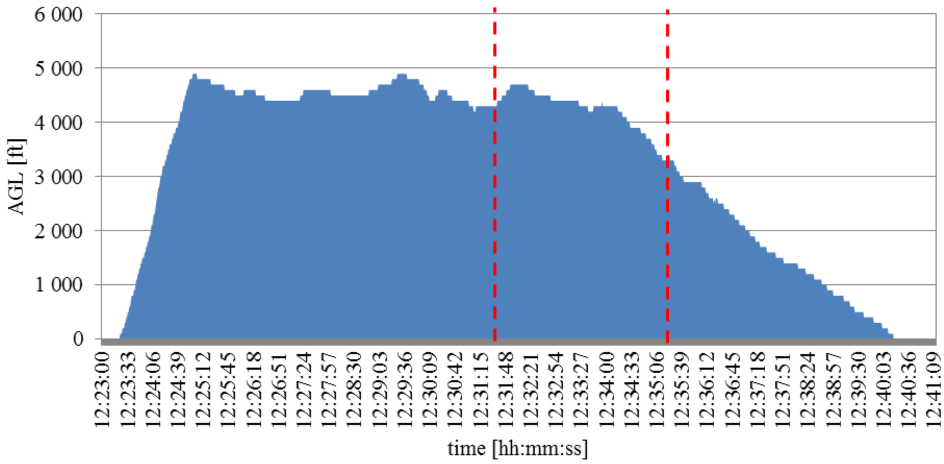

Fig. 6. Flight altitude AGL during the second flight for the tested 1

During the second flight a higher level of concentration was observed (Fig. 7). At the time of the first snowfall level of concentration of the pilot decreased slightly. The lowest score throughout the study (approx. 10%) was achieved After a minute, this value began to grow, and finally, at the time of the least favorable conditions, the level of concentration of the pilot was much higher than before the change (reached 60%). When the snow stopped, until landing at in the Zielona Gora airport, the level of concentration remained on average at around 50%.

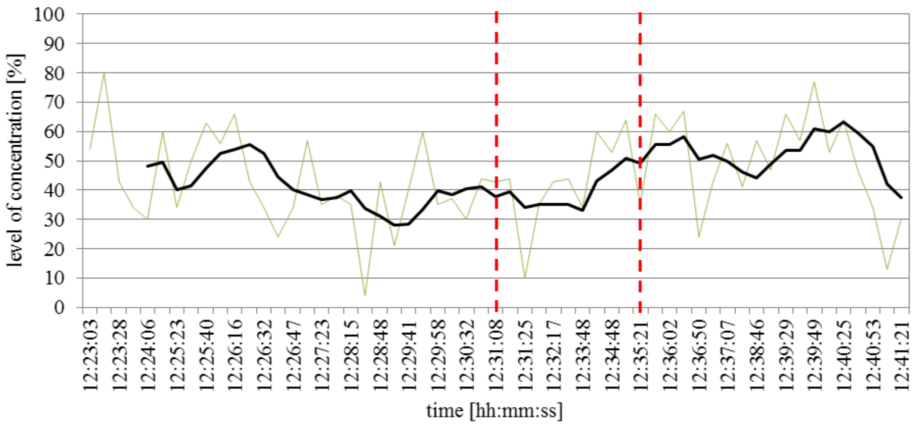

Fig. 7. Level of concentration during the second flight for the tested 1

3.2. Pilot 2

The second investigation have shown that changing weather conditions can significantly affect the problems keeping flight stability. A continuous reduction of the flight level was shown. The pilot's task was to keep the flight at an altitude of 4000 ft. During the rain the flight level was dropped by as much as half. After stabilization of weather conditions the pilot pointed out the problems with the level of flight and tried to reach the required. He was forced, however, already begin the approach procedure. The flight altitude during the first flight made by second pilot is shown in Fig. 8.

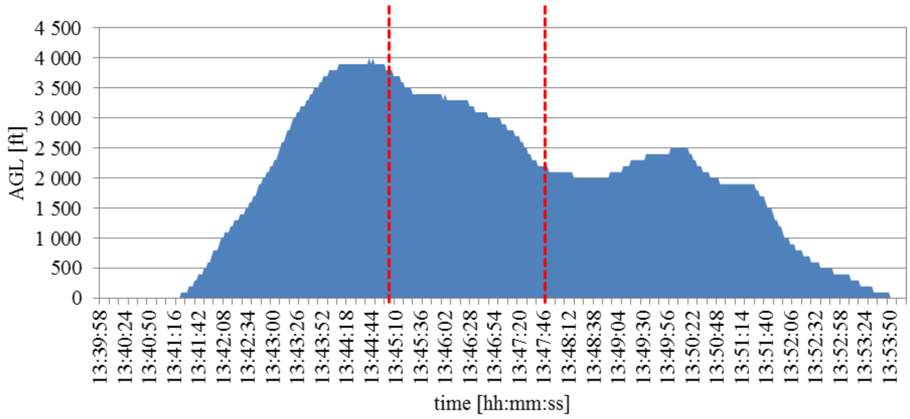

Fig. 8. Flight altitude AGL during the first flight for the tested 2

Despite the fact that the pilot had trouble with keeping the flight stability, significant changes in the level of concentration was not observed. Throughout the test there were only a few and insignificant changes. The impact of changes in weather conditions on the concentration of the pilot was not noticed (Fig. 9).

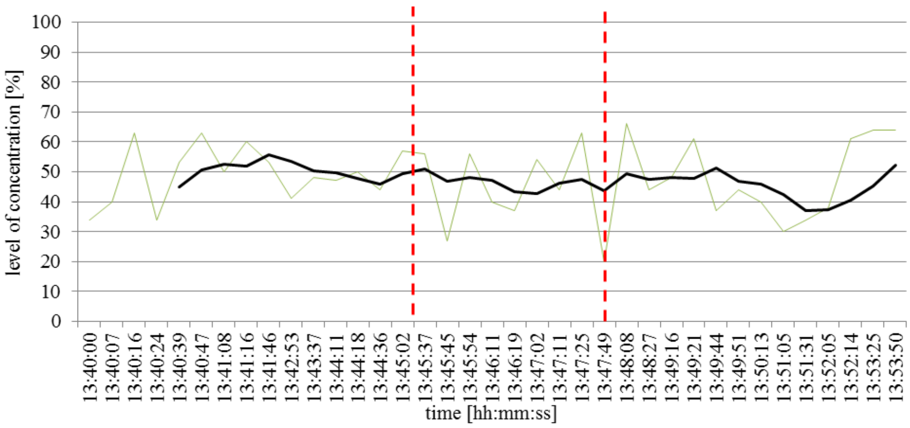

Fig. 9. Level of concentration during the first flight for the tested 2

In the second flight the pilot assumed that the flight will take place at approx. 4000 ft. After a successful start and climb most of the flight managed to keep the established parameters. At the time of the snowfall start pilot completely lost control of the flight altitude. Flight level has been lowered by up to 1000 ft. In the mid-term snowfall pilot managed to stabilize the flight. Then he began the approach procedure. The flight altitude during the second flight is shown in Fig. 10.

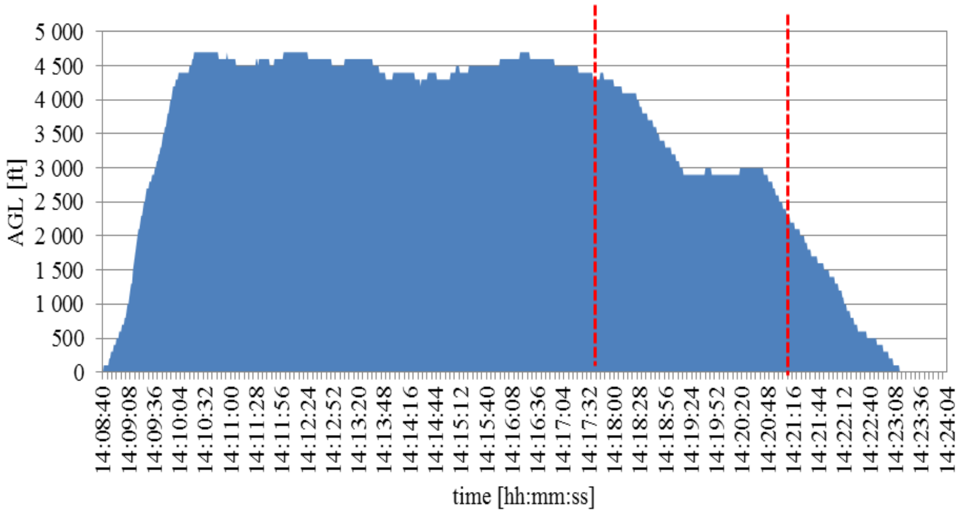

Fig. 10. Flight altitude AGL during the second flight for the tested 2

Just as in the first flight level of pilot's concentration was stable. During the snowfall a slight decrease was observed but the differences are not significant.

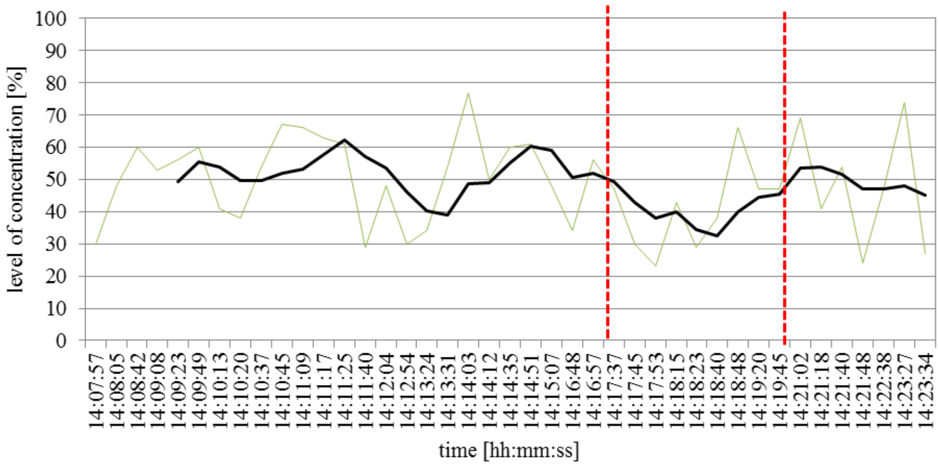

Fig. 11. Level of concentration during the second flight for the tested 2

4. SUMMARY

The changes in weather conditions has negative effect on level of pilot's attention. Decrease of attention level during weather changes was observed in whole test group. During rainfall pilots could not keep appropriate flight level. During snowfall keeping appropriate flight level was easier but level of attention changed in larger range. Large flight level changes result in passenger comfort level decreasing. Pilot's reaction trends between first and second flight are the kept, but differ in percentage value. Demand to reduce the participation of the human factor in accidents is still important, what results in a growing of interest in flight simulators for training and research. Pilot's psychophysical condition is a growing field of flight simulators further investigations. Advantage of research with simulators is a possibility to achieve the same conditions for the whole test group, which is impossible in real flight. It should be noted that research like that do not directly involve risking the pilots live and health.

REFERENCES

Astle D., Scerif G., 2009, Using Developmental Cognitive Neuroscience to Study Behavioral and Attentional Control, Developmental Psychobiology, Vol. 51, No. 2, p. 107–118.

Crowley, Katie, et al., 2010, Evaluating a Brain-Computer Interface to Categorise Human Emotional Response [The 10th IEEE International Conference on Advanced Learning Technologies ICALT], Sousse, Tunisia.

CKAS MotionSim5 FSTD Operations Manual, 2015, Melbourne, Australia.

Galant M., Merkisz J., 2015, The impact of sudden deterioration in weather conditions on road safety, Journal of Mechanical Transport and Engineering, Vol. 67, No. 4.

Jukiewicz M., Merkisz J., Orszulak B., 2013, Wykorzystanie urządzenia Mindwave do biopomiarów wskaźnika koncentracji w pracy badawczej związanej z symulatorem pojazdu osobowego, Logistyka [CD], nr 3.

Merkisz J., Galant M., 2015, Badania zmian koncentracji kierowcy w czasie treningu symulatorowego, Logistyka [CD], nr 3.

Merkisz J., Galant M, Karpiński D., Orszulak B., 2014, Wykorzystanie Aparatu Piórkowskiego do oceny porównawczej zdolności psychomotorycznych kierowcy przed i po treningu symulatorowym, Logistyka [CD], nr 4.

Merkisz J., Markowski J., Fuć P., Galant M., 2015, Przegląd metod pomiaru obciążenia zadaniowego operatora w badaniach z wykorzystaniem symulatorów, Logistyka [CD], nr 3.

Niezgoda M., Kamiński T., Ucińska M., Kruszewski M., 2011, Effective methods for drivers research with use of a driving simulator, Journal of KONES Powertrain and Transport, Vol. 18, No. 3.

Paszkiel S. (red.), 2014, Analiza zmian sygnału EEG za pomocą urządzenia MindWave Mobile, Rola informatyki w naukach ekonomicznych i społecznych, Innowacje i implikacje interdyscyplinarne Wydawnictwo WSH, Kielce.

Rebolledo-Mendez, Genaro et al., 2009, Assessing Neurosky's usability to detect attention levels in an assessment exercise, Human-Computer Interaction, New Trends, Springer, Berlin Heidelberg.

Sałabun W., 2014, Processing and spectral analysis of the raw EEG signal from the Mindwave, Przegląd Elektrotechniczny, Vol. 90, No. 2, p. 169–173.

Teplan M., 2002, Fundamentals of EEG measurement, Measurement Science Review, Vol. 2, No. 2.

ACKNOWLEDGEMENTS

This article was financially supported within statutory activity funds for youg researchers. Title of project: Analysis of thermal processes and emission of harmful substances in selected transportation applications.

BADANIE WPŁYWU WARUNKÓW ATMOSFERYCZNYCH NA KONDYCJĘ PSYCHOFIZYCZNĄ PILOTA

Streszczenie

Dynamiczny rozwój transportu lotniczego wiąże się ze zwiększoną ilością eksploatowanych statków powietrznych. Powoduje to konieczność prowadzenia badań w kwestii bezpieczeństwa w transporcie lotniczym. Najczęstszą przyczyną wypadków lotniczych jest czynnik ludzki. Postanowiono zatem przeprowadzić analizę poziomu koncentracji pilota podczas treningu symulatorowego. Badania prowadzone były w Laboratorium Badań Symulatorowych Instytutu Silników Spalinowych i Transportu Politechniki Poznańskiej. Dzięki zastosowaniu zaawansowanego technicznie symulatora lotu CKAS MS5 i urządzenia do monitorowania bioelektrycznej aktywności mózgu MindWave produkowanego przez firmę NeuroSky możliwe było określenie wpływu pogorszenia warunków pogodowych na koncentrację pilota. Badania wykazały, że dla większości respondentów nagła zmiana warunków pogodowych silny wpływ na poziom koncentracji pilota oraz na stabilnosc lotu.

Słowa kluczowe: bezpieczeństwo transportu lotniczego, symulator, pilot, EEG