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THE NEW POLISH CENTRIFUGE AS A DYNAMIC FLIGHT SIMULATOR. NEW APPLICATION AND IDEAS

NOWA POLSKA WIRÓWKA I SIMULATOR LOTU. NOWE ZASTOSOWANIA I IDEE

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ABSTRACT: *Development of the new training procedures and programs for aircrews of the Polish Air Force can be fulfilled by modern human training centrifuge, where new technologies, innovative solutions and advanced materials have been applied to ensure compliance based on STANAG technical parameters and high standard of aviation medicine specialists and others. Centrifuge can provide a safe alternative to raise awareness of aircrews in case of possibilities unwanted effects of accelerations, such as G-LOC loss of consciousness or spatial disorientation. Costs of a such training are definitely lower then possible costs of the modern combat aircraft and not even mention about human life. Improvement of the flying skills, conducting air combat and full use of the resources of the plane in the laboratory, with full monitoring of biomedical indicators are the main functions of the modern centrifuge used as training simulator. The centrifuge aviation training simulator is specifically designed for survey, training of candidates for pilots and pilots of highly-maneuvering aircrafts (combat, acrobatic and sport), and experimental technical tests*

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STRESZCZENIE*: Rozwój nowych procedur treningowych i programów dla załóg lotniczych Polskich Sił Powietrznych może zostać zrealizowany przez zastosowanie nowoczesnej wirówki przeciążeniowej połączonej z symulatorem treningu lotniczego, w której najnowsze technologie, innowacyjne rozwiązania z zastosowaniem wysokiej jakości materiałów, zostały wykorzystane na potrzeby spełnienia wymagań nie tylko procedur standaryzacyjnych STANAG. Wirówka przeciążeniowa zapewnia bezpieczną alternatywę uświadomienia załóg lotniczych pod względem możliwości wystąpienia niepożądanych skutków działania przeciążeń, takich jak przeciążeniowa utrata świadomości czy dezorientacja przestrzenna. Koszty treningu wirówkowego są zdecydowanie niższe od ewentualnych kosztów szkolenia z użyciem nowoczesnego samolotu bojowego, o życiu ludzkim nie wspominając. Udoskonalanie umiejętności lotniczych, przeprowadzania walki powietrznej i pełnego użycia zasobów statku powietrznego w warunkach laboratoryjnych z pełnym monitoringiem parametrów fizjologicznych stanowią główne funkcje nowoczesnej wirówki przeciążeniowej użytkowanej jako symulator treningu lotniczego. Wirówka przeciążeniowa-symulator lotu jest przeznaczona do badania, szkolenia i treningu kandydatów na pilotów oraz pilotów samolotów wysokomanewrowych (bojowych, akrobacyjnych oraz sportowych), jak również do technicznych badań eksperymentalnych*

SŁOWA KLUCZOWE: *wirówka, symulator lotniczy, Wojskowy Instytut Medycyny Lotniczej*

Introduction

A new human centrifuge with dynamic flight simulator option is a new challenge for flight crew training for the Polish Air Force. This device is going to be part of a comprehensive training program of strategic importance from the standpoint of national defense. Development of a new training procedures and programs is also the main statutory objective of the Military Institute of Aviation Medicine in Poland. Fulfilling this obligation impose on the Institute necessity to dispose modern human centrifuge combined with simulator aviation training, during which a new technologies, innovative solutions and rare materials will be applied to ensure compliance with the required STANAG (but not only) technical parameters and high standard of aviation medicine specialists.

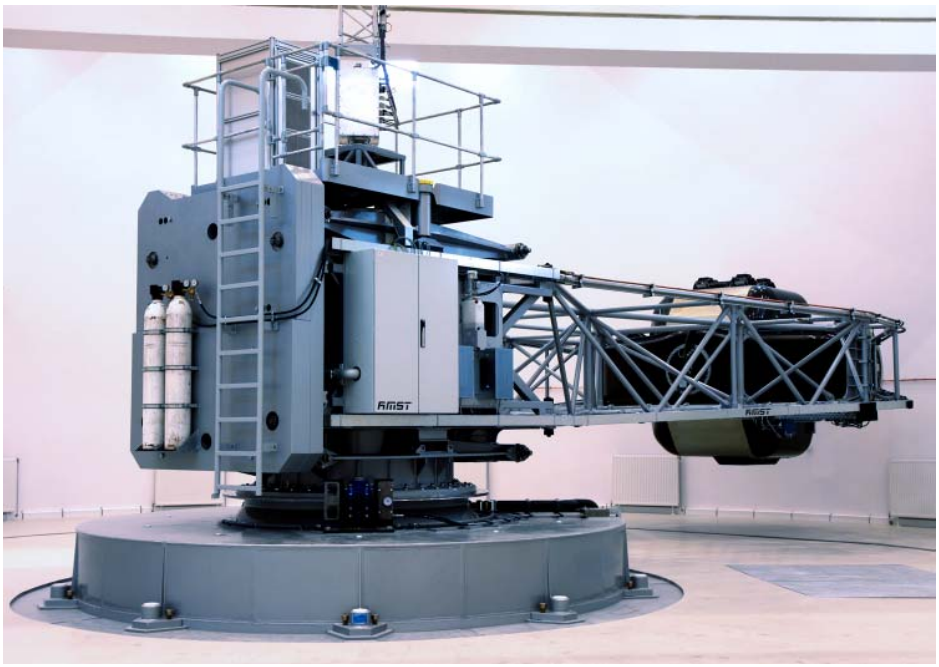

Fig. 1. New human centrifuge at Military Institute of Aviation Medicine in Warsaw, Poland.
Ryc. 1. Nowa wirówka przeciążeniowa w Wojskowym Instytucie Medycyny Lotniczej w Warszawie.

New centrifuge will allow, under a laboratory conditions, to reproduce the flight and thus will ensure a perfect professional preparation of pilots for the complicated and dangerous air missions currently used in the Polish Air Force F-16 [8] and MIG -29 and maybe in near future also a new training plane. One of the main advantages of using a human centrifuge is an option to use it as a training simulator to improve crew safety. It will be able to validate the operational skills necessary for the handling of unexpected emergency situations.

Centrifuge technical parameters will also allow for the pre-start medical check, the VFR flight and navigation training, fixing and maintaining the aircraft position from unusual locations, the efficient management of resources in case of technical failures and flight incidents, the use of combat equipment. The pilot can be trained to avoid the spatial disorientation and improve the situational awareness [5]. These basic types of training in conjunction with the selected type of aircraft allows for a perfect visualization of the air situation and reconstruction of sound effects occurring in the flight environment and will allow in an extremely effective manner to increase the level of crew training.

The need for a modern spin-simulation results from a completely different body's physiological response to accelerate the pilot with a very large gradient onset rate (about 8 - 10 G per second and more). With the relatively slow growth of acceleration such as occurs in the currently used aircraft, the pilot experiences the so-called warning signs of overload before the occurrence of loss of consciousness [6]. They

come from the visual system (mainly in the form of narrowing the field of view) and finally loss of peripheral vision. With a rapid onset rate there are no symptoms of losing consciousness [3]. In addition, the rapidly increasing acceleration requires from pilots different techniques and perfect interaction with equipment on board of the aircraft.

Dynamic flight simulation

The Polish human centrifuge with dynamic flight simulation is understood that both factors (acceleration and flight tasks) are able to work together with the spin controlled automatically or freely by the pilot/instructor in response to the stimuli inflicted during rotation [2]. Ideal technical solution will allow the centrifuge perfectly imitate model of aircraft response. Precision and coordination of the simulator's response time and accelerations speed to that of the F-16, Mig-29 aircrafts is very significant for proper and adequate training. Nowadays it is estimated how much theoretical assumptions suit real accomplishments. All these elements need prior training on the centrifuge with the option of generating acceleration similar to those found on aircraft in operation today. To emphasize the importance of this problem, it is enough to cite the fact that about 90 percent of accidents in military aviation are due to the so called human factor caused for example by loss of consciousness, which took place on board of the F-16 aircraft.

Simulator training

Fig. 2. Gondola and arms of the new polish centrifuge.
Ryc. 2. Gondola i ramię wirówki przeciążeniowej.

The experience of NATO members shows that the extensive use of flight simulators, increase the effectiveness of military missions, greatly reduces the possibility of losing pilots' health and greatly minimize the amount of plane crashes and at the same time significantly reduces the costs of training of new generation pilots. Detailed calculations made by USAF Department of Defense lead to the conclusion that the cost of initial training of military pilots for basic flight skills is about $ 1 million, and further training to the level when the pilot is fully operational can reach the value of $ 9,000,000 [4]. The increasing cost of training of the pilots for the new generation aircraft contributed to the widespread use of specialized training in the aviation simulators. Economic benefits of such a training also contributed to the rapid development of increasingly sophisticated human centrifuges-training simulators faithfully reproducing the conditions of the pilot operations.

Among the simulators that can meet the above mentioned feature, of this device is achieved by adequate construction requirements. Rotating cabin in 3 axes (in a controlled manner) provides authentic simulation of any acceleration occurring during the real flight.

Exchangeable, depending on the needs and the required type of aircraft cockpit equipment, allows for any kind of training and at the same time gives the possibility of physiological data collection necessary for pilot medical status evaluation [13]. This makes the perfect combination of simulator training with the centrifuge G-forces.

Physiological aspect of the combat mission performed exposes the crew to a complex combination of high acceleration and rotation leading to physical loads. Crew members are exposed to high G and overload conditions of rapid change resulting from multi-axis accelerations. Such effects usually occur during aircraft maneuvers in combat or in the course of acrobatic maneuvers of the aircraft. The use of aircraft with high maneuverability exposes pilots to high congestion in all axes, the value of which may even exceed 9 G. These factors cause a number of problems related to overloads: from the effect of weight gain, through blurred vision and spatial disorientation, to the complete loss of consciousness (G-LOC) [15]. The causes of air accidents do not result only from an emergency associated with lack of proper training and practice, which alone can ensure a new generation of training simulators. Ordinary centrifuge overload do not meet these requirements.

The purpose of these devices is to determine the tolerance limits of the system while using various preset acceleration characteristics. Although centrifuge is also a form of training aircraft, but it can not reproduce the full functional capability and maneuvers of the aircraft, while performing different combat tasks including risk of spatial disorientation [10].

Improvement of flying skills, conducting air combat and full use of the plane resources in laboratory, with full monitoring of biomedical indicators are the main functions of the modern centrifuge used as the training simulator. As a result, the use of such equipment and its associated advanced training program can provide the required level of training of flying personnel and achieve the adequate tolerance to environmental factors in pilot work, thereby increasing the level of safety and quality of combat missions [9].

Training in terms of increasing tolerance of overloads for pilots is regulated by „Instructions for specific training in aero medical crew of the Polish Armed Forces'

sign. Zdr. 244/2008. This instruction provides training MUST transition to the centrifuge overload every 5 years, in the event of interruption of flight for medical reasons which lasted more than 3 months, in the event of interruption of flight for reasons other than medical, which lasted over 3 years in case of an overload by a low tolerance organizer or pilot flight training and in the case of annual flying time of less than 70 hours.

Potential research areas on the new polish human centrifuge

The various psychological/medical problems potentially evaluated in the human centrifuge are given in Table 1. Recommendations can also be made for specific medical and psychological conditions regarding the suitability of exact investigative Human Centrifuge. For example, it will be possibly to diagnose level of mental stress and individual reaction of g-forces and flight tasks also from gender perspective [1]. Due to high automation of flight pilot's understanding of proportion between automation and heuristic principles will be important. One specific area of potential research specifically for the superagile pilot will be to find the right way to work with symbolic information simultaneously with analog information and psychomotor performance. The rule „Right information in the right format and right time" will be also worth to consider [8].

Tab. 1. New option for early detection of disabilities/dysfunctions/states with medical subsystem of a new centrifuge

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Name of the System	Disabilities/dysfunction/state Detected	Physiological signals measured
Central Nervous System	- spatial disorientation - information overload - fatigue / boredom - situation awareness - attention lapses - fight/flight reaction - air sickness - blackout - giddiness - fear of flight	- performance measures - spontaneous brain activity - event related potentials - reaction times - galvanic skin response - eye movements (oculography) - biofeedback
Cardiovascular System	- low G tolerance - hyper/hypotension - ECG abnormality - EEG abnormality - mitral valve prolapse - vaso-vagal syncope	- blood preasure - volume plathysmography - infrared plethysmography - skin temperature - near infrared brain circulation - respiratory wave - ECG

Fig. 3. The new gondola for centrifuge training (F-16 or Mig-29 cockpit inside).
Ryc. 3. Gondola nowej wirówki przeciążeniowej (F-16 oraz Mig-29, wnętrze kokpitu).

Research and training pilots for the Polish Air Force and preparing them to perform multi-mission tasks is the main purpose of the Military Institute of Aviation Medicine. However, due to very high technical and functional parameters of a new human centrifuge - training simulator can be used also to contract training and research for other countries. It is fully feasible because of the ability to quickly adapt the device to the specific requirements of the potential customer (the change of equipment, the characteristics and dynamic properties corresponding to a particular

type of aircraft in less than 1h). It will be a modern human centrifuge - a training simulator installed in Poland and the applications for this type of device can be very large [12].

The type and quality of research and training that can be performed on the new Polish human centrifuge - simulator training depends of what most countries are seeking for. The main reasons for this are:

- pilot training strategy is implicit and will not be disclosed to other countries,
- biomedical data of the pilots are not available outside the country,
- research on your own equipment make it possible to develop knowledge and promote the development of its advanced and increasingly sophisticated methods and training programs,
- the possibility of matching methods and training programs to specific national conditions,
- reducing the costs of training with a long (30 years) product life
- no additional costs and loss of time resulting from sending pilots for training abroad,
- the device is available on request, in the case of a foreign pilot training equipment, you need to adjust their cycles of training for owner free spin terms, which, given the dynamically changing international situation, can be very uncomfortable,
- the rental of a centrifuge with similar parameters in European countries is at least 10 to 15 thousand € per day.

According to the companies involved in the production and use of flight simulator training, e.g. centrifuge, allows for huge savings and increasing quality of training, compared with the training carried out solely on the basis of real flights. In terms of operating costs - time of flight simulator is 28 times cheaper than an airplane flight. Sevenfold greater availability for individual pilots to undergo training missions (there are no restrictions related to weather, availability and condition of aircraft, the maintenance service intervals, it is not required to involve the entire aviation infrastructure to secure the workout - no need to keep in readiness aerodromes, staff guidance and flight control, etc.).

Polish human centrifuge doubles the efficiency of flight training, in the case of the need of additional flight training is carried out immediately, without additional planning. The use of a centrifuge - a training simulator also greatly increases the lifetime of a aircraft resource, which can be devoted to the tasks of combat instead of training [11].

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