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UPGRADING THE EFFICIENCY OF AIRSPACE FLIGHT SIMULATORS FOR EMERGENCY-RESPONSE TRAINING OF SPACE CREWMEMBERS

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Both the flight safety and space crew efficiency depend for the most part upon the crewmembers' professional qualities achieved with the aid of different training systems. The inconvenience of such systems consists in their failure to provide an overall simulation of some psycho-physiological sensations experienced by the crewmembers in real space flight conditions, e.g. air sickness, distortion of equilibrium sense, fatigue, apprehension, anxiety, pain sense modality, etc. With regard to the significance of the above component of space crew training a simulator model with improved training efficiency was designed. The multidimensional effects of the simulating system suggested provide facilities for quality improvement in the crewmembers' training and development of the appropriate decision-making, managerial and other skills essential to the crew in both standard and emergency situations.

Key words: Flight simulator system, operator, psycho-physiological sensations, emergency situations

Introduction

Currently, a great number of methods are available for simulating psycho-physiological sensations in training simulators [1] based on which the characteristics of an object's behaviour are calculated on the real-time basis, the psycho-physiological sensations are synthesized in data paths and converted into the sensations of spatial movements, "in-cockpit" and "out-of-cockpit" visual over-reliance, auditory information (noise and voice data), tactile and kinaesthetic information (from the control devices).

The inconvenience common to simulation systems available consists in their failure to simulate some of psycho-physiological sensations of discomfort that are experienced by crewmembers in real-life space flight conditions, e.g. air sickness, blur of vision, fatigue feeling, apprehension, anxious feeling, pain sense modality, euphoria, distortion of equilibrium sense, etc.)

The designers engaged in development of integrated training systems used to be sceptical about possibility of simulating, by using the technical aids available, the complete real-life information environment including the psycho-physiological stress experienced by the aircrew. For this reason, the object's emergency conditions simulated were marked by representative incompleteness, under-coverage, a kind of conventionality and lack of the sensational component. Consequently, it had its impact on the training efficiency and offered no prospect for acquiring the appropriate skills and decision-making abilities essential in both standard and emergency situations.

In the course of the data analysis on the subject it was found that the occupational activity of air crews, including space crews, is a variety of a complex combination of brain work, physical labour, a nervous activity and emotional tension notable for a dramatic psycho-physiological stress. Based on the results of the expert survey [2] four blocks of essential professional qualities were selected:

- disciplinary and occupational qualities (diligence, responsibility, industry, discipline, performance ability, etc.);
- specific professional qualifications (engineering culture, imaginative thinking, clairvoyance, speciality knowledge, practical knowledge and skills, etc.);
- leadership (managerial abilities, exactingness, critical judgement, educational and character building skills, etc.);
- psychological properties (target aiming function, speed of decision and command, emotional stability, initiative, resoluteness, attentive behaviour, personal autonomy, etc.).

It should be noted that development, accumulation and evaluation of the above qualities are carried out directly during operation and service of a system at real-life strategic facility. According to the analysis the first three blocks of the qualities mentioned are integrated with the psychological properties of a trainee and they determine not only the crew behaviour in a relevant area but also have an effect on the crew flight performance.

Additionally, during the research it was found that most of the psycho-physiological sensations experienced by a person in a real-life environment are caused by the infrasonic field of the vehicle that acts as a very-low-frequency conic transducer [3…5]. For this reason the training systems to which the flight simulator in question belongs are to provide a more complete and most accurate reproduction of information environment of a real-life object with due regard for the performance features of various human analysers (auditory sense, visual sense, odour sense, tactile and kinaesthetic sense, acceleration and psycho-physiological sensations, etc.) [1].

With regard to all these essential components of the space flight crew training a flight simulator model was developed by the authors with its improved training performance based on additional representation of new information flows that occur in real-life objects with allowance for representation of the human factor aspect at a higher qualitative level. All the above will finally enhance a general confidence in the flight simulators by validating their characteristics and high-realism performance. The model suggested is based on the method of psycho-physiological sensations simulation in a vehicle simulator [6].

Description

In the block diagram shown on Figure 1 a method is presented for simulation of psycho-physiological sensations in an aerospace flight simulator. The simulator system incorporates:

- real object behaviour simulator 1 (ROBS);
- instructor control panel 2 (ICP);
- acceleration stress simulator 3 (ASS);
- voice information simulator 4 (VIS);
- out-of-cockpit visual information simulator 5 (OCVIS);
- in-cockpit visual information simulator 6 (ICVIS);
- tactile and kinaesthetic information simulator 7 (TKIS);
- very-low-frequency generator 8 (VLFG);
- very-low-frequency variable intensity amplifier 9 (VLFVIA);
- very-low-frequency sonic converter 10 (VLFSC);
- infrasonic vibration analyser 11 (ISVA);
- operator workstation 12 (OWS);
- infrasonic vibration damper 13 (IVD).

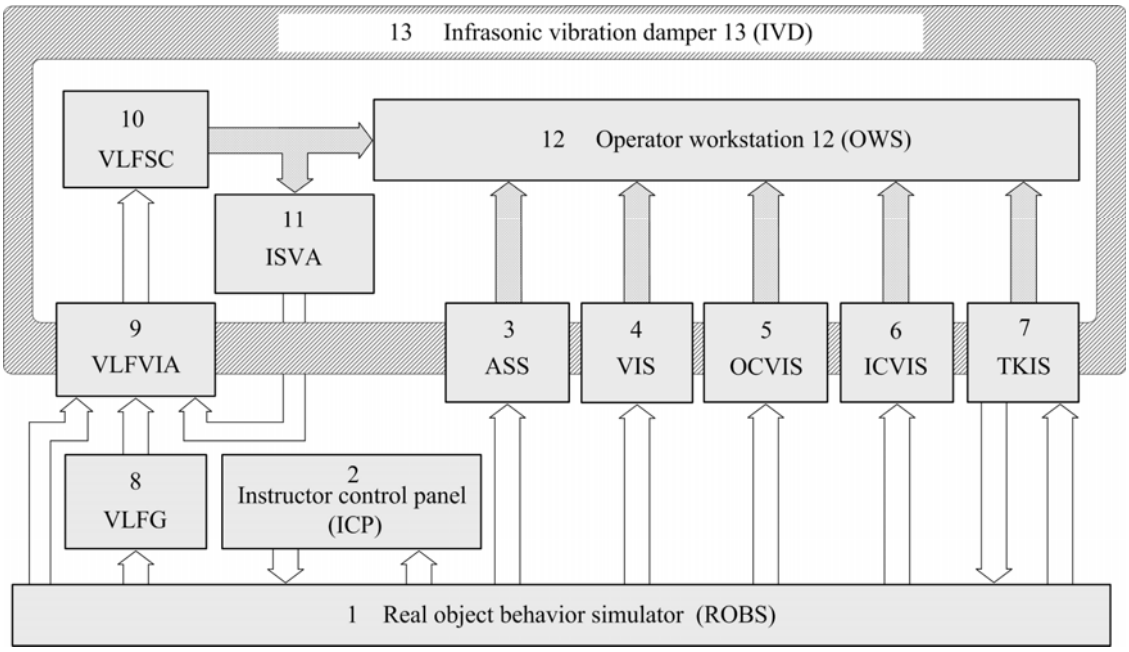

Figure 1. Flight simulator block diagram

The operator 12 performing a training task activates the control devices located in the tactile and kinaesthetic information simulator 7. As this takes place, the electrical signals formed in the simulator 7 are transferred via the data bus to the real object behaviour simulator 1. The simulator 1 is a hardware and software package used to solve the equations for real-time representation of the behaviour simulator of a real object, e.g. an airspace vehicle. The package also enables calculation of the dynamic factor, the aerodynamic coefficient and other parameters as well as the kinematical relation, logic and differential equations which describe the kinematics of behaviour of the simulated object and its onboard systems.

On the signals received from the tactile and kinaesthetic information simulator 7 the simulator 1 synthesizes the parameters of the real object operation and, by data bus transfer, operates the simulators 3...7, the instructor control panel 2, the VLF generator 8, and the VLF variable intensity amplifier 9. In response to these signals:

- the acceleration stress simulator 3, according to the program of sensation of motion simulation and by means of the dynamic stand, acts on the operator 12 and creates an illusion of spatial motion.
- voice information simulator 4 synthesizes the audible signals and acts on the acoustic apparatus of the operator 12, thus creating for him an illusion of the operating engines, internal modules, the simulated vehicle, the in-cockpit and out-of-cockpit ambient noise, enc.;
- the out-of-cockpit visual information simulator 5 generates the out-of-cockpit space images and creates for the operator 12 an illusion of visual presence in some space environment;
- the in-cockpit visual information simulator 6, via the onboard instruments and indicators, provides the operator 12 with the information on the trajectory parameters of the simulated vehicle;
- the tactile and kinaesthetic information simulator 7 represents the realistic characteristics of the effort experience on the control devices according to the simulated situation;
- the instructor control panel 2 provides the instructor with the information on the functioning of the simulated vehicle systems and the current actions of the operator 12 necessary for further evaluation of his flight performance. During performance of the training task, the instructor 2, without prior warning the operator 12, by using the control panel 2, enters to the simulator 1 input the data on various emergency situations that might occur in a real-life object (vehicle).
- the VLF sonic converter 10 converts the electric signals received from the VLF variable intensity amplifier 9 into infrasonic vibrations. The frequency and intensity of these vibrations are determined by the input signals in generator 8 and the amplifier 9;
- the infrasonic vibration analyser 11 provides continuous monitoring of timing data, energy characteristics, and frequency response of the infrasonic vibrations in the source 10. In case the infrasonic intensity limiting value is reached or exceeded an emergency signal is formed which is applied to the variable input of the amplifier 9 to decrease the amplification factor to the safe level. Considering the operating efficiency requirements to the simulator acoustic system tight standards are established for their quality which must be adhered to over the rated service life. The most suitable among the variety of the systems of the type is the magnetostrictive converter of the motion parameters of the VLFSC acoustic vibration system 10.

With a view to limit the infrasonic effect of the ambient environment the simulator cockpit with the operator workstation 12, analyser 11 and vibration source 10 are enclosed in the damper 13.

Conclusions

The simulation method suggested can be applied in training strategic facility operators, who experience mental stresses and, thus, require emotional maturity, good memory and perceptual ability, endurance and stamina. The multidimensional effects of the simulating device provide the possibility for optimisation of the psycho physiological state of the trainees and for development of the appropriate professional skills essential in both standard and emergency situations.

Significant results were obtained by the students in the course of the research in this area carried at the Automation and Control Department of Penza State Academy:

- an application for an alleged invention was filed and Patent of the Russian Federation was received [6];
- The Intelligent Flight Simulators and Training Systems project Award (Diploma), The “Eureka-2007” All-Russian Higher School Students Scientific and Technical Creativity Review Competition, Novochrekassk;

- The Advanced Scientific and Technical Inventive Activity Award (Medal) for "The R&D of Automated Control System for Airspace Simulator" project in category "The Best Research Project in Engineering Sciences", The All-Russian Youth Projects and Programs Competition ("Scientific and Technical Creativity of Youth –NTTM Exhibition", Moscow, July 2009);

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