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INFORMATION TECHNOLOGIES – BASIS OF TRAINING, RETRAINING AND ADVANCED TRAINING SYSTEMS FOR HELICOPTER PILOTS

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In the early 90s there was a need for the complex development of training, retraining, maintaining and professional development system designed for the most popular Mi-8 helicopter pilots oriented at modern information technologies. The system covers all the stages of pilot training, starting with the initial stages of professional activity up to its completion. The technical means compiling specifications for the whole range training were determined by the results of the pilot in-flight activity analysis. The proposed optimal range of technical facilities for training consists of technical means with different levels of out-of-cockpit and in-cockpit environment simulation. The utilization of these means allows to minimize the expenditures on proficiency level support and cost of pilot training. The set of technical training appliances such as: automated training courses of theoretical disciplines, computer functional and situational simulators, navigation simulators and flight complex simulator includes the facilities that provide training of the pilot actions at each stage of the flight. The individual schedule of computer based self-development classes is drawn up for each student. While compiling the individual schedule logical sequence of all training stages was carefully observed: firstly we begin with a thorough study of helicopter structure, then goes the study of functional system or equipment normal operation, functional system or equipment in special situations operation, and finally, the routine technology of crew operation in normal flight conditions and the crew actions in dangerous and emergency situations. In addition to the direct training of students, the initial stage of training solved the tasks of practical check and improvement of previously taken decisions.

Key words: educational technologies, computer-based training, automated training courses, functional and situational simulators, flight simulator.

INTRODUCTION

In the conditions of the Russian Federation with its vast territories and lack of a developed network of highways, helicopter aviation has become one of the most important factors in the further development of distant regions of the North and Siberia, which are rich in natural resources. In addition to transporting work in the undeveloped regions, modern helicopters do a good deal of so-called aviation work: oil and gas pipelining, power poles installing, forests conservation, forest fires suppression and so on.

One of the steady requirements to the civil helicopter aviation is the insurance of flight safety. The safety of flights is determined by two main factors: the technical condition of helicopters and the professional qualification of the flight crew.

Unfortunately the system of flight qualification maintenance of civil helicopter pilots, inherited by Russia after the collapse of the USSR, is morally and physically outdated and did not meet the requirements of domestic and international regulations. Flight simulators which existed at that time were based on an outdated element base. There was no systematic approach to the pilot's entire "professional life" support, beginning with the basic training up to the termination of flight activity or retirement. Modern training technologies were not used in practice [1, 2].

There was a need for the complex development of training, retraining, maintaining and professional development system for helicopter pilots based on modern information technologies. The staff of the ATC (aviation training center) of JSC "SPARK" set a task to create a similar system for the pilots of the Mi-8 helicopters – the family which is very popular and widespread (about 3000 helicopters of different modifications of this family are operated in Russia and in foreign countries) [3].

The system of training, maintenance and professional skills improvement of helicopter pilots which is being developed is focused on the use of new training tools and technologies (hereinafter the System), should cover all the stages of pilot professional training activity, beginning with its initial training to its completion. The overall structure of the System is shown in Figure 1.

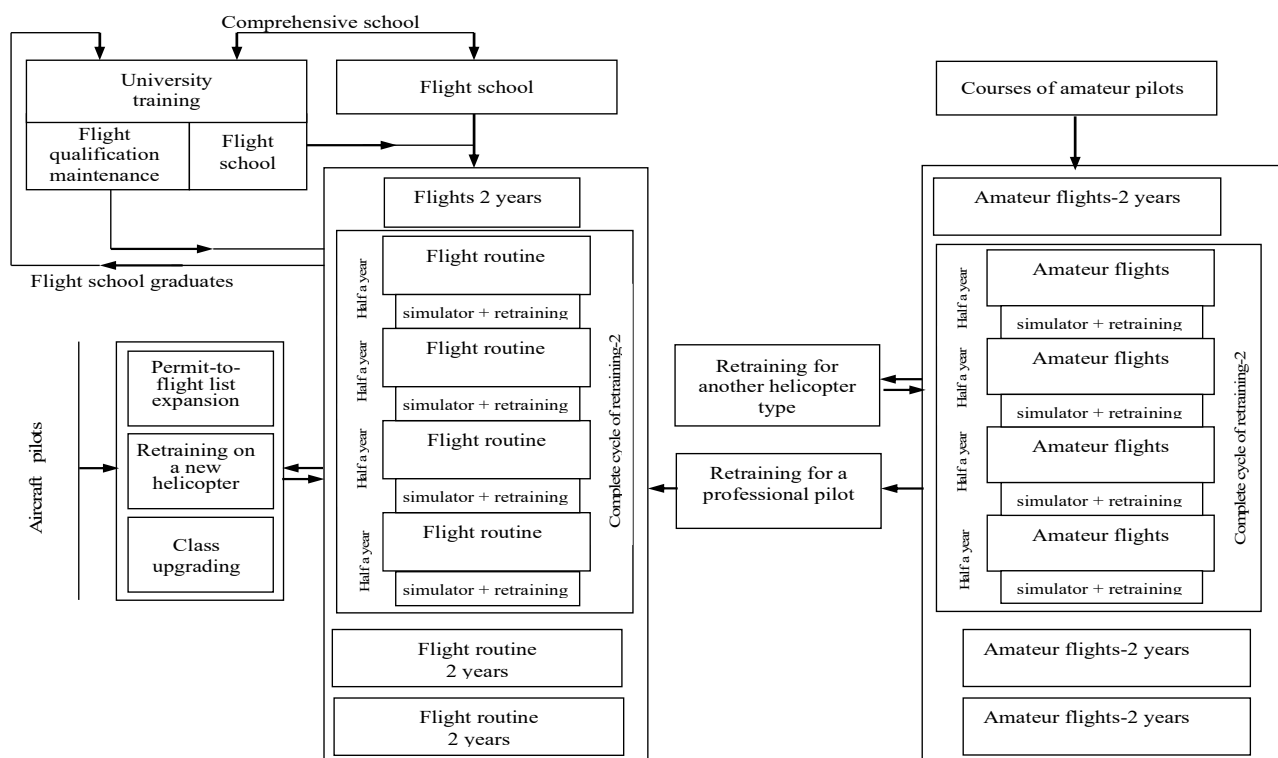


Fig. 1. The structural System of training, maintenance and professional development for helicopter pilots (in 2010, the full cycle of the refresher courses was cut up to 1 year)

The basic principles laid down in the System being developed are:

- Curriculums for all stages of the System are interconnected, focused on the perspective educational techniques and exclude duplication.
- The optimal set of training tools is determined for each level of the System. The set takes into account the individual characteristics of the organizational forms of the stages and ensures the link goal achievement in the shortest time and with minimal economic costs.
- Educational means are based on the present-day educational technologies using the wide range of computer technology.

The requirements for the formation of technical means of training were determined according to the pilot in-flight action results analysis. The pilot's actions, as the operator of flying object, are represented by the list of "homogeneous" tasks solved by him at different stages of the flight:

- 1) visual and instrumental detection of the helicopter setting in the air;
- 2) the impact on the controls for changing (maintaining) the position of the helicopter in space;
- 3) search of instrument readings and evaluation of the helicopter functional systems;
- 4) the control of the helicopter functional systems and AEE (aviation and electronic equipment);
- 5) the solution of navigational problems and setting up navigation equipment;
- 6) radio communication;
- 7) the solution and implementation of results of specific tasks during the flight routine.

In the course of taking solution for each of these tasks, the pilot uses the informational data obtained from the analyses of out-of-cockpit and (or) in-cockpit situation, however, each task requires different amount of this information.

The proposed optimal range of technical means of training consists of technical facilities with different scopes of out-of-cockpit and in-cockpit environment simulation.

This allows us to minimize the expenses for preparation and pilot professional skills support. The less is the scope of out-of-cockpit and in-cockpit environment simulation, the cheaper and more affordable are the technical means of training and coaching.

Therefore, it is reasonable to point out the stages of the pilot whole qualification training and maintenance process which are directed at a specific class of technical means:

1. The stage of theoretical disciplines. The technical means used at this stage are not connected with the simulation of any flight conditions. Separate fragments of the out-of-cockpit and (or) in-cockpit environment can be used as well as any other illustrations (drawings, diagrams, etc.).

2. The stage of professional training with the simulation of minimal required actual effects impact volume.

3. The stage of professional training with such volume of simulation influences that allows you to consider the conditions of training to be close to flight conditions.

4. The stage of professional training with simulation of flight conditions in full.

5. The stage of professional training in real flight conditions.

The set of technical training tools includes the tools which train the pilot to act at each stage of the flight:

– The stage of theoretical training – automated training courses (ATC) of relevant disciplines make use of means with video and audio information, animation, film fragments and other modern media.

– Display functional and situational simulators are used for the stage of professional training which requires the minimal volume of impact simulation. Functional simulators are designed to work out the actions aimed to control functional systems and AEE (aviation and electronic equipment).

– Situational simulators are aimed for practicing the actions in difficult and emergency situations. The simulators provide the possibility of practicing individual actions and actions as a member of the crew.

– The cockpit simulators without visualization and navigation (display or screen), with incomplete and simplified visualization of out-of-cockpit space are used at the stage of professional training with imitation of such an exposure that allows to consider training conditions to be close to the flight ones.

– The equipment used for the stage of professional training of the real flight simulation is a combined flight simulator with a fixed platform and a combined flight simulator with a mobile platform.

– The stage of professional training in real conditions takes place in training flights on a real helicopter.

– The structure and the content of each technical device is determined by the need for it at different stages of the training process aimed at retraining the pilot to operate helicopter and further maintenance of the pilot's professional skills. The distribution of the material being studied between the computer training products is made as a result of the detailed analysis of each topic.

In order to approximate the flight conditions on the simulator to the conditions of a real flight, aircraft flight simulators are equipped with a mobility system allowing us to simulate overloads which occur during the normal operating conditions of aircraft. But the simulator mobility system makes the cost of the simulator several times more expensive and consequently, the cost of the flight hour of the simulator as well.

A very important characteristic of the MI-8 helicopters family flying simulators which are wide-spread and popular in Russia is its price. At the same time, the Mi-8 civil helicopter is not designed for maneuvering flights. Calculations have shown that while accelerating and braking according to the flight operating manual horizontal overload equals to 0.17...0.26, and the overload for the helicopter Mi-8MTV normalized turn with a maximum roll angle of 45 degrees equals to 1.41.

On the basis of the research work [4] devoted to the influence of overloads upon operating capacity of the pilot it is possible to draw a conclusion that in-flight overloads effecting on the pilot of the civil Mi-8MTV helicopter do not give any negative impact on the pilot's working capacity. This justifies the choice of flight complex simulator with a fixed cockpit for creating the first stage of the System.

AUTOMATED TRAINING COURSES FOR THE STUDY OF GENERAL AVIATION DISCIPLINES AND DISCIPLINES OF A PARTICULAR HELICOPTER

The following requirements provided the basis of general aviation disciplines development [5, 6, 7]:

1. To provide the students with opportunity to study general aviation disciplines in two modes: in the mode of consecutive study with the use of hyperlinks and explanation and in the mode of a directory with an independent choice of the required material volume.
2. To outline the training material so that the basic provisions of the disciplines included in the scope of the training material are identified without breaking the sequence of the whole material presentation.
3. The Structure of the automated training courses in disciplines should provide an opportunity to edit existing fragments and add new fragments to the program without taking much time and resources.

In the process of designing disciplines for a particular aircraft, the requirements for the volume and depth of knowledge for each crew member in accordance with the flight operations manual were taken into account¹. The automated training course "Mi-8, Mi-8MTB, Mi-8AMT (M17) helicopters structure and flight operation" is a redesigned course for computer presentation giving a detailed description of the helicopter construction, its systems and instruments. The course is illustrated with photos and three-dimensional computer graphics of general views of helicopters, their units, assemblies and components, systems structural schemes, cutaways and in-depth details. As an example you can see two fragments of this course in Figure 2.

An important element of computerized learning system is the programs which help to control the students' material acquisition.

In the system of computer-based training intermediate and final controls are carried out by means of computer testing programs using test tasks [8, 9]. While designing test assignments for general aviation disciplines (GAD) and disciplines of a particular helicopter (DPH) the choice was made in favor of the closed-type tasks on the level of "Knowledge", "Understanding", "Analysis", "Synthesis".

The developed test kits on the disciplines in the mode (graphics + question + supposed answers) were analyzed with the aim to determine the characteristics and to establish compliance of these characteristics with the indicators adopted in the theory of testometrics.

While assessing the professional knowledge of helicopter pilots, the peculiarities of the pilots' professional activities were taken into account. The helicopter crew is the last and most important link in the chain of ensuring flight safety. In all the amount of knowledge that pilot should possess there is the knowledge that directly affects the flight safety. The pilot must possess this knowledge by all

¹ The manual on flight operation of the Mi-8MTV helicopter. Moscow, 1994.

means. With the experts' aid the test tasks which directly effect the flight safety were selected from the discipline test set.

Another important moment in the process of helicopter pilot knowledge control is the limited time for test performance.

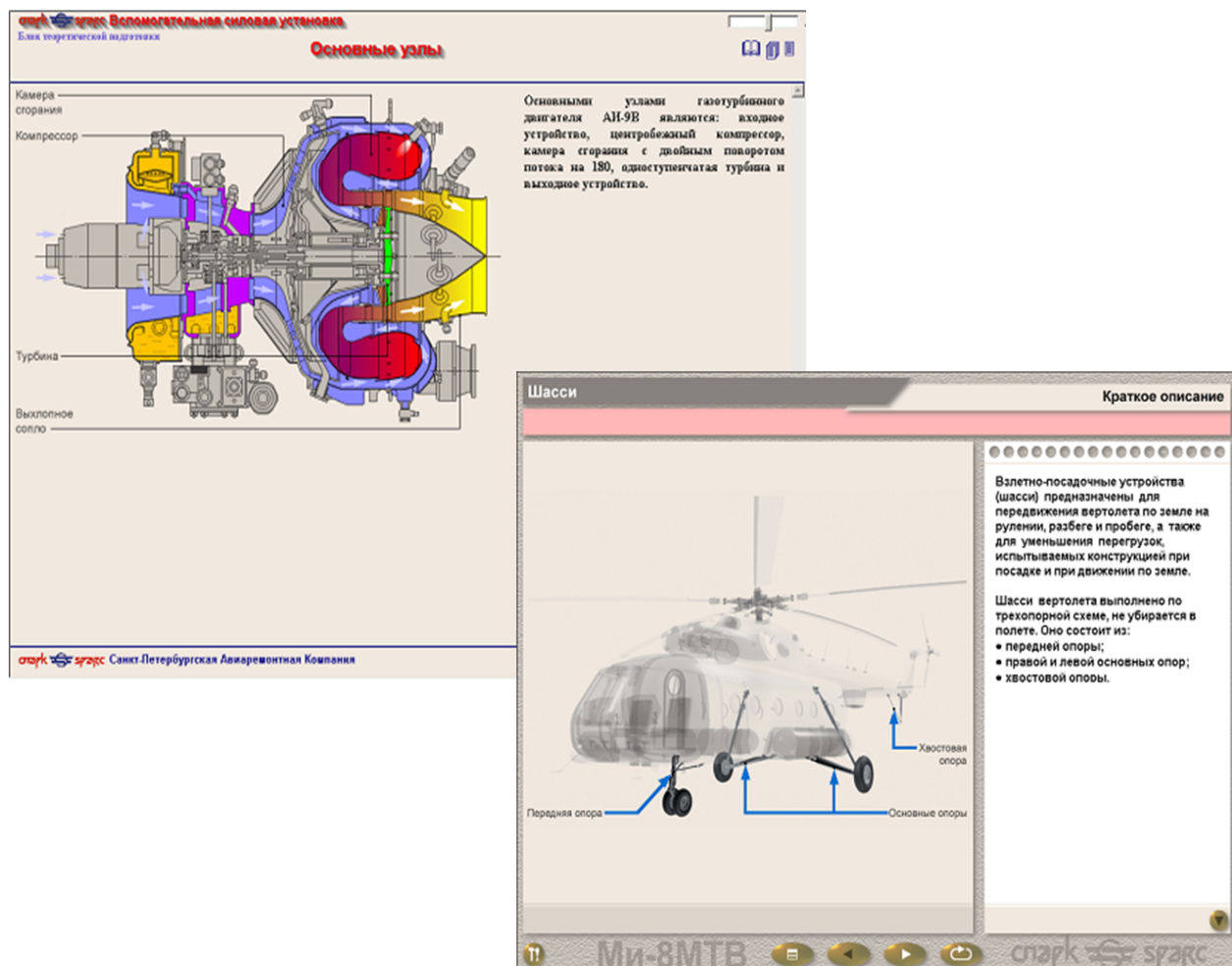


Fig. 2. Automated training courses
"Mi-8, Mi-8MTV, Mi-8AMT (M 17) helicopters structure and flight operation"

COMPUTER FUNCTIONAL AND SITUATIONAL SIMULATORS

Computer functional and situational simulators are designed to teach pilots how to control functional systems, air navigation and radio electronic equipment in normal flight situations, complex and emergency situations. Functional simulators are designed for working off the actions aimed at checking the operation of functional systems, basically, during the pre-flight training period. Each crew member works off his actions in emergency situations on situational simulators in accordance with the flight operations manual (FOM).

The information necessary for practicing on simulator is sent to the trainee via the display which shows the fragments of instrument panel with controls of the system as well as instruments and displays demonstrating the system operation. The fragments are located on the background of the helicopter cabin indicating their place on the dash board. The information presented on the display can be

static (the position of toggle switchers, knee switchers and other controls), dynamic discrete (ignition and extinction of the indicator board and warning lights) and dynamically continuous (readings of pointer instruments and digital indicators (figure 3) [10].



Fig. 3. Simulator "Engine TV3-117BM starting up"

In addition to visual information the pilot perceives audio information as well. It can be the sound of units in operation, reports and communication of the crew members, call-signals of radio stations, orders and air traffic controllers' information. The necessary sound information is simulated and issued to the pilot at the right moment either through the headphones or through the computer speaker.

For each test and for each situation two computer products are developed: DEMONSTRATION and TRAINING ones.

DEMONSTRATION is a passive narration (text or audio) about the sequence of actions aimed at checking the system with the display of controls and controls of the operating system on the fragments of dash boards, with the display of controls when the system is inoperative, with the display of the steps preventing the system from failure if a problem is detected.

TRAINING is an interactive computer simulator. The trainee interacts with the active zones on the computer display, changes the location of the functional system controls in the sequence recommended by the flight operations manual (FOM), monitors the readings of the system controls and draws conclusions about its operability.

Computer simulator is the device developed for training therefore, the principle of giving immediate information to a trainee about the error he has made has been the basic. If the error is not crucial the trainee is offered to amend it (the hint may be given) and continue working on the simulator. If the error is vital the simulation is stopped and the task is regarded to be undone.

All the trainees' actions are strictly evaluated. According to the results of the trainee's performance the protocol is formed. The grading scale is designed in a way that any serious error leads to an unsatisfactory result.

NAVIGATIONAL SIMULATOR

This is the simulator for practicing navigational tasks using both cabin navigational and ground based navigational tools. The visualization system for solving navigational problems ensures compliance of three main requirements: it shows the space along the routes that are programmed in the exercises, plausible flight dynamics (horizontal flight speed, turning rate, vertical speed), the real location of ground radio navigation aids. The simulated cockpit instrumentation corresponds to the real aviation and radio electronic equipment of the helicopter. Helicopter control simulators are used to change the mode of flight (figure 4). Naturally, the training of navigation tasks performance on a simulator with a limited scope of use (navigation simulator) is much cheaper than practicing these tasks on a complex flight simulator.



Fig. 4. The general view of navigational simulator

A real polygon on which navigational exercises were supposed to be performed was chosen in order to form the stage. Operating landmarks and operating ground-based radio navigation aids have been located along the proposed routes. The visual display system allows the trainee-pilot to observe the flight from the cockpit in any of the eight directions (figure 5).



Fig. 5. View from the cab in the forward direction (left)

The dashboard is displayed at the bottom of the screen when the direction of observation is forward. Part of the equipment placed on additional dashboards can be used by the request of the trainee. You can minimize the additional equipment panels to maximize your visibility. It is possible to monitor the flight from any point outside the cockpit, including in the "repeat" mode.

COMPLEX FLIGHT SIMULATOR

The most important link in the helicopter pilot training process is the complex flight simulator [11]. Due to a number of reasons peculiar to the end of the 90s, it was decided to develop complex flight simulator Mi-8MTV with a fixed cockpit.

Mathematical models and generators of simulation impacts are implemented in the computer complex of the simulator. These are: models of helicopter flight dynamics, models of engines and auxiliary power plant, models of helicopter systems and equipment, model of flight range, models of climatic, temporal and meteorological flight conditions. To control various devices of flight conditions simulation, generators of simulation actions which work together with mathematical models in a computer complex are implemented. These are: external environment generators, forming frames for projectors, generators of vibration effects, in-cab acoustic generators, simulating the sounds of constantly operating engines, propellers, equipment, etc. and the sounds audible at the moments of one-time events like touching the ground by the helicopter landing gear during landing, etc., generators of audio signals and messages, generators of the cabin information field which generate signals for setting the arrows of needle indicators on dashboards and indicator boards in the desired position for the moment. The mathematical model of climatic, time and meteorological conditions allows us to simulate winter and summer, any time of the day as well as rain, snow and other weather conditions. Mathematical model of simulator comprises all mathematical models simulating the operation of many heterogeneous units, assemblies and systems in their relationship. The structure of mathematical model of simulator is shown in Figures 6 and 7.

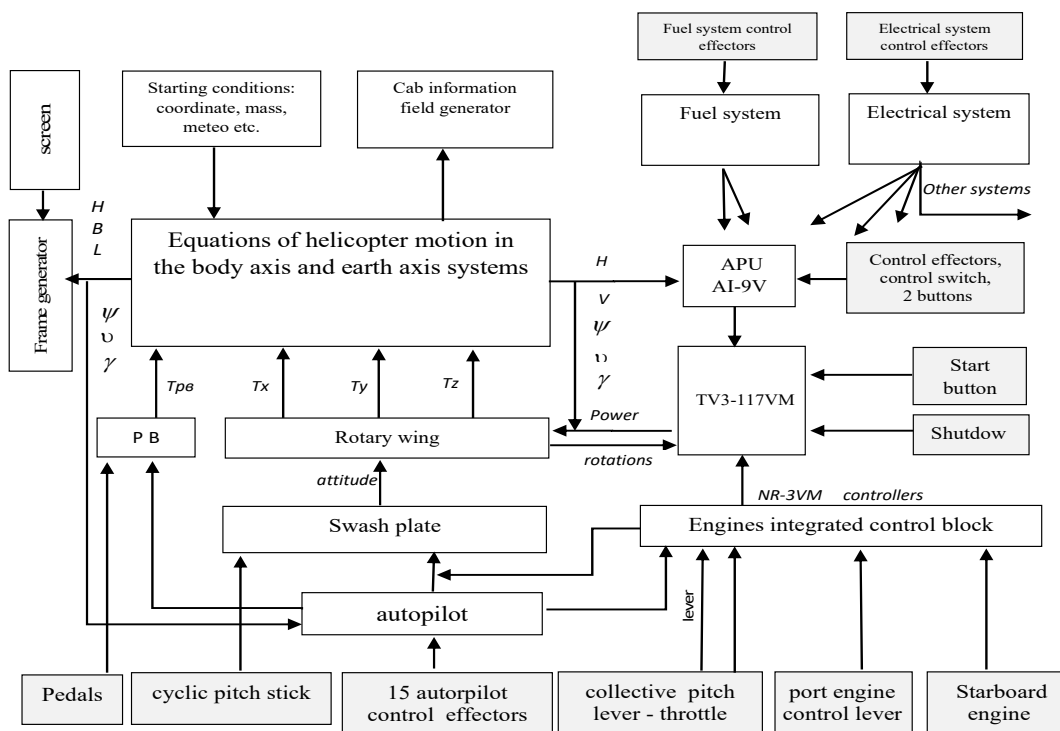


Fig. 6. Mathematical model of the simulator scheme (fragment: helicopter movement)

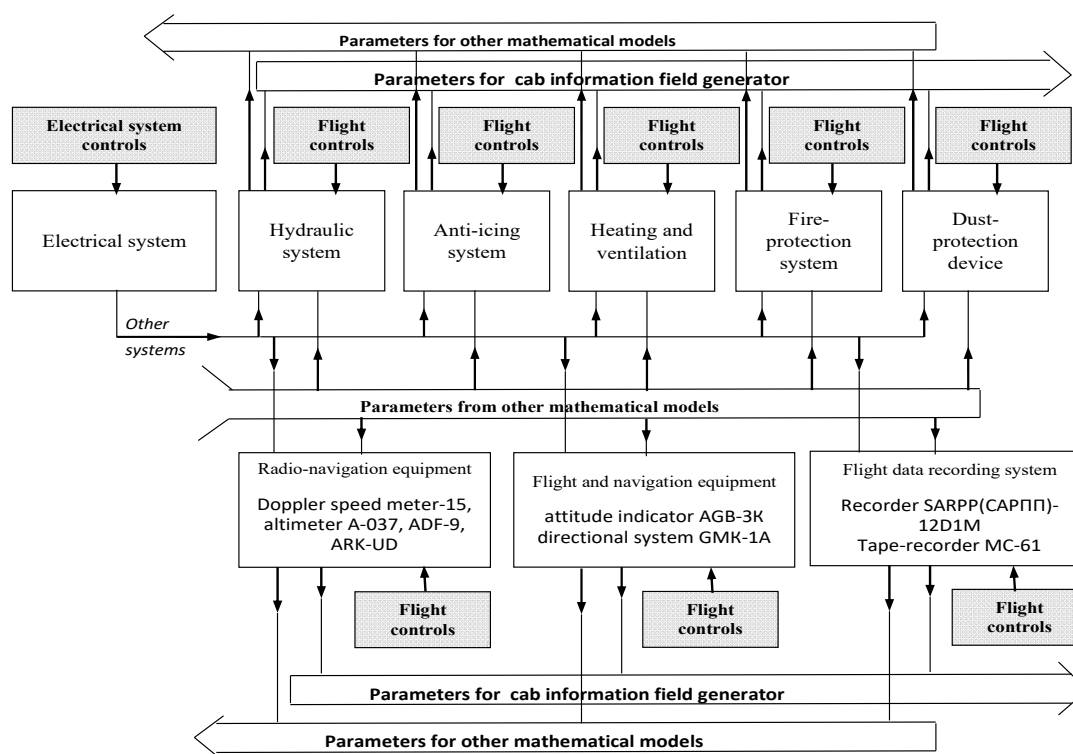


Fig. 7. The simulator's mathematical model scheme (fragment: systems and avionics)

ORGANIZATION OF THE TRAINING PROCESS

Having received the complex flight simulator MI-8MTV helicopter certificate in 2001 and developed the software products – a set of automated training courses and a full range of display and screen computer simulators the specialists of aviation training centre (ATC) Joint stock company "SPARK" started to implement the method of individual pilot training into practice, using computer products developed at the ATC. The register of preparation courses focused on the method of individual training was formed. During the process of curriculum development for each type of preparation course and at drawing up the programs included into the curriculum the requirements of Guidance documents issued by the Federal Agency for Air Transport² on the one hand and peculiarities of individual training mode with the use of developed computer products on the other hand were taken into account.

Since the very beginning of the flight simulator operation, the specialists of aviation training centre (ATC) Joint Stock Company "SPARK" have carried out methodological improvements on the optimal distribution of flight tasks between the simulator and training flights. As a result the document regulating the flight tasks solvable at simulator and the tasks solvable in training flights was prepared. On the base of this document the Regulating State Body issued a new curriculum for flight training³.

Each trainee has an individual schedule if he masters the subjects by using computer products (automated training courses, functional and situational display simulators, navigational simulators) independently (figure 8).

² Federal aviation regulations "Preparation and flights performance in the Civil Aviation of the Russian Federation". Moscow, 2009.

³ The training rules for helicopters flight personnel with take-off weight capacity from 7 to 20 tons. Moscow: VAVT, 2011.

Учебный центр ОАО "СПАРК"										
РАСПИСАНИЕ ЗАНЯТИЙ										
Часы	9	10	11	12	13	14	15	16	17	
Понедельник 01-ый рабочий день	Вводная		АОС		Обед		АОС			
Вторник 02-ой рабочий день	АОС				Обед		АОС			
Среда 03-ий рабочий день	АОС				Обед		АОС			
Четверг 04-ый рабочий день	АОС				Обед		АОС			
Пятница 05-ый рабочий день	АОС				Обед		АОС			
Суббота	выходной									
Воскресенье	выходной									
Понедельник 06-ой рабочий день			АОС		Обед		БРФ		Урок 1 КФТ, НТ РП	
Вторник 07-ой рабочий день			АОС		Обед		БРФ			

Fig. 8. Schedule of individual training sessions

The logical sequence of the material studied was taken into account during the process of drawing up the schedule: initially goes the study of the structure, then goes the study of the functional system or equipment normal operation and the operation of functional system or equipment operation in special situations, and finally the crew operation in normal flight conditions and work of the crew in difficult and emergency situations. The schedule is accompanied by a detailed distribution of educational materials between training days and "lessons". In addition to the study of theoretical material using passive aviation training course (ATC), the trainee practices the "lessons" using interactive computer simulators.

At the initial stage of preparation, in addition to the direct training of students, the practical tasks of checking and improving the earlier-taken decisions were solved. The pilots, who were trained at the initial stage of JSC "SPARK" work, were invited as experts to assess the quality of the flight simulator with a fixed cabin. The experts are sure that it is basically enough to train on a simulator with fixed cabin. But 20% of experts considered the training on a simulator with a movable cabin for 1 hour for hovering and for 0.5 hour for horizontal braking, coordinated banked turn with a small roll, coordinated banked turn with a maximum roll and a turn with a slide to be really important.

RESULTS

Since 2001, Aviation Training Center JSC "SPARK" has accumulated extensive experience in training helicopter Mi-8 pilots using new computer-based training tools and a flight simulator with a modern visualization system. During this period, more than 1000 pilots and more than 350 flight mechanics from Russia and CIS, as well as more than 250 pilots and more than 40 flight mechanics from different countries of Europe, Asia and Latin America were retrained from other aircraft to the Mi-8MTV helicopter pilots at the "Spark" Aviation Training Center. In addition, the active Mi-8MTV helicopter crews underwent periodic (quarterly/semi-annual) training sessions utilizing the simulator of

the "Spark" ATC. More than 3000 crews of Russian and foreign airlines have undergone periodic training during the period of ATC operation.

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ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ – ОСНОВА СИСТЕМЫ ПОДГОТОВКИ, ПЕРЕПОДГОТОВКИ И ПОВЫШЕНИЯ КВАЛИФИКАЦИИ ПИЛОТОВ ВЕРТОЛЕТОВ

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В начале 90-х годов возникла необходимость комплексной разработки системы подготовки, переучивания, поддержания и повышения профессиональной квалификации пилотов наиболее распространенных вертолетов семейства МИ-8, ориентированной на современные информационные технологии. Система рассчитана на охват всех этапов подготовки пилота, с начала профессиональной деятельности (первоначальная подготовка) до ее завершения. Требования к формированию всего ряда технических средств обучения определялись по результатам анализа деятельности пилота в полете. Предлагаемый оптимальный ряд технических средств обучения состоит из технических средств с разными объемами имитации внекабинной и внутрикабинной обстановки. Это позволяет минимизировать затраты на подготовку и поддержание профессиональной квалификации пилотов. В комплект технических средств обучения включаются следующие средства, обеспечивающие обучение пилота действиям на каждом этапе: автоматизированные обучающие курсы теоретических дисциплин, компьютерные функциональные и ситуационные тренажеры, навигационные тренажеры и летный комплексный тренажер. Для самостоятельного освоения дисциплин с использованием компьютерных продуктов составляется индивидуальный план-график занятий для каждого слушателя. При составлении план-графика учитывалась естественная последовательность изучения материала: вначале изучение конструкции, далее нормальная эксплуатация функциональной системы или оборудования и эксплуатация в особых ситуациях функциональной системы или оборудования, и, наконец, технология работы экипажа в нормальных условиях полета и технология работы экипажа в сложных и аварийных ситуациях. На начальном этапе обучения помимо непосредственного обучения слушателей решались задачи проверки на практике и совершенствования принятых ранее решений.

Ключевые слова: образовательные технологии, компьютерное обучение, автоматизированные обучающие курсы, функциональные и ситуационные тренажеры, летные тренажеры.

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