саморегулирования охлаждения активной зоны реактора. Чем больше тепловая мощность, выделяемая реактором, тем больше уровень мощности насосной турбины, вращающей циркуляционный насос, тем более интенсивное охлаждение активной зоны реактора. Таким образом, обеспечивается гомеостаз безаварийной работы сложных систем с ядерным реактором.

В результате может быть обеспечено повышение надежности и безопасности работы атомной электрической станции.

С учетом уже имеющегося опыта в атомной энергетике ликвидация аварий атомных электростанций с ядерным реактором требует десятилетий и материальных затрат на сумму в сотни млрд. долларов США.

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The method of ontological design of emergency events modeling of incapacitation of the flight crew of aircraft

Abstract. In this paper, the analysis of research on the subject of loss of capacitation of the flight crew of civil aviation (CA) is performed. The loss of performance of the pilot (Pilot Incapacitation) (PI) and especially all the crew members (All Pilot Incapacitation) (API) is a critical, extremely dangerous event. The development of the API subject method in flight can be carried out in technical and organizational directions.

Keywords: incapacitation, impairment, civil aviation, flight crew, simulator experiment, emergency delegation

Introduction. In this paper, the analysis of research on the subject of loss of capacitation of the flight crew of civil aviation (CA) is performed. A method of emergency delegation (ED) in case of loss of flight crew capacitation has been developed. The purpose of the study is to assess the risks of successful completion of the flight when delegating control of the aircraft to a third party in the event of loss of crew capacitation. There are total loss of performance (Incapacitation) and temporary or partial loss of performance (Impairment). The loss of performance of the pilot (Pilot Incapacitation) (PI) and especially all the crew members (All Pilot Incapacitation) (API) is a critical, extremely dangerous event. In case of partial loss, the pilot can perform some functions, such as reading the checklist, maintaining communication. In case of complete loss of capacitation, the individual is not able to perform the duties. The first plane crash, the causes of which were tried to establish as a result of PI in flight, occurred in 1911[1]. For the period 1993-1998, 50 events were recorded: 11 partial and 39 full PI, which is the frequency of 0.013 and 0.045 per 100 thousand flight hours, respectively. Two events ended not fatal aviation accidents (AA), which makes the probability $p < 0.001$. The frequency of PI in the age of pilots 45-59 years is more than twice as high as in the age group 25-44 years [2]. This can be explained by: a) the statistical sample of this analysis may have been insufficient; b) full PI are a more serious event and are documented more strictly; c) partial PI events can be hidden by pilots due to the threat of decommissioning [3]. Combined analyses of full and partial PI indicate frequencies of 0.019-0.059 per 100,000 flight hours [4]. For military aviation, this figure is significantly higher. The frequency of AA due to PI in [5] is determined by the value of 0.14 in 20 cases out of 146, in [6] it is determined by the value of 0.28 in 20 cases out of 59. In series of simulator experiments with full and partial PI in flight was performed [7]. It was found that the average detection time of the pilot's PI in the crew is 1.5 minutes. The conclusions was, that state that AA due to PI are less than one percent.

All Pilot Incapacitation Emergency Delegation Experiment. The API ED experiment (Aeroflot airline, 2012) contains the following scenario. In the flight of a modern multi-seat commercial aircraft, both pilots of the two-member crew suddenly lose their ability to work. The main result of the experiment is proof of a plausible and possible successful completion of API ED. A rational construction of the

experiment would require establishing the same conditions and the same sequential complication, entering failures for all participants. Perhaps the differences in flight scenarios, the time limit for a military pilot, affected the differences in the results of flight outcomes for each event.

Calculation of PI and API Events vs AA Probabilities. The calculation of AA probabilities requires stable statistical frequencies of events, which are considered insufficient and unrepresentative in research on the subject of PI and API. In these circumstances, probability measures and likelihood measures are used to describe the subject area under study. In relation to probabilistic measures, these measures are less clear. To calculate PI events, it is used interval probability estimates, probability estimates, and plausible reasoning.

Due to the vagueness of identification of partial and full PI events, their joint plausible frequency was established in the confidence intervals of 0.013-0.059 for civil aviation and 0.14-0.28 for military aviation per 100,000 flight hours. In the global AA statistics, it is used the measure of risk per million flights. For developed countries, it is equal to about one accident per 1.5-2 million flights, or the AA probability value of about $P=10^{-6}$ for all the combined causes of AA, attributed to the person, machine and environment. To take the average flight duration of four hours for the CA and one hour for the military, these frequencies are approximately the same and equal to the average value of about three percent (3%) of all causes of AA with a probability less than $P=10^{-7}$. The calculation of the probabilities of AA values for PI and API based on probability measures and plausible reasoning is presented (table 1).

Table 1 – Calculation of probabilities of AA values for PI and API

Loss of capacitation	Pilot PI	Crew API
Impairment	$P = 10^{-5}$	$P = 10^{-6}$
Incapacitation	$P = 10^{-7}$	$P = 10^{-8}$

It is assumed that Impairment have frequencies two orders of magnitude higher than Incapacitation. The basis for this statement is the data from surveys and questionnaires, in which the facts of incomplete performance according to the confessions of pilots are indicated in two out of five cases. Then the probability of Impairment is about $P=10^{-5}$. The API events are unique and there are no statistical studies available. We assume that the simultaneous loss of capacitation of all (two) crew

members is an event much rarer than the PI of a single crew member. The basis for this reasoning is the fact that the main causes of PI are medical factors: heart attack or stroke in two pilots at once is an order of magnitude less likely. In the case of fatigue, depressurization, and hypoxia, of course, the PI and API events are close or identical in frequency.

Developing an Emergency Delegation Method. The concept of ED is introduced for critical situations to make decisions to completely change the delegation strategy. ED is identical to dynamic reservation of technical objects. This problem makes it necessary to develop a management method and standard actions for such events. The problem is that the subject of the malfunction is fuzzy. Partial and complete failure is not easy to distinguish. The measure of the threshold or level of partial inactivity of a crew member, when there is a threat to flight safety, is also difficult to establish. If an event is associated with a cabin depressurization, it can be classified as extremely rare and extremely critical. But if partial inactivity is due to fatigue, then this is the usual state of the pilot. Non-trivial is the method of establishing inoperable inside the flight crew or cabin crew members, flight attendants.

An API event is extremely complex and depends on many unequal conditions, circumstances, and factors. It is not possible to check all the components of the API event, scenarios for how the event will flow, and flight outcome options, even in a series of simulator experiments, due to an infinitely large combination of factors. Therefore, it is necessary to prepare a preliminary theoretical content of the API, in which the most plausible, possible and probable conditions and factors are structured.

To make up the content of the research method, it is necessary to make various selections of plausible events. To do this, it is guided by an analysis of the known facts of the events of the loss of crew performance, common sense and plausible reasoning. The result of this work should be the preparation of the most possible scenario of the event and the calculation of the probability of variants of the flight outcome. Thus, it is necessary to move from the initial fuzzy content of empirical data: from likelihood measures to probability measures.

The development of the method can be carried out in technical and organizational directions. Technical measures to prevent AA from dangerous API events may include: a) the creation of "smart" modern aircraft, the development of automation, their ability to complete the

flight automatically without human participation; b) similar development of technical means of controlling the aircraft from the ground and remote flight control. Organizational measures can be aimed at reserving piloting functions: training in automated approach and landing of cabin crew; providing preferential or free flights to persons with a flight specialty.

Composition of the Method Content. The complexity of an API event requires a heuristic approach to creating the most truthful scenarios. The components of a complex API event are installed heuristically, based on experience, and expert-based on knowledge. The composition content can be designed for scenarios based on the greatest likelihood of occurrence of the elements of the event and that they lead to a favorable outcome; scenario of probable events of this type require the highest data completeness, suggesting a relative independence and equivalence of the component of the complex event.

For example, whether there is an experienced pilot-instructor with current experience of this type of aircraft and active knowledge of the cabin and equipment. If not, how long does it take to get it to the ATC communication console. A small part of the most intensive and important components can be taken into account in an event without taking into account the rest. If any objects are not taken into account, they can be added later when detected. Each object is structured into components that are reviewed and commented on. A detailed assessment is made and a plausible component is named, which may be part of the most likely event. After careful preparation of plausible content, one can begin to describe the most likely ED event.

Interpretation of the Most Likely ED Event. The method of plausible reasoning allows to create the following possible PI scenario of the most likely ED event. On a commercial multi-seat passenger plane, in a horizontal flight 40-60 minutes after takeoff, both pilots lose their capacitation due to food poisoning. Flight attendants discover the fact for five minutes in the course cockpit crew service. As a result of the discussion of the emergency by the cabin crew, the senior flight attendant establishes a connection with the ATC.

An event can contain only three key and critical components: (1) a modern aircraft with high automation; (2) a flight attendant; and (3) an instructor pilot with up-to-date experience in direct ATC communication. The probability of the presence and composition of

these components is the highest. Since the simulator experiment proved the possibility and likelihood of a successful completion of the flight, standards and regulations for emergency actions can be formed,

Discussion. The existing description of the PI subject is blurry and needs to be more clearly defined. The basis for the determination can be the outcome of the flight: if the flight ended safely, then the pilot and crew were able to work properly. PI studies confirm the "U-profile" of the pilot's age-related dependability. In older age groups of pilots, the probability of PI is more than twice as high as the probability of PI at a young age. Statistical samples of most PI studies cannot be considered representative and sufficient. It is argued that the risks of AA due to PI may be lower due to errors in retrospective assessments and analyses, erroneous perceptions and judgments of pilots about the facts of their actual capacitation. Partial PI may be more dangerous for a favorable end to the flight. Heart attacks are life-threatening, but they may still be partially functional. In the study, two AA occurred in cases of partial rather than complete PI: (1) due to acute fatigue, and (2) during a rough landing by a pilot who was wearing monovisual contact lenses. The current operational workload and flight fatigue play a crucial role in the probability of PI and API. PI should be considered in the context of crew capacitation. If the PI of a crew member leads to an increase in the unacceptable workload on the piloting pilot, the crew dependability resources are discriminated against. The PI event goes to the API event.

The results of the performed API simulator experiment in flight and numerous experiments of training sessions show the likelihood of a possible successful completion of ED situation in case of loss of crew capacitation. The cabin depressurization has a decisive impact on the appearance of PI and API. The development of the method can be carried out in solving the problems of automated event detection and aircraft control from the ground.

Conclusion. This paper describes the heuristic content of an extremely complex event, tasks and method of API ED and forced control of the aircraft by a third party. The heuristic approach is the only possible way to start forming this subject of research and development. To promote the method, an extended model of experimental simulations is needed. The result of such research is an analysis and method for developing standards and guidelines for joint actions of people on board

in a state of extreme danger and ground-based flight operations and emergency services.

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Этапы развития российских промышленных компаний

Аннотация: Рассматриваются условия и этапы адаптации отечественных промышленных компаний при переходе к рыночной экономике. Отмечается, что на первых трех этапах вплоть до 2014 года стратегические перспективы компаний определял поиск способов встраивания их производственных и технологических возможностей в мировую экономику. Рассматривалось ускоренное инновационное развитие и переход к «экономике знаний». Возможность такого перехода базировалась на поддержке малых инновационных предприятий (МИПов), способных осуществить такой переход. В качестве основных сформулированы задачи концепции.