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Repository Citation

Petrenko, O. (2015). Possibilities of Using the On-Board Intelligent Voice Informing Systems in Complex Flight Situations. *18th International Symposium on Aviation Psychology*, 49-54.
https://corescholar.libraries.wright.edu/isap_2015/99

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POSSIBILITIES OF USING THE ON-BOARD INTELLIGENT VOICE INFORMING SYSTEMS IN COMPLEX FLIGHT SITUATIONS

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The paper discusses expediency and possibility of using the on-board voice informing systems aimed at issuing messages which help recognize hazardous scenarios and work out correct strategies of flight crew activities. Important possibilities of man-to-machine speech interactions in intelligent cockpits analyzed taking into account the wide range of psychological characteristics of speech. Voice channel of machine-to-man interaction regarded as one of the tools of effective conjugation of capabilities of intelligent cockpit and human's special heuristic potential. In the context of cockpit intellectualization prerequisites for the voice information reporting system functions transformation appear. The concept and flowchart of Intelligent Voice Support System (IVSS) is described and proposed as a mean of assistance for realization of human potential in a perspective socio-technical systems.

In the current context, automation is characterized by the brand new features which bring about changes in approaches to the management and support of a man-machine interaction. The systemic thinking becomes one of the most important approaches to hazard analysis and scenario forecasting (Leveson, 2013). That also requires implementation a new technologies of informing a crew for control of a situation. These technologies must comply with peculiarity of work at the modern automated workplace. Information technologies expansion led to the automation of the most complicated control processes traditionally subject to being managed by human beings only. Automation systems get the artificial intelligence characteristics somehow approximating to the human abilities. Nevertheless, the exceptionally high potential of a human being in the process of heuristic problems solving makes it necessary to construct such a man-machine interaction system which could be optimal in the context of on-board systems intellectualization still having a human being as an active control manager.

A review of recent papers shows that current man-machine systems and interfaces construction concepts reflect approaches aimed at providing a human with information of general nature as, for example, in a brand new multimodal avionics cockpit called "intelligent cockpit". The idea of intelligent cockpit finds its implementation in the construction of "Intelligent Situation-Aware Crew Assistant System" and a man-machine interface "Anticipation Support for Aeronautical Planning" (Mouthaan, Ehlert, Rothkrantz, 2003). As we can see, all above-mentioned approaches build bridges to brand new changes in the crews professional activity process structuring and transformation of their activity operational nature.

Given that the main special quality of man is his ability to heuristic activity, it is strategically correct that automated cockpit is evolving towards best conditions for such tasks as scenario forecasting, understanding the flight situation as a whole, planning, development of new algorithms for action, decision-making under conditions of lack of information (Petrenko, 2013). This is an activity which a human performs better than a machine but in order that man could realize their full potential, it must be sufficiently man-machine conjugation.

It is obvious that man-machine interaction construction approaches should provides means of this interaction and nature of the problems solved in the process of this interaction to be in harmony with each other. There are researches which make it possible to impose a task of monitoring and considering of a current human operational abilities on the on-board systems (Dorneich, Passinger, Beekhuyzen, Hamblin, Keinrath, Whitlow & Vašek, 2011). These developments allow flexible redistribution of the control tasks among crew members taking into account each human being individual status, as well as setting aside of low grade tasks reducing information stream intension with respect to the operational situation priorities.

Low grade tasks elimination may be very important at certain moments, but it is not a goal in itself. Moreover, solving problems of such type may be useful for a human being as for keeping the best control over pace of possible changes and being ready to react immediately to any deviation (P. Schutte). Nevertheless, under the conditions of technologies and automation systems becoming more and more reliable and correct, the main safety threat results from the human assessments, priorities and strategies system. Therefore, the question what and how information for human should provide the intelligent cockpit systems, must be addressed from the standpoint of creating the conditions for the disclosure of exceptional opportunities of a man. We should talk not only about unloading a human giving them more opportunities to solve heuristic tasks but providing human beings with a direct assistance in the process of tackling in the new situation of almost partnerships human and intelligent machine. But the question is what kind of tasks such a cockpit must perform and how intelligent onboard systems should convey to human the results of their capabilities.

Considering a relation between human intelligence and a speech function the use of a voice channel for conjugation of capabilities of intelligent cockpit with the potential of human is causing a particular interest. It can be assumed that verbal modality is one of the most promising channels of machine-to-man interaction in conditions of intelligent cockpit. The validity of this opinion becomes even more apparent when we begin to analyze the psychological characteristics of speech and compare them with the requirements for the channels of machine-to-man interaction in such workplaces.

The meaning and difficulties of use a speech in machine-to-man interaction

Voice information reporting system available performs the task of issuing a message of a clearly defined nature and time point. Typically such message contains information on the event or an important parameter value which requires corresponding actions to be taken, as well as a prompt about necessary current action to be applied. In all these cases the choice of a voice modality for information submitting is determined by considerations of information processing visual channel saturation and switching to the less loaded information channel, situation urgency and immediate important command performance, data collection time-saving, signal correct acceptation provision, information perception provision under the conditions of multitasking activity.

The analysis of both the crew activities in the context of the highly automated cockpit and new intelligent cockpit possibilities connected with achievements in the IT field allows to emphasize new different aspects of the voice information reporting system usage ideology relying on the role of speech for the human activities.

Ability to speak is a key feature of a human being. It is the speech that corresponds best to all represented as highly polysemious and infinite because it’s connected with the human

intelligence ability for abstract thinking. Speech has large information capacity. It meets the requirement of submitting highly generalized information to the best advantage.

It was noted that man's verbal abilities are very intimately related to his planning abilities (Miller, Galanter, Pribram, 1960, p. 38). Speech properties allow its successful usage for the human consciousness meta-structures control. The sample of such a meta-structure is a generalized flight image which contains a number of interrelated components including motivational and emotional ones. Speech makes it possible to represent a generalized event forecasting or describe preferable acting strategies, form a correct decision quickly or direct the data collection process to the necessary way.

Speech also has a great suggestive potential owing to which a spoken message is able to run through the mind dominance. Speech can help in stereotypes coping, liberating from illusion, mobilization of individual resources. Thus, automated *voice* instructing may be helpful while executing the complex manoeuvre when the sensory component of immediate perception within the multicomponent acting image can interfere with a pilot activity, especially in nontypical situation. Conceptual element integrated to the acting image allows its rational correction when necessary.

Speech is also connected with the adaptation to the social structure. It is considered that the need in such adaptation is one of the Homo Sapiens language abilities actualization factors, and social and psychological adaptation is connected with finding a common language in a team. Ability to speak is also the way for a human to identify a speech partner of a like nature.

In this regard, it is interesting to note that a number of researches comprehends changes not only of a person’s activity nature while interacting with equipment, but also of operator teams and crews functioning nature while working in the specific environment of the intelligent technological systems. This refers, in particular, to the “hybrid team” (Eschen-Léguedé, Knappe, Keye, 2011), as a significant phenomenon, when a machine becomes a symbiotic partner of a human and is perceived by them as another crew member or as an extension of their own mind.

It was shown that working successfully in highly automated Human-Machine-Interfaces in a “hybrid team” conditions demands different aspects of personality and attitudes. It should be noted that the concept of "team" is directly related to the concept of "communication" and also "personal communication», which has speech as a main modality. That’s why the usage of speech in man-machine interaction is expected to promote the garmonization of the “hybrid team”.

Approaches to the construction of onboard intelligent voice support system

The foregoing affords ground for giving more thought to the creating of a brand new man-machine verbal interaction systems being different from the voice information reporting systems available and realizing perfectly the speech capacities in man-machine interactions. The essence of the difference is seen in using voice modality not just as one of the alternative channels for the reliable single information signal deliverance but as specific means of transmitting of highly generalized capacious information which reflects the combination of the current situation aspects and tendencies. Development of such systems presents severe difficulties. Speech capacities when deal with polysemous notional units run into the problem of possible information understanding distortion risk. There arises the task to overcome controversy between need to use complex notional units and provision of the sense distortion elimination.

The problem of a correct message understanding in the “human-human” interaction is solved due to the process of dialogue when the ambiguity can be eliminated in the context of the

discourse. Similarly, discourse is important for machine-to-man interaction. Therefore machine-to-man interaction should be realized as a continuous process of tracking of crew activity, rather than separate episodes. Still another approach to the providing of the accurate meaning transmission, to our mind, may involve issuing tuple of several alternative meaning-like statements outlining the conceptual field that allows neutralize subjective perception variations of meanings.

The voice informing of a human in the intelligent cockpit should be fulfilled taking into account the human being state. It obviously deals with both message meaning and form. Creating of the adaptive voice information reporting systems suggests using message construction algorithms based on the situation pattern processing and a human being state data in the aggregate.

Interaction suggests two-way communications. There naturally arises a question on the expedience of uniting of the voice information reporting system and the crew voice messages perception system. Poll held by us showed that psychologically to a greater extent air line pilots are ready to work with intelligent voice information reporting systems rather than with voice control systems [3]. Another common factor represented the correlation between the positive attitude to the opportunity of verbal interaction with on-board systems and positive attitude to the cockpit automation. Sceptical attitude to the prospects of possible verbal interaction with on-board intelligent systems was expressed only by 27% of the pollees. Greater degree of readiness among pilots to work with intelligent voice information reporting systems rather than with the voice control systems can be explained by the fact that for the operator the voice reaction task is more difficult than the task to react to the voice. This fact was confirmed in the process of our laboratory study when the multitasking voice-inclusive operator acting conditions simulator was used. Differential voice information processing was experimentally followed by errors of 8% of the testees whereas differential voice commands issuing errors were made by 20,6% of the same testees.

It’s obvious that the active voice function is more effort-taking for a human being and in an extremely tense situation it the one which would suffer more than the voice perception function. It affords ground to view the voice information reporting systems as the top-priority means of the man-machine verbal interaction assigning a support role to the crew members voice processing systems with no need for the crew to issue any specific voice commands. It seems possible for the whole crew voice activity to be specifically processed. Its analysis will allow to assess the crew members functional state and their subjective perception of the situation urgency. This speech analysis is informative in terms of tempo, intensity, intonations, frequency spectrum as well as content and conceptual harmony (speech act completeness, clarity, timeliness, adequacy). Analysis of the crew verbal interaction actual implementation correspondence to the regulations of standards and current circumstances allows to consider the beginning of the professional experience deformation process as the breakdown presage. Here we can refer to the professional experience deformation model empirically confirmed (Karapetian, Mikhailik, Pichko, Prokof’ev, 1989). According to this model, the professional experience has a multilayered structure and in tense acting situations the process of this structure deformation spreads from the outer layers to the deeper ones. Furthermore, the very first to be destructed is the outer layer, the one of the crew members interaction experience including its immanent speech component, then the cognitive, voluntary and motor layers as follows.

Figure 1 shows the Intelligent Voice Support System (IVSS) implementation model offered by us. It consists of two units, namely unit of situations and scenarios recognition and unit of voice transactions generating.

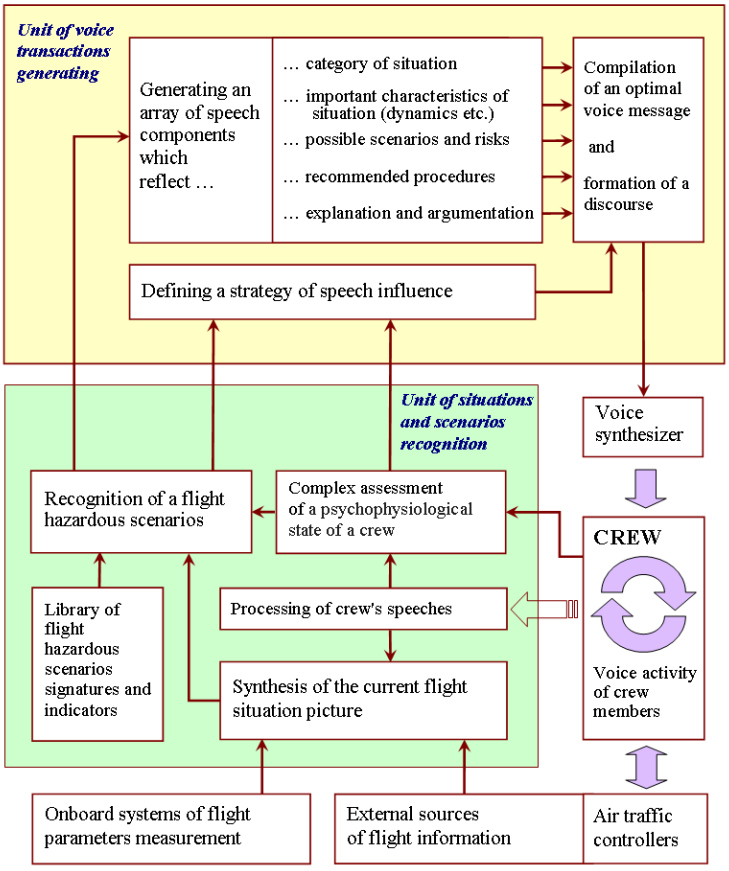

Figure 1. The flowchart of Intelligent Voice Support System (Petrenko, 2014-2015)

The main task of this system is to prevent choosing dangerous and unreasonable strategies for the crew performance, as under the conditions of various situations and circumstances they can provoke rise of nonadequate attitudes and stereotypes, faulty assessment of its abilities by the crew, etc., and lead to violation of the set principles, rules and standard operational procedures endangering the safety.

For the purpose of setting the requirements to the construction of the on-board voice support system messages which are able to help crews to recognize and overcome the flight hazardous scenarios, at the present time we launched an empirical investigation involving in it a sample group of pilots of different flight performance experience. It is expected that this investigation results would allow to take a step closer to understanding of the main principles of the voice warning and recommending transactions generating.

Conclusion

In the context of aircraft cockpit intellectualization prerequisites for the voice information reporting system functions transformation appear. IT state-of-the-art allows on-board voice information reporting systems to use speech specific properties connected with high information capacity, polysemous notional units representation possibility and highly generalized information representation. Development of real systems based on the proposed concept of IVSS requires a depth psychological researches to clarify principles of formation and patterns of understanding machine speech messages including in the context of flight crew activities.

We note finally that the focus on the complex concepts operated by the professional in their activities means eventually the focus on their professional weltanschauung, understanding of their personal role and limits, personal ambitions, etc. This affords ground to consider the intelligent voice support system construction as a forerunner of a human factor control new ideology formation in aviation. The idea is focused on the personality of the professional, not on the individual with a number of cognitive abilities. Though it is easy to say, hard to do, we hope "hard" involves its being of great interest.

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