EVALUATING THE EFFECTIVENESS OF CREWS OF AN AIRCRAFT

Malishevsky, Alexei V. – Ph.D. (Tech), associate professor of St. Petersburg State University of Civil Aviation, St. Petersburg, Russia.
Brovkin, Pavel E. – Ph.D. student of St. Petersburg State University of Civil Aviation, St. Petersburg, Russia.
Vlasov, Evgeny V. – Ph. D. student of St. Petersburg State University of Civil Aviation, St. Petersburg, Russia.

ABSTRACT

The article provides an analysis of the results of a series of experiments conducted during 2003–2013 years with professional pilots, air traffic controllers and students-pilots of University of Civil Aviation to assess the effectiveness of cooperation in working pairs of crew members of aircrafts. The main criteria were the style of behavior, which served as an integral indicator of a person's readiness to perform joint functions and prognostic socionic criterion based on intertype relations. The article shows correlation of received parameters with data of color sociometry and computer tests.

ENGLISH SUMMARY

Background. The problem of errors in designation of crew of an aircraft remains outside the attention of international aviation community as contrary to «mainstream» existing now. Nevertheless, the relevance of a problem is rather convincingly illustrated by a sad example of crash of Boeing 737–505 of Russian airline «Aeroflot-Nord», which occurred on the 13th of September 2008 in the area of Bolshoe Savino (Perm). In the «Final report on the results of investigation of the accident» of Interstate Aviation Committee commission it was stated that «designation of a crew was carried out without taking into account the level of training of the aircraft commander (hereinafter- AC), and the second pilot. Besides AC with little experience in this position, in the binomial crew the second pilot was appointed, having little experience on this type of aircraft; both pilots had previously performed flights only in the multi-crew. According to independent experts- psychologists, while crew designation individual psychological features of pilots were also not taken into account».

There are people who are very difficult and sometimes even impossible to effectively interact with. And the training program «cockpit management» [1] cannot completely correct this situation. The authors believe that it is necessary to develop techniques which, if not provide an optimal selection of crews, at least will not allow to designate a crew with obviously inappropriate people.

Objective. The objective of the authors is to analyze the results of experiments conducted during 2003–2013 years with professional pilots, air traffic controllers and students-pilots of University of Civil Aviation to assess the effectiveness of cooperation in working pairs of crew members of aircrafts.

Methods. The authors use analytical method and description.

Results. At the level of existing official documents in the field of civil aviation (hereinafter- CA) of the Russian Federation the problem itself is not rejected in principle and its solutions are even declared. In the relevant «Guide» [2] it is proposed to use «Recommendations› [3] for it, but they cannot, alas, forecast the effectiveness of interaction in the formed crew, as they are based on the methods of sociometry, i. e. all team members should be familiar with each other's teamwork.

Other prognostic approach is required that would reasonably answer the question of the suitability of a formed crew. Such a forecast that meets the modern requirements for aviation safety (hereinafter- AS) [4], as has been repeatedly stressed (for example, [5–9]), can be obtained using socionic techniques.

On the basis of socionic model of intertype relations (hereinafter-SMIR) [5] at various times it has been proposed to calculate such prognostic socionic performance criteria (hereinafter-PSPC) as צ [6, 7], $צ_{02}$ [8] and $צ_{03}$ [9]. In our experiment we used $צ_{04}$, which was determined from the expression:

$$צ_{04} = צ_{(+)} - צ_{(-)},$$

where $צ_{(+)} = (6\Omega_1 + 6\Omega_3 + 6W_5 + 6W_7 + 3W_9 + 3\Omega_{11} + 3\Omega_{13} + 3\Omega_{15}) / 8;$

$צ_{(-)} = (6\Omega_{16} + 6\Omega_{14} + 6\Omega_{12} + 6\Omega_{10} + 3W_8 + 3W_6 + 3W_4 + 3\Omega_2) / 8;$

Ω_i is i-th component of SMIR, calculated for intertype relations (hereinafter- IR) according to V. V. Gulenko [5, 10].

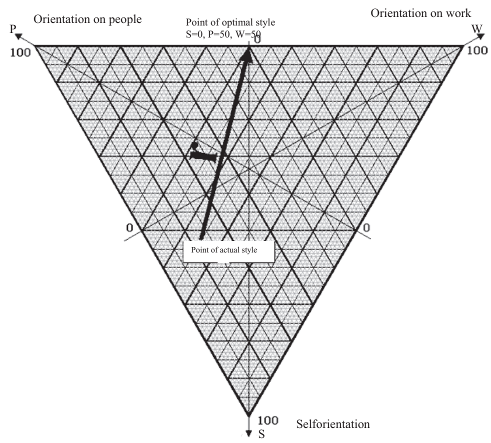
Another criterion for evaluating the effectiveness of interaction in the crew is a style of behavior of its members. In the first program «Cockpit Resource Management» (CRM) [11] R. R. Blake and J. S. Mouton actually equate these concepts. Style of behavior is an integral indicator of a person's readiness to cooperate. At the moment, it is considered only as characterizing the human personally and is not used for assessment of joint action in the pair. Our article is an attempt to revise the conventional approach.

According to S. I. Ozhegov, «style» is «a method, a set of techniques of any work, activity, behavior», that reflects the holistic human behavior, as the way he «usually behaves› [12]. With the help of the method «MMYA-1» [13], developed at St. Petersburg State University of Civil Aviation, the style of behavior is just determined in the manner, which clearly shows at what vector of human interests it is directed.

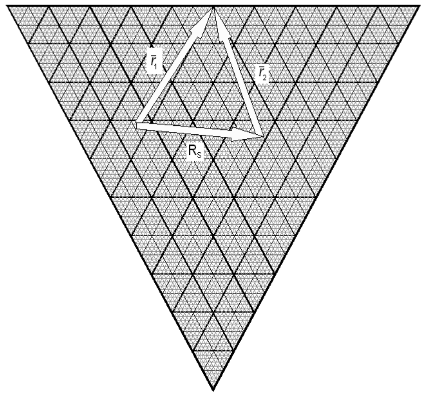
«Different motives form a complete structure – orientation of a personality, which is characterized primarily by hierarchical pattern, availability of dominant motives that define the basic vectors of activity of a person (in relation to reality, other people, and himself as a predominant focus on a substantive work, on other people, on him personally). So S.L.Rubinstein considered such an orientation as dynamic trends that determine human activity as motives› [14]. (It should be noted that, although with the filing of the authors [11] in the CRM program it is accepted to use the term «style of behavior», in fact we are talking about «style of activity».)

Developing the first program of CRM, R. R. Blake and J. S. Mouton used in the established «Grid» [11], only two basic orientations allocated by So S. L. Rubinstein: on substantive work and on other people. In the grid of University of Civil Aviation μ_2 [15] there are all three main orientations of a person (Pic. 1) that has complicated the classification of styles of behavior, but has made it more complete.

In the published article there is an attempt to use the data on individual styles of behavior of persons in the pair, for the prediction of the effectiveness



Pic. 1. Grid μ_2 [13,15] (by S. L. Rubinstein [14], orientation on substantive work (W), other people (P) and on yourself (S)). Determination of r value.



Pic. 2. Evaluation of effectiveness of interaction with the sum (Σ_S) and difference (Δ_S) of modules of vectors defining an individual style of behavior on the grid μ_2, and the distance between the points that define an individual style of behavior on the grid μ_2 (R_S).

of their interaction, that is, an attempt to assess how combination of individual styles of behavior is combined with the efficiency of the interaction. For that purpose we consider the sum (Σ_S) and difference (Δ_S) of modules of vectors defining the individual style of human behavior on the grid μ_2, and the distance between the points that define an individual style of behavior on the grid μ_2 (R_S) [13, 15]. Values, taken for evaluation and shown in Pic. 2, are found from the expressions:

$$\Sigma_S = \left|\overline{r_1}\right| + \left|\overline{r_2}\right|;$$

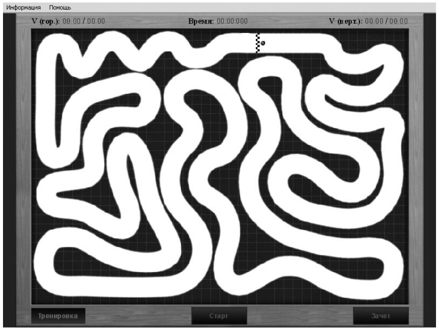
$$\Delta_S = \left\|\overline{r_1}\right| - \left|\overline{r_2}\right\|;$$

$$R_S = \sqrt{(Э_1 - Э_2)^2 + (Л_1 - Л_2)^2 + (P_1 - P_2)^2},$$

where $Э_i$, $Л_i$, P_i are coordinates on the grid μ_2, defining an i-th style of behavior;

$\left|\overline{r_i}\right| = \sqrt{Э_i^2 + (Л_i - 50)^2 + (P_i - 50)^2}$ *is a module of a vector on the grid μ_2, defining i-th style of behavior ($i = 1,2$).*

It was assumed that the higher is each of these three values, the lower will be the efficiency of interaction in the pair. In the first case, simply because both members of the pair do not have enough good behavior styles, and in two other cases – because the styles are very different from each other.



Pic. 3 Graphical interface of a software product «Viper».

Clearly, such an approach does not take into account many factors, which ultimately affected the results obtained.

Additional criteria for evaluating the effectiveness of interaction were also cumulative – normativity (N), valence (V) and the overall evaluation on the color relation test (CRT) (Σ_{NV}), defined by the method of A. M. Etkind [15, 16], adequately described in [5–9].

However, the total normativity, valence and overall evaluation on CRT are integrated indicators, taking into account the background in the pair of people,

Table 1

Software products, used in experiments

Software product		Developers	Type of interaction	Reference to description
1	«Ring-2»	A.V. Malishevsky, E.V. Vlasov	motor	[17, 18]
2	«Azef»	A.V. Malishevsky, E.V. Vlasov	motor	[17, 19]
3	«Chkalovsky-2»	A.V. Malishevsky, P.E. Brovkin	motor	[20]
4	«Viper»	A.V. Malishevsky, P.E. Brovkin	motor	-
5	«Stels» (2nd version)	N.F. Mikhailik, A.V. Malishevsky, E.V. Vlasov	cognitive	[15, 17]
6	«Gomeostat»	A.V. Malishevsky, I.A. Parfenov	cognitive-motor	[6, 7]
7	«CrossCheck 1»	A.V. Malishevsky, E.V. Vlasov	cognitive-motor	[17]
8	«CrossCheck 2»	A.V. Malishevsky, E.V. Vlasov	cognitive-motor	[17]

Table 2

Correlation identified between indicators צ$_{04}$, N, T_{Ring}, T_{Azef}, ש$_1$ and ש$_2$ in the survey of 52 pairs of participants in the experiment

1-st value / 2-nd value	צ$_{04}$	N	T_{Ring}	T_{Azef}	ש$_1$	ש$_2$
צ$_{04}$		-0,3029	-0,2302	-0,1489	-0,1091	0,1108
N	P > 0,95		-0,0739	0,0666	-0,0933	-0,0096
T_{Ring}	P ≤ 0,95	P ≤ 0,95		0,0508	-0,0468	-0,1147
T_{Azef}	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		-0,0868	-0,0131
ש$_1$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		0,7516
ש$_2$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P > 0,999	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

Table 3

Correlation identified between indicators צ$_{04}$, N, T_{Azef}, $N_{ош.}$, ש$_1$ and ש$_2$ in the survey of 62 pairs of participants in the experiment

1-st value / 2-nd value	צ$_{04}$	N	T_{Azef}	$N_{ош.}$	ש$_1$	ש$_2$
צ$_{04}$		-0,1808	-0,0646	0,0133	0,0079	0,0903
N	P ≤ 0,95		-0,0175	0,1058	-0,2429	-0,0877
T_{Azef}	P ≤ 0,95	P ≤ 0,95		0,1386	-0,0711	-0,0576
$N_{ош.}$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		-0,1879	-0,2101
ש$_1$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		0,7188
ש$_2$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P > 0,999	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

Table 4

Correlation identified between indicators צ$_{04}$, N, as well as values T_{Ring}, T_{Azef}, $N_{ош.}$, ש$_1$, ש$_2$, L_{cp} and L_{max} in the survey of 33 pairs of participants in the experiment

1-st value / 2-nd value	צ$_{04}$	N	T_{Ring}	T_{Azef}	$N_{ош.}$	ש$_1$	ש$_2$	$L_{cp.}$	L_{max}
צ$_{04}$		-0,1646	-0,3954	-0,049	-0,1526	-0,0488	0,2385	-0,0458	-0,054
N	P ≤ 0,95		0,0605	0,0614	0,0735	-0,0884	-0,034	0,003	0,2893
T_{Ring}	P >0,95	P ≤ 0,95		0,0526	0,0174	0,0891	0,0499	-0,2168	-0,19
T_{Azef}	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		0,2347	-0,0934	-0,0692	-0,1734	-0,145
$N_{ош.}$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		-0,3424	-0,4142	0,2051	0,1489
ש$_1$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		0,7493	0,2024	0,1808
ש$_2$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P > 0,95	P>0,999		-0,0153	0,0703
$L_{cp.}$	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95		0,7956
L_{max}	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P ≤ 0,95	P>0,999	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

Table 5

Correlation identified between indicators צ_{04}, N, V, Σ_{NV}, Σ_S, Δ_S, and R_S in the survey of 914 pairs of participants in the experiment (professional pilots and students- pilots)

Performance indicators	צ_{04}	N	V	Σ_{NV}	Σ_S	Δ_S	R_S
צ_{04}		0,0182	-0,0205	-0,0014	-0,0884	-0,0833	-0,1553
N	$P \leq 0{,}95$		0,2823	0,8009	0,0731	0,0009	-0,0321
V	$P \leq 0{,}95$	$P > 0{,}999$		0,8006	0,1283	0,1025	0,0795
Σ_{NV}	$P \leq 0{,}95$	$P > 0{,}999$	$P > 0{,}999$		0,1257	0,0645	0,0295
Σ_S	$P > 0{,}99$	$P > 0{,}95$	$P > 0{,}999$	$P > 0{,}999$		0,3586	0,2241
Δ_S	$P > 0{,}95$	$P \leq 0{,}95$	$P > 0{,}99$	$P \leq 0{,}95$	$P > 0{,}999$		0,5579
R_S	$P > 0{,}999$	$P \leq 0{,}95$	$P > 0{,}95$	$P \leq 0{,}95$	$P > 0{,}999$	$P > 0{,}999$	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

Table 6

Correlation identified between indicators צ_{04}, N, Σ_S, Δ_S, and R_S in the survey of 2193 pairs of participants in the experiment (professional pilots, air traffic controllers and students-pilots)

Performance indicators	צ_{04}	N	Σ_S	Δ_S	R_S
צ_{04}		-0,0018	-0,0391	-0,0499	-0,0993
N	$P \leq 0{,}95$		0,0495	0,0255	0,0076
Σ_S	$P \leq 0{,}95$	$P > 0{,}95$		0,0361	0,0881
Δ_S	$P > 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$		0,5966
R_S	$P > 0{,}999$	$P \leq 0{,}95$	$P > 0{,}999$	$P > 0{,}999$	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

and the criterion צ_{04} estimates convenience for mainly information exchange between pilots. Therefore, the authors conducted development of alternative methods for direct estimation of the efficiency of interaction in the pair of crew members of an aircraft. One of these was the use of special software (see. Table 1).

Software product «Viper» (here we cannot provide a reference to its description, because it is fairly new), as well as software products «Ring-2» [17, 18], «Azef» [17,19] and «Chkalovsky- 2» [20], have a task designed for testing motor interaction in the pair and monitoring its effectiveness.

After activation of a file, launching a program, on a computer screen program interface is displayed, shown in Pic. 3.

The main menu consists of two submenus «Information» and «Help». The algorithm of the program provides a number of characteristics that influence the properties of a dynamic object, i. e. points. Activating the item «Settings› on the screen we get a dialog window for changes of «Dynamic object properties› and «Evaluation criteria». Through control keys two persons under test should as soon as possible carry a red point from start to finish through a complex circular route. Touching lateral boundaries of the route is penalized with temporary loss of control; point is repainted from red to blue. One testee controls a point in the horizontal plane and the other in the vertical.

At the top of the graphical interface of the exercise current speed parameters of the point in both horizontal and vertical planes with the maximum speed reached in a game, through the inclined line are displayed. Here, information is presented as time counter. At the bottom there are three buttons: «Training», «Start», «Passed». Mode «Training» is designed to familiarize participants with the process of the exercise. It ends after the completion of the travel route completely, and relevant information appears. Then automatically a window «Results› appears with current and previous results.

All software products, listed in Table 1, were used in varying degrees in the course of experiments with pilots in 2003–2013.

In order to somehow compare mixed results, according to the results of several exercises some mean overall evaluation of the effectiveness of interaction ($\aleph_\Sigma$) was introduced, which, of course, is not quite correct, and is suitable only for very approximate estimations. Experimental conditions were also somehow different, which also left its negative impact on the final result.

As shown in Table 2–4, a satisfactory solution of the problem has not been found yet. Results of the test are not well joined to one another.

In Tables 2–4 the following notations are used:

- *$T_{Azef} = T_{уд.F}$ – time for keeping «bar» within acceptable limits;*
- *T_{Ring} – time of passage of turnout angle of a fixed path;*
- *$N_{ош.}$ – number of errors committed during the period of 300 s;*
- *$L_{ср.}$ (м) – average linear cross track angle of turnout angle;*
- *L_{max} (м) – maximum linear cross track angle of turnout angle on the final section (length 2 km) of a fixed path;*
- *ש_1 – average score for two testees in the exercise «CrossCheck2» (the worst result);*

Table 7

Correlation identified between indicators צ_{04}, N, V, Σ_{NV}, Σ_S, Δ_S, R_S and $\aleph_\Sigma$ in the survey of 61 pairs of participants in the experiment (professional pilots and students- pilots)

Performance indicators	צ_{04}	N	V	Σ_{NV}	$\aleph_\Sigma$	Σ_S	Δ_S	R_S
צ_{04}		-0,0961	0,2217	0,0825	-0,039	0,0044	0,1102	-0,2532
N	$P \leq 0{,}95$		0,1971	0,7705	0,04	0,2747	0,2444	0,1754
V	$P \leq 0{,}95$	$P \leq 0{,}95$		0,7768	0,0303	0,091	0,317	-0,0429
Σ_{NV}	$P \leq 0{,}95$	$P >$	$P >$		0,0454	0,2356	0,3631	0,0848
$\aleph_\Sigma$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$		0,1119	0,2121	-0,0235
Σ_S	$P \leq 0{,}95$	$P > 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq$		0,282	0,2086
Δ_S	$P \leq 0{,}95$	$P \leq 0{,}95$	$P > 0{,}95$	$P > 0{,}99$	$P \leq$	$P > 0{,}95$		0,4288
R_S	$P > 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq$	$P \leq 0{,}95$	$P >$	

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

Table 8

Correlation identified between indicators צ_{04}, N, Σ_S, Δ_S, and R_S and $\aleph_\Sigma$ in the survey of 130 pairs of participants in the experiment (professional pilots and students- pilots)

Performance indicators	צ_{04}	N	$\aleph_\Sigma$	Σ_S	Δ_S	R_S
צ_{04}		-0,0798	-0,0492	-0,0879	-0,0764	-0,2313
N	$P \leq 0{,}95$		0,0243	0,1504	0,137	0,0822
$\aleph_\Sigma$	$P \leq 0{,}95$	$P \leq 0{,}95$		0,0528	0,0781	-0,0602
Σ_S	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$		0,1942	0,1414
Δ_S	$P \leq 0{,}95$	$P \leq 0{,}95$	$P \leq 0{,}95$	$P > 0{,}95$		0,5633

Right and at the top there are values of Pearson correlation coefficient [13] between the performance indicators, and left and at the bottom – significance characteristics of the correlation.

• *ש_2 – average score for two testees in the exercise «CrossCheck2» (the best result);*

As it can be seen from Tables 2–8, the largest discrepancies with the rest of the results were valence (V), the total evaluation on CRT (Σ_{VN}), as well as time for keeping «bar» within acceptable limits (T_{Azef}) in the exercise «Azef». In the exercise «Ring-2» a scatter of the results is very small.

Exercise «Azef» includes tasks for development of anticipation of a pilot. Being very useful for training and workout, it is too sensitive to random errors. This greatly reduces the possibility of the exercise for diagnosis of the efficiency of interaction.

Exercise «CrossCheck 1» is a task for developing cognitive-motor interaction in the pair in the mode of cross-monitoring and evaluation of its effectiveness. As it can be seen from Tables 2–4, it showed sufficient match with almost all experimental results, except for the exercise «Azef». But then a nuance appears. In older age groups, there are problems associated with the use of a personal computer: the great response and acceptable coherence they have insufficient motor skills in the application of input / output devices, which adversely affects the timing of the exercise and the result. (In other words, some older pilots have difficulties finding necessary symbols on a keyboard.) At the same time, for the younger generation this problem is not relevant and, therefore, additional correlation of the experimental results and the age of persons under tests is natural.

Exercise «Stels», although it has been proven successful in trainings in the training program «CRM Russia» [15], but as a performance criterion has a low distinctive character in a quantitative aspect. But the exercise «Gomeostat» is overloaded with specificity and does not reflect interaction in a pure form. In general, we can make a disappointing conclusion that there is no breakthrough in the field of direct quantitative assessment of the effectiveness of interaction in the pair.

Similar conclusions can be made when considering the tables 5–8. Integral assessment $\aleph_\Sigma$ very weakly and often not in accordance with the theoretical predictions correlates with other performance criteria (Table 7–8).

If we take the results shown in Tables 5 and 6, the sign of the correlation coincides with the projection in 29 cases out of 31, i. e. 93.5% of cases. Moreover, only in 12 cases (38, 7%) the correlation is insignificant. In other cases, it is significant (16, 1%), highly significant (6, 5%), and even very highly significant (38, 7%). In the correlation between values N and Σ_{NV}; V and Σ_{NV}; Δ_S and R_S – this is trivial. At other times – no. From Tables 5–8 it is clear that as one of the possible prognostic criteria of the effectiveness of the interaction can be considered the value R_S.

Conclusion. *Although it is clear that the problem posed in the article is still very far from its solution, obviously, that the planned ways of its solutions are of great interest, and firstly, the further accumulation of statistical material (with a correct statement of the experiment) is required, and secondly, attraction of multivariate statistical analysis is necessary, because in some cases the reasons for weak correlations are on the surface and are related to the influence of factors unaccounted by the authors of this article.*

Keywords: *civil aviation, crew, interaction, style of behavior, socionic characteristics, performance criteria, intertype relations.*

REFERENCES

1. Federal Aviation Regulations: Preparation and execution of civil aviation flights of the Russian Federation [*Federal'nye aviatsionnye pravila: Podgotovka i vypolnenie poletov v grazhdanskoy aviatsii Rossiyskoy Federatsii*]. Moscow, Vozdushnyj transport publ., 2009, 86 p.

2. Guide to psychological support of selection, training and professional work of pilots and controllers of civil aviation of the Russian Federation [*Rukovodstvo po psihologicheskomu obespecheniyu otbora, podgotovki i professional'noy deyatel'nosti letnogo i dispetcherskogo sostava grazhdanskoy aviatsii Rossiyskoy Federatsii*]. Moscow, Vozdushnyj transport publ., 2001, 279 p.

3. Recommendations for flight crew designation and optimization of moral and psychological climate (p. I and II) [*Rekomendatsii po komplektovaniyu letnyh ekipazhey i obespecheniyu optimal'nogo moral'no-psihologicheskogo klimata (ch. I i II)]*. Moscow, GosNIIG A publ., 1985, 43 p.

4. Safety Management Manual (SMM). Doc. 9859-AN / 474. 2nd ed. [*Rukovodstvo po upravleniyu bezopasnost'yu poletov (RUBP). Doc. 9859-AN/474. 2-e izd*]. Montreal, ICAO, 2009,318 p.

5. Leychenko, S.D Human Factors in Aviation: In 2 vol. – Vol. 2 / Leychenko, S.D., Malishevsky, A.V., Mihaylik, N.F. [*Chelovecheskiy faktor v aviatsii: V 2 t. – T. 2*]. St. Petersburg, St. Petersburg State University of Civil Aviation publ., 2006, 506 p.

6. Arinicheva, O.V., Kovalenko, G.V., Malishevsky, A. V. et al. The study of management practices in the field of air transport with the use of socionic models [*Issledovanie metodov upravleniya v sfere vozdushnogo transporta s ispol'zovaniem sotsionicheskih modeley*]. *Polet*, 2008, No.1, pp. 45–49.

7. Arinicheva, O. V. Improvement of management practices of the system «crew-aircraft» by reducing negative impact of human factors on flight safety. Ph. D. (Tech.) thesis [*Sovershenstvovanie metodov upravleniya resursami sistemy «ekipazh-vozdushnoe sudno» putem snizheniya otritsatel'nogo vliyaniya chelovecheskogo faktora na bezopasnost' poletov. Dis ... kand. tehn. nauk*]. St.Petersburg, 2008, 199 p.

8. Malishevsky, A.V., Parfenov, I. A. Application of socionic models for management and planning in the field of air transport [*Ispol'zovanie sotsionicheskih modeley dlya upravleniya i planirovaniya v sfere vozdushnogo transporta*]. *Scientific Bulletin of Moscow State Technical University of Civil Aviation*, 2010, No. 154 (4), pp. 117–123.

9. Malishevsky, A.V., Brovkin, P.E., Abdusattarov, K.S., Said, S. S. The results of the direct determination of the efficiency of interaction conducted with students-pilots [*Rezul'taty eksperimentov po neposredstvennomu opredeleniyu effektivnosti vzaimodeystviya, provedennyh so studentami-pilotami*]. *Problems of flight operations and flight safety: Interuniversity collection of works*. Iss. VI., St. Petersburg, 2012, pp. 204–211.

10. Gulenko, V. V. What kind of relationship were built by Yung (intertype conditions of stability in the dyad) [*Kakie otnosheniya postroil by Yung (usloviya intertipnoy ustoychivosti v diade)]. Sotsionika, psihologiya i mezhlichnostnye otnosheniya,* 1998, July, pp. 45–52.

11. Blake, R.R., Mouton, J. S. Cockpit Resource Management (CRM). In 2 books. Book. 2. The managerial grid. 2nd ed. [*Cockpit Resourse Management (CRM). V 2 kn. – Kn. 2: «Upravlenie resursami kabiny soglasno setke «Grid». 2-e izd.*]. Austin, Scientific Methods, Inc., 1990, 133 p.

12. Ozhegov, S. I. Russian dictionary. 20th ed., stereotype [*Slovar' russkogo yazyka. 20-e izd., stereotip*]. Moscow, Russkiy yazyk publ., 1988, 750 p.

13. Special training in the field of human factors: guidelines for psychological diagnosis. Comp. by Arinicheva, O.V., Malishevsky, A.V. [*Spetsial'naya podgotovka v oblasti chelovecheskogo faktora: metodicheskie ukazaniya po provedeniyu psihologicheskoy diagnostik*i]. St. Petersburg, St. Petersburg State University of Civil Aviation publ., 2010, 74 p.

14. Allahverdov, V.M., Beznosov, S.P., Bogdanov, V.A. et al. Psychology: a textbook [*Psihologiya: uchebnik*], chief ed. Krylov, A.A., 2nd ed., rev. and enl. Moscow, Prospekt publ.; TK Velbi, 2008, 752 p.

15. Leychenko, S.D., Malishevsky, A.V., Mihaylik, N. F. Human factors in aviation: in 2 vol. Vol. 1 [*Chelovecheskiy faktor v aviatsii: V 2 t. – T. 1*]. St. Petersburg, St. Petersburg State University of Civil Aviation publ, 2005, 473 p.

16. Etkind, A. M. Color test of relations and its application in the study of patients with neuroses [*Tsvetovoy test otnosheniy i ego primenenie v issledovanii bol'nyh nevrozami*]. *Socio-psychological research in psycho neurology: collection of scientific works SRI psycho neurology n. a. V. M. Bekhterev*. Leningrad, 1980, pp. 110–114.

17. Vlasov, E. V. The use of applied software in the process of training of aviation personnel [*Primenenie prikladnogo programmnogo obespecheniya v protsesse podgotovki aviatsionnogo personala*]. *Problems of flight operations and flight safety: interuniversity collection of scientific works*. Iss. VI. St. Petersburg, 2012, pp.182–188.

18. Malishevsky, A. V. The results of experiments to evaluate the effectiveness of interaction conducted with students-pilots of University of civil aviation [*Rezul'taty eksperimentov po otsenke effektivnosti vzaimodeystviya, provedennyh so studentami-pilotami Universiteta grazhdanskoy aviatsii*]. In: Malishevskiy, A.V., Vlasov, E.V., Adilov, Zh.Zh., Vahabov, M. A. *Problems of flight operations and flight safety: interuniversity collection of scientific works.* Iss. V. St. Petersburg, 2011, pp. 53–59.

19. Malishevsky, A.V., Vlasov, E.V., Musahodzhaev, A.F., Saidhanov, T. H. Analysis of the results of an experiment to evaluate the effectiveness of interaction conducted with students-pilots of University of civil aviation [*Analiz rezul'tatov eksperimenta po otsenke effektivnosti vzaimodeystviya, provedennogo so studentami-pilotami Universiteta grazhdanskoy aviatsii*]. Problems of flight operations and flight safety: interuniversity collection of scientific works. Iss. IV. St. Petersburg, 2010, pp. 62–69.

20. Brovkin, P. E. Analysis of an immediate evaluation of effectiveness of cooperation in military aircraft of armed forces of the Russian Federation [*Analiz neposredstvennoy otsenki effektivnosti vzaimodeystviya v voennoy aviatsii vooruzhennyh sil Rossiyskoy Federatsii*]. *Problems of flight operations and flight safety: interuniversity collection of scientific works*. Iss. VI., St. Petersburg, 2012, pp. 171–181.

Координаты авторов (contact information): Малишевский А. В. (Malishevsky, A.V.) – 9909395@bk.ru, Бровкин П. Е. (Brovkin, P. E.) – pilot05bp@mail.ru, Власов Е. В. (Vlasov, E.V.) – jeka.vlasov@gmail.com.
Статья поступила в редакцию / article received 25.05.2014
Принята к публикации / article accepted 04.08.2014