New Methods for Air Traffic Controller Main Solution Taking Dominant Determination Concerning Their Attitude to Risk

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Taking into account the influence of human factor on flight safety one may say that ICAO flight safety main concept components mutually influence each other. This is based on the perspective of "aviation personnel attitude to safe actions and conditions" as the main factor of flight safety. This attitude may be found with help estimate usefulness functions construction and analysis for aircraft flight norms values based on air traffic controllers indexes in decision taking tasks. One way to find the main solution is taking dominant that defines air traffic controller attitude to flight level norms violation as to risk (tending, indifferent, non-tending to risk) is with the help of a "risk premium" criterion. Historically, the criterion included a single variable point in estimate usefulness function. Two improved criteria that include several characteristic points of usefulness function are proposed. As a result of new criteria appliance the main solution taking dominant determination efficiency increased up to 18 %.

Keywords: air traffic controllers attitude to flight norms violations, closed decision taking task, estimate usefulness function characteristic points, risk premium, efficiency of main solution taking dominant determination.

1. INTRODUCTION

Interaction of ICAO safety concept components from their influence on the human factor point of view may be presented in "aviation personnel attitude to risky actions or conditions" part, as it is shown in Figure 1.

For front line air operators their professional activity that directly influences flight safety (in positive and negative way) may be presented as continuous chain of processes and decisions implemented under the influence of various factors (objective/subjective, external/internal), especially different kinds of stochastic and deterministic risks [1, 2] being open or hidden from observation. Aviation institutions, specialists and researchers considering human factor as the main measure applied to assure required flight safety level [2-7 and others]. This means that researches of that area should include peculiarities of aviation operators decision taking technologies and procedures.

It is obvious that the mentioned "attitude" grounds on several components among which, in context of this paper, attention should be paid to block (i), that shows basic decision taking dominants (inclined to risk, not inclined to risk, indifferent to risk). Moreover, corresponding to ICAO recommendations about implementation proactive human factor strategies and alike, these dominants determination is deeply proactive [2, 8-13].

Motivation for gaining success (risk inclination) or avoiding failures (risk non-inclination) is defined by main decision taking dominant defines. Estimate usefulness functions parameters being built by limited number of key points received from special lotteries with open decision taking tasks are source to find there dominants. It should be taken into account that initially dominant determination procedures were used mostly in economical researches and they were brought and developed in air operators scientific area by professor O.M. Reva along with his scientific school representatives.

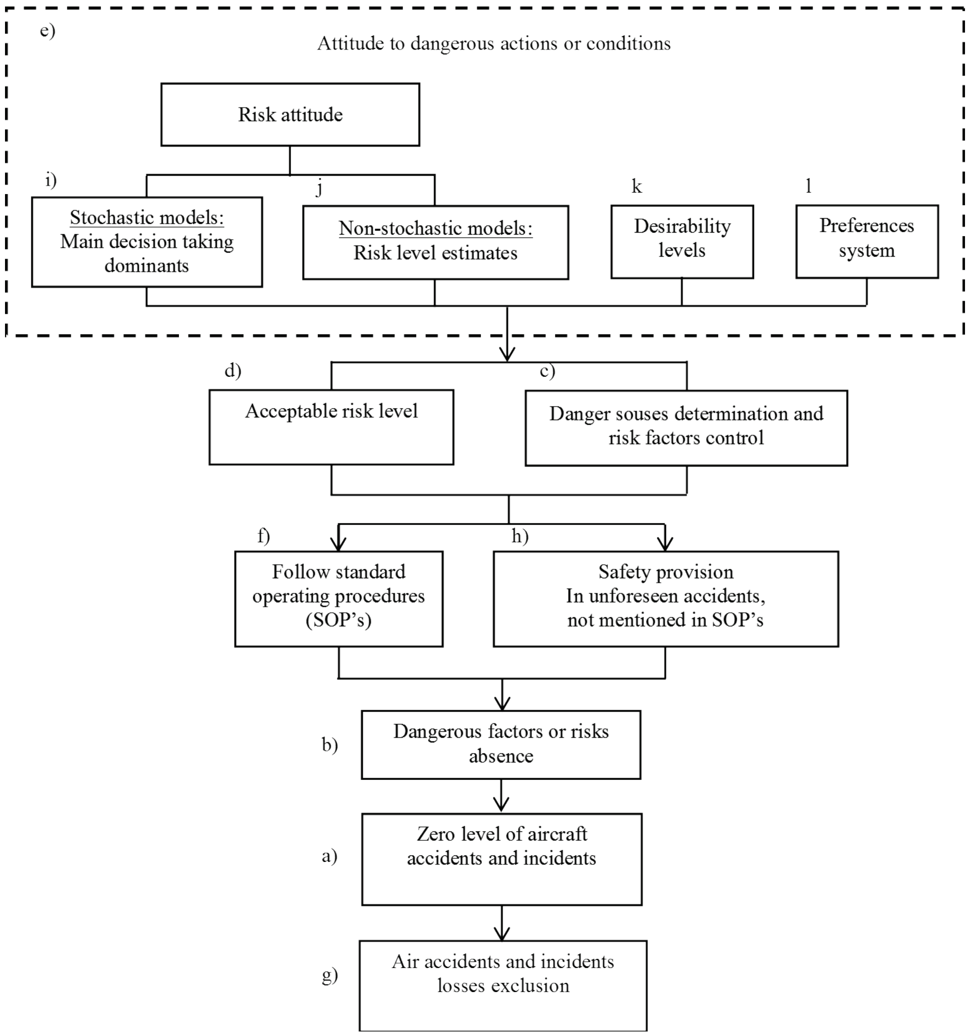

Fig. 1. ICAO safety concept components mutual influence concerning human factor.

2. PREVIOUS RESEARCHES

Classic estimate usefulness functions construction is based on three key points. Having usefulness $f_{UF}(S)$ equal to *0, 0.5* and *1* (for points $S_0, S_{0.5}, S_1$ correspondingly), estimate usefulness function were built for flight norms continuum S. Key points S_0, S_1 has predefined distance values of 0 km. and value equal to flight level norm defined by ICAO (for example 12 kn.). Distance for key point $S_{0.5}$ was selected by respondent. Three given key points were used to build usefulness function, that was used to define respondent attitude to risk.

ATC attitude to risk, i.e. main solution taking dominant, is found with help of risk premium. It is equal to ratio between taken flight norm median and usefulness 0.5 ($S_{0,5}$) lottery equivalent (fig. 2). In context of current research determined lottery equivalent is considered to be such distance between aircrafts in limits of certain flight level norm that makes air traffic controller indifferent in choice between its value or 50%-50% lottery between maximal and proposed minimal values (absolutely acceptable/satisfactory value and absolutely unacceptable/unsatisfactory value) [14, 15].

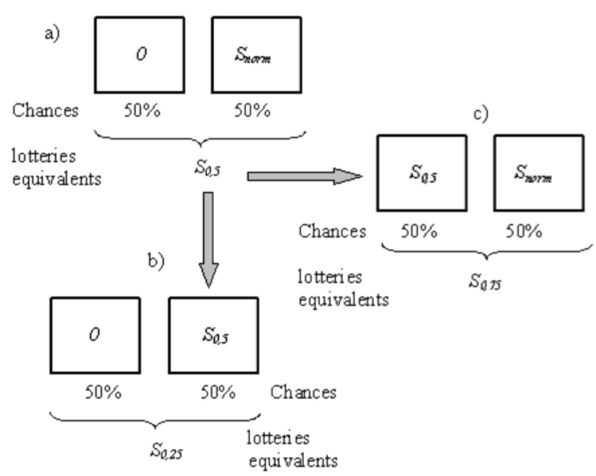

Fig. 2. Lotteries example.

A Received premium shows main solution taking dominant along whole norm interval.

$$RP_{S_{0,5}} = \bar{S} - S_{0,5} = \begin{cases} > 0 & \text{- noninclined to risk} \\ < 0 & \text{- inclined to risk} \\ = 0 & \text{- indifferent to risk} \end{cases}$$

where $\bar{S}$ - average lottery win, given at fig. 2 a):

$$\bar{S} = 0,5 \times S_0 + 0,5 \times S_1 = 0,5 \times (S_0 + S_1)$$

Tendency to risk i.e. motivation to reach the success here is taken as desire for playing the lottery to receive best possible distance value between aircrafts. Also when small desire means that respondent wants to avoid risk i.e. he is not inclined to it. Risk-indifferent respondents are considered to be “objective” since they has linear estimate usefulness function. Graphically, this is shown as excess of area above the usefulness functions line or its shortage. (fig. 3).

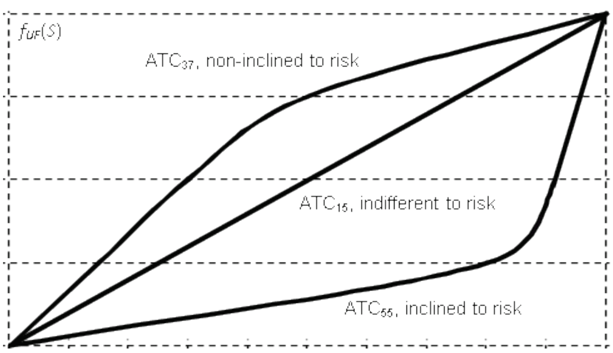

Fig. 3. Typical empiric individual estimate usefulness functions for flight norm continuum.

3. PROBLEM STATEMENT

From all stated above the goal of current research is development of enhanced criteria for main solution taking dominant determination on the base of risk premia.

4. RESULTS OF THE RESEARCH

To improve this method two more intermediate points $S_{0,25}, S_{0,75}$ were introduced. Increase in points number allows to build more complicated usefulness function that leads to precision increase.

Open task lotteries were used to find intermediate key points of usefulness function (fig. 2). While solving them respondents should state three determined usefulness lotteries equivalents for points $S_{0,25}, S_{0,5}, S_{0,75}$. As a result five key points $S_0, S_{0,25}, S_{0,5}, S_{0,75}, S_1 = S_{norm}$ were received. Their usefulness is defined and equal to $(0, 0.25, 0.5, 0.75, 1)$ and distances are predefined for S_0, S_1 (0 km., and current flight level norm distance). Other three distances are received from respondents answers (lotteries solutions).

First new method to find risk premium use areas of figure underlined by usefulness function (fig. 4).

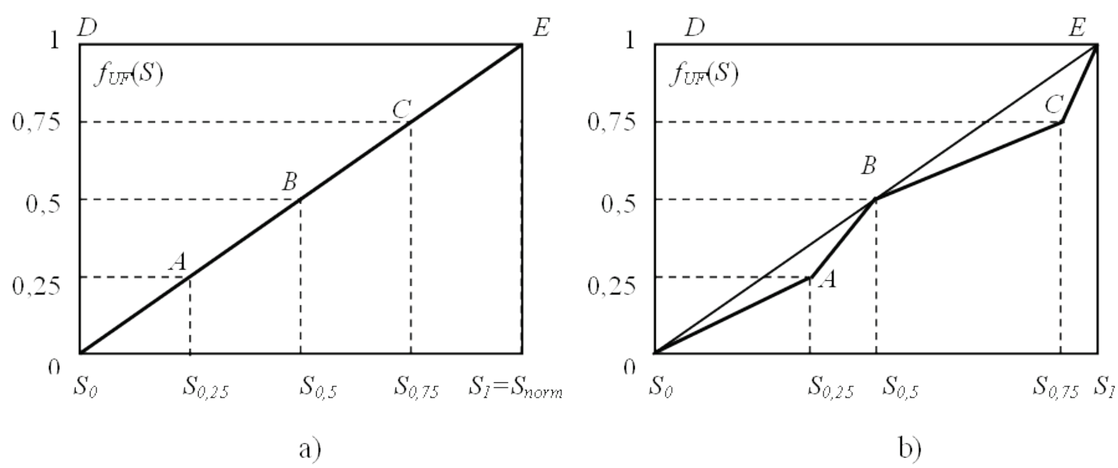

Fig. 4. Area method for risk premium determination by usefulness functions for: a) – risk indifferent respondent; b) – respondent with risk dependent attitude.

In general case area of S_0ABCES_1 figure, may be found by the following formula (based on geometrical properties of triangles and trapezes) regardless respondent's attitude to risk:

$$RP_L = L - L_{BDTD} = 2,5S_{norm} - L_{BDTD} = \begin{cases} >0 & - \text{non-inclined to risk} \\ <0 & - \text{inclined to risk} \\ =0 & - \text{in dim merent to risk} \end{cases}$$

$$Area\left(S_0ABCES_1\right) = S_{S_0AS_{0,25}} + S_{S_{0,25}ABS_{0,5}} + S_{S_{0,5}BCS_{0,75}} + S_{S_{0,75}CES_1} =$$
$$= \frac{1}{2}\Big\{S_{0,25}f_{UF}\left(S_{0,25}\right) + \left(S_{0,5} - S_{0,25}\right)\left[f_{UF}\left(S_{0,25}\right) + f_{UF}\left(S_{0,5}\right)\right] +$$
$$+\left(S_{0,75} - S_{0,5}\right)\left[f_{UF}\left(S_{0,5}\right) + f_{UF}\left(S_{0,75}\right)\right] + \left(S_1 - S_{0,75}\right)\left[f_{UF}\left(S_{0,75}\right) + f_{UF}\left(S_1\right)\right]\Big\} =$$
$$= \frac{1}{8}\left[S_{0,25} + 3\left(S_{0,5} - S_{0,25}\right) + 5\left(S_{0,75} - S_{0,5}\right) + 7\left(S_1 - S_{0,75}\right)\right] =$$
$$= \frac{1}{2}\left[\frac{1}{4}S_{0,25} + \frac{3}{4}\left(S_{0,5} - S_{0,25}\right) + \frac{5}{4}\left(S_{0,75} - S_{0,5}\right) + \frac{7}{4}\left(S_1 - S_{0,75}\right)\right] =$$
$$= \frac{1}{8}\left[7S_1 - 2\left(S_{0,25} + S_{0,5} + S_{0,75}\right)\right].$$

As a result risk premium in case of areas method will be equal to:

$$RP = S_{norm} - \frac{1}{4}\cdot\left[7\cdot S_{norm} - 2\cdot\left(S_{0,25} + S_{0,5} + S_{0,75}\right)\right] = \begin{cases} >0 & - \text{inclined to risk} \\ <0 & - \text{noninclined to risk} \\ =0 & - \text{indifferent to risk} \end{cases}$$

Second method, proposed for the same problem solution is based on the of key points $S_0, S_{0,25}, S_{0,5}, S_{0,75}, S_1$ projection to the X axis. Assuming that attitude to risk is absent and respondent is indifferent to risk, the result of linear estimate usefulness function summary index of projections will be equal to:

$$L = S_0 + S_{0,25} + S_{0,5} + S_{0,75} + S_1 = S_{norm} =$$
$$= 0 + \frac{1}{4}S_{norm} + \frac{2}{4}S_{norm} + \frac{3}{4}S_{norm} + S_{norm} = 2,5S_{norm}$$

Hence, for ATC indifferent to risk, inclined to risk and not inclined to risk individual summary indexes of key point projection into X axis should be equal to:

$$L_{ind.} = L \Rightarrow L_{ind.} = 2,5S_{norm}$$
$$L_{inc.} > L \Rightarrow L_{inc.} > 2,5S_{norm}$$
$$L_{non-inc.} < L \Rightarrow L_{non-inc.} < 2,5S_{НЕПС}$$

United together, this gives the following risk premium RP_L formula expressed through basic decision taking dominant L_{BDTD} of respondent indifferent to risk:

5. PRACTICAL IMPLEMENTATION

Real carried out research that used new methods included 132 air traffic control students from National aviation university and Kirovohrad flight academy (Ukraine) along with 70 professional air traffic controllers of main centre of united air traffic control system of state owned enterprise AZANS (Republic of Azerbaijan). Researches were carried out according to single method for eleven flight norms set by ICAO for horizontal plane including 1 norm for distance of 8 km., 4 norms for distance of 10 km., 1 norm for distance of 12 km., 4 norms for distance of 20 km., 1 norm for distance of 30 km.

According to calculations based on classical method received proportions of persons that tends (T), are indifferent (I) and doesn't tends (N) to risk is shown in table 1.

Table 1. Proportion of persons with different risk attitude for three data processing methods.

Norm # (distance)	Method 0,5			Projection method			Area method		
	T	I	N	T	I	N	T	I	N
1 (20)	5	34	90	6	20	103	6	20	103
6 (20)	2	23	103	3	12	113	3	12	113
8 (20)	3	31	93	3	21	103	3	21	103
9 (20)	5	29	92	**7**	**20**	99	**8**	**19**	99
2 (10)	3	25	101	5	8	116	5	8	116
4 (10)	2	20	107	**4**	5	**120**	**5**	5	**119**
10 (10)	3	20	103	4	10	112	4	10	112
11 (10)	4	22	98	5	8	111	5	8	111
3 (8)	2	22	102	2	14	110	2	14	110
5 (12)	3	12	110	6	9	110	6	9	110
7 (30)	4	20	102	4	5	117	4	5	117

Due to unique combination of calculation rules peculiarities and incorrect answers of the respondents several results differs for two newly proposed methods in norms #9 and #4. Nevertheless, since mismatch is equal to 2 answers relative to overall number of 1395 answers it may be neglected.

Overall results of answers correction are shown in table 2.

Table 2. Answers corrections after data processing methods applied.

Norm (distance)	Increment			Increment %		
	C	C	Б	H	Б	H
1 (20)	1	-14	13	0.78%	-10.85%	10.08%
6 (20)	1	-11	10	0.78%	-8.59%	7.81%
8 (20)	0	-10	10	0.00%	-7.87%	7.87%
9 (20)	2	-9	7	1.59%	-7.14%	5.56%
2 (10)	2	-17	15	1.55%	-13.18%	11.63%
4 (10)	2	-15	13	1.55%	-11.63%	10.08%
10 (10)	1	-10	9	0.79%	-7.94%	7.14%
11 (10)	1	-14	13	0.81%	-11.29%	10.48%
3 (8)	0	-8	8	0.00%	-6.35%	6.35%
5 (12)	3	-3	0	2.40%	-2.40%	0.00%
7 (30)	0	-15	15	0.00%	-11.90%	11.90%

From the table analysis it is evident that overall changes applied to the initial calculation results cover approximately 18% of respondents answers. Taking into account that area of the research concerns flight safety and human factor, this number must be considered as significant and be taken into account in future.

6. CONCLUSIONS

The presented new methods of air operators main decision taking dominants determination and associated practical results allow to point out the following main achievements:

Newly proposed methods for main decision taking dominants determination, based on risk premium for five key points of estimate usefulness function, are successfully tested. Method precision increase in 18% is stated to be significant and must be taken into account in future researches about main decision taking dominants.

Further researches should be held in direction of:

- spreading proposed method into all variety of flight norms recommended by ICAO;
- implementing of received results into ATC educational process;
- development of intellectual solution taking support module for ATC.

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