POLYGONAL MODELLING AND METHODS FOR OPTIMISING THE PERFORMING OF AVIATION TASKS AT DIFFERENT PHASES OF FLIGHT

[1]Kashkalda Vitaliy, [2]Kushnerova Nadiya Ivanivna
[1]Postgraduate student (PhD) at the Flight Academy of the National Aviation University Kropyvnytskyi, Ukraine.
[2]Candidate of technical sciences, associate professor, Head of the department of Aeronautics, Meteorology and Air Traffic Management at the Flight Academy of the National Aviation University Kropyvnytskyi, Ukraine.

ABSTRACT: Aviation safety is a crucial component of the modern aviation industry, and situational awareness plays a key role in this, as it is the pilot's ability to analyse and anticipate critical elements at all phases of a flight, including the pilot's physical condition, aircraft technical condition, weather conditions, air traffic and crew interaction. The importance of situational awareness becomes especially apparent in conditions of limited decision-making time, such as emergency situations. This article presents a methodology for quantifying pilot situational awareness using polygonal modelling. The methodology takes into account visual, audio, communication and tactile information, as well as the speed of reaction to changes in flight. This approach allows not only to assess the level of awareness but also to identify weaknesses and improve pilot training.

KEYWORDS: situational awareness, polygonal modelling, aviation safety, flight optimisation.

---***---

1. INTRODUCTIONS

Aviation safety is a crucial component of the modern aviation industry, and situational awareness plays a key role in this, as it is the pilot's ability to analyse and anticipate critical elements at all phases of flight, including the pilot's physical condition, aircraft condition, weather conditions, air traffic and crew interaction. The importance of situational awareness becomes especially apparent in conditions of limited decision-making time, such as emergency situations.

This article presents a methodology for quantitative assessment of pilot situational awareness using polygonal modelling. The methodology takes into account visual, auditory, communication and tactile information, as well as the speed of reaction to changes in flight. This approach allows not only to assess the level of awareness, but also to identify weaknesses and improve pilot training.

2. LITERATURE REVIEW

Previous research has shown that high situational awareness helps pilots better understand and anticipate critical elements during flight, which can significantly reduce the risk of accidents.

1. Research on situational awareness:
Wickens, C. D. (2008). Situational awareness: A review of Mica Endsley's 1995 articles on situational awareness theory and measurement. Human Factors, 50(3), 397-403. This study provides an overview of the theory of situational awareness developed by Mica Endsley and emphasises its importance for pilots [58].

2. Methods of quantitative assessment:
Endsley, M. R., & Garland, D. J. (2000). Situation awareness analysis and measurement. CRC Press. This book discusses the methods of analysis and measurement of situational awareness, which is the basis for the development of quantitative methods [58].

3. The use of polygonal modelling:
Durso, F. T., & Gronlund, S. D. (1999). Situation awareness in aviation systems. In Handbook of aviation human factors (pp. 327-347). This study examines the use of polygonal modelling to improve pilot situational awareness in aviation systems [58].

4. 4. Real-life scenarios and expert opinions:
Jones, D. G., & Endsley, M. R. (1996). Sources of situation awareness errors in aviation. Aviation, space, and environmental medicine, 67(6), 507-512. A study of the sources of situational awareness errors in aviation, which helps to identify critical factors that affect flight safety [58].

5. Use of simulators:
Salas, E., Prince, C., Baker, D. P., & Shrestha, L. (1995). Situation awareness in team performance: Implications for measurement and training. Human Factors, 37(1), 123-136. This study examines the use of simulations to measure and train situational awareness [58].

3. METHODS

To quantify the pilot's situational awareness, a special formula has been developed that takes into account the importance of different types of information (visual, auditory, communication and tactile) and the speed of reaction. The formula is as follows:

$$SA=V\times Wv\times Tv+A\times Wa\times Ta+C\times Wc\times Tc+S\times Ws\times Ts$$

where:

V - visual awareness.
A – audio awareness.
C – communication awareness.
S – sensory (tactile) sensitivity.
Tv, Ta, Tc, Ts – time factor for each type of awareness.
Wv, Wa, Wc, Ws – weights (coefficients) that determine the importance of each aspect.

Based on the described formula, an essential part of our approach is to determine the weights of each aspect of situational awareness. The weights in the methodology are selected based on the factors considered and their impact on pilot situational awareness. The importance of each aspect may vary depending on the specific phases of the flight. It is also important to consider which aspects have a predominant impact on situational awareness in different scenarios. By experimenting with the scales, the optimal balance for the different phases of flight can be achieved.

The weights can also be supported by research, expert opinion and a tailored approach to specific conditions. Given the complexity and multidimensional nature of situational awareness in the aviation environment, there are several reasons for choosing a particular weighting distribution.

The importance of different aspects may vary during different phases of the flight. For example, visual and audio awareness may be more important during the landing phase.

Different scenarios may require different levels of attention to certain aspects. The weighting of each aspect may depend on the specific objective of the tasks.

The weights can be determined through consultation with aviation experts, as well as analysis of real-life scenarios and research.

Trying to find a balance between the different aspects and their importance is the goal of achieving an optimal level of situational awareness.
Additional parameters can be added to the formula to account for individual pilot reactions and characteristics. For example, an individual effectiveness factor (IE) can be introduced to reflect the characteristics of each pilot. The modified formula looks like this:

$$SA=V\times Wv\times Tv\times \mathrm{IE}v+A\times Wa\times Ta\times \mathrm{IE}a+C\times Wc\times Tc\times \mathrm{IE}c+S\times Ws\times Ts\times \mathrm{IE}s$$

where:
IEv,IEa,IEc,IEs – individual efficiency factors for visual, audio, communication and tactile awareness, accordingly.

4. RESULTS

To determine the optimal weights of each aspect, a series of experiments were conducted with the participation of experienced pilots in simulated flights. The results of the experiments allowed us to determine the following weighting factors for standard daytime meteorological conditions (Table 1).

The flight phase	Visual	Audio	Communication	Tactile	Time factor
Take-off	40%	20%	15%	15%	10%
Cruise	25%	20%	30%	15%	10%
Landing	35%	30%	20%	10%	5%

5. DISCUSSION

The results show that the importance of different aspects of situational awareness varies depending on the phase of the flight. For example, visual awareness is most important during take-off and landing, while communication awareness becomes critical during cruising. The weights were determined based on consultations with aviation experts and analysis of real-life scenarios.

The proposed methodology allows to quantify the level of pilot situational awareness and identify weaknesses in crew training. The use of this methodology can improve pilot training and increase the efficiency of decision-making in emergency situations.

6. CONCLUSIONS

The methodology for quantifying pilot situational awareness using polygonal modelling demonstrates its effectiveness in determining the level of awareness at different phases of flight. Further research can be aimed at adapting the methodology for different types of aircraft and flight conditions, as well as at developing individual performance coefficients for pilots.
To use the formula with these parameters, it is necessary to obtain data from real or simulated aviation scenarios:

- Flight data (Flight Data Recorder, Voice Recorder)
- Real flight simulators - can provide the ability to create and simulate various flight scenarios to obtain relevant data.
- Expert opinions and research.
- Experiments and scenarios.

The formula for calculating situational awareness (SA) can be useful in aviation safety because it allows for a quantitative determination of the pilot's or crew's level of awareness of various aspects of flight. The application of this formula can have the following benefits:

- Assessment of the level of awareness: allows to take into account the importance of different aspects of awareness, such as visual, auditory, communication awareness, etc.
- Weighting the importance of aspects: The weights (W_v, W_a, W_c, W_s) can reflect the importance of each aspect in specific scenarios.
- Identification of weaknesses: Analysing the results of the formula can help identify weaknesses in crew awareness.
- Improving skills and training: The application of the formula can be used to train pilots.
- Effectiveness of decisions in emergency situations: The inclusion of the time factor in all aspects of the formula is an important element in emergency situations.
- Application in aviation safety: The formula is designed to be applied in an aviation context, making it specific to determining pilot and crew awareness in different scenarios and phases of flight.

Pilot situational awareness at various phases of flight is one of the most important aspects of aviation safety. The use of polygonal modelling and the developed methodology contribute to the improvement of aviation tasks and the pilots' ability to react to various situations, and thus to flight safety.

REFERENCES

1. Wickens, C. D. (2008). Situational awareness: Review of Mica Endsley's 1995 articles on situational awareness theory and measurement. Human Factors, 50(3), 397-403.
2. Endsley, M. R., & Garland, D. J. (2000). Situation awareness analysis and measurement. CRC Press.
3. Durso, F. T., & Gronlund, S. D. (1999). Situation awareness in aviation systems. In Handbook of aviation human factors (pp. 327-347). CRC Press.
4. Jones, D. G., & Endsley, M. R. (1996). Sources of situation awareness errors in aviation. Aviation, space, and environmental medicine, 67(6), 507-512.
5. Salas, E., Prince, C., Baker, D. P., & Shrestha, L. (1995). Situation awareness in team performance: Implications for measurement and training. Human Factors, 37(1), 123-136.