# OPERATOR'S SUBJECTIVE DECISIONS
# Improving the operator's (Pilot and Air Traffic Control) decision making

**Utku KALE**
**Mehmet Burhan TEKBAŞ**
Budapest University of Technology and Economics
Faculty of Transportation Engineering and Vehicle Engineering
Department of Aeronautics, Naval Architecture and Railway Vehicles
Stoczek utca 6,
Building J, 4th floor
Budapest, H-1111
Hungary
e-mail (Kale): kaleutku@gmail.com
telephone(Kale): +36 70 198 5670
e-mail (Tekbaş): btekbas@gmail.com
telephone(Tekbas): +36 20 934 5424

## Abstract
*The aim of this work is to use the methods of subjective analysis to operator (pilot, air traffic controller) decision for improving the decision making in order to achieve more reliable flight operations, air traffic control. The WhitePaper, GreenBook, SESAR, NextGen vision and projects develop plans for the high density air traffic in near future in which the role of pilots and operators will be changed. Therefore, understanding and improvement of operator's decision making has a crucial role on safety and reliability of high density air traffic of future. This paper describes the basic elements of the subjective decision making.*

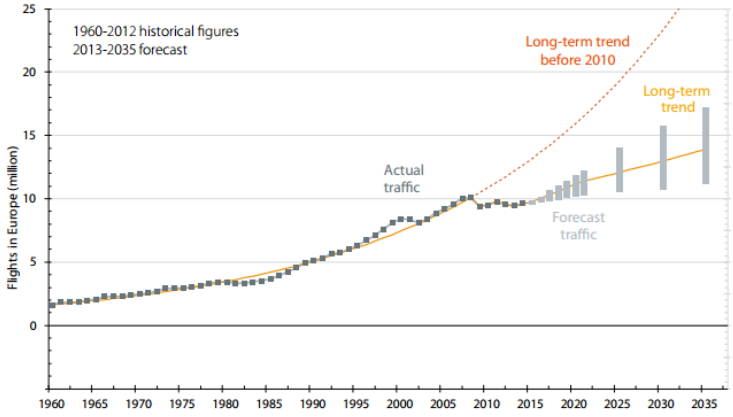
***Keywords:*** *workload; mental condition; air traffic controller; air traffic management; subjective decision making*

## 1. Introduction

The accelerating technology development: small air transportation system, new air traffic control system, SESAR, NextGen, and other international project catalyzes the radical changes in air transportation. It seems the predicted development is slowing (Figure 1), but it may not defer the intended changes and automation of future air transport that enhances the operators' i.e. pilot and ATCO subjective decisions. In planned and developing future air traffic, for example, the role of air traffic controllers (ATCOs) in transition from traditional conflict management to capacity, trajectory and separation management [1]. This changes increasing the role of mental condition in situation awareness and decision making.

This lecture studies the subjective decision making and subjective characters of operators (pilots and ATCOs), roles of knowledge, practice and mental condition in situation analyses and decision defines a novel driver models characterizing by information, task, work and mental loads, and shows how the methods of subjective analysis might be used in operators' decision support.

**Figure 1 Instrument flight rules (IFR) traffic in Europe**




*Source: (SESAR, 2015) [2]*

The lecture will call attentions on three specific conclusions: (i) the subjective features of operator' should be taken into account in future operator' decision support developments, (ii) the on board online monitoring the operators' mental conditions must be developed and (iii) the information load must be analysed in development of the future instrumentation of the air transport system. These conclusions are utilized in development of the air operating system i.e. flight simulator and ATCO working environment at the Department of Aeronautics, Naval Architecture and Railway Vehicles at Budapest University of Technology and Economics (BME) working together with HungaroControl [3].

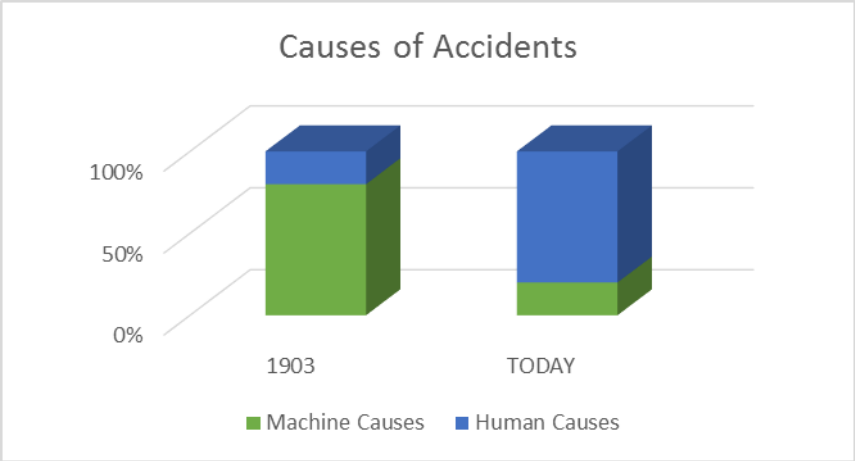
## 2. Human Operator Role in Technical Systems

The human as operator is not only an element of the system, but he controls and manages the system. Nowadays, the operator plays determining role in operational safety (Figure 2). Therefore, the human behaviours, working ability, the human – machine interface, interaction and working environment must be studied in details. Even more, by increasing the level of system automation, the role of operators is changing from their active control to passive monitoring. So, the operator roles must be re-evaluated and the human – machine interface, the working environment should be redesigned. In future system, the operator-driver support systems must be widely developed and applied.

The future operator supporting systems will contain;

- sophisticated info-communication systems,
- monitoring the operator loads and,
- supporting the situation awareness and decision making.

**Figure 2 Causes of Accidents**




*Source: Data taken from (Rankin, 2017) [4]*

The first, the info-communication system provides information about the operational condition of the operating system (as aircraft), environment and interacting, namely cooperating or non-cooperative other systems, like traffic information.

The second, the monitoring the operator loads is a very complex problem, because it contains [3];

- well defined task load (what to do),
- information load (because the not harmonised information origin from different sources)
- work load (depending on the real operating situations, real environment, interaction with other systems), and
- mental load (psycho-psychological condition of the operator).

Finally, the situation awareness and decision making is the major task of the operators. It is a rather complex process too, that might be solved on different levels [4];[3]. The first level, is the skill-based control that is applied by the operators (pilots or ATCOs) when the situation is normal and the operator can easily recognize the situations and can work ‘‘automatically’’. At the second level, the operators must recognize and identify the situation

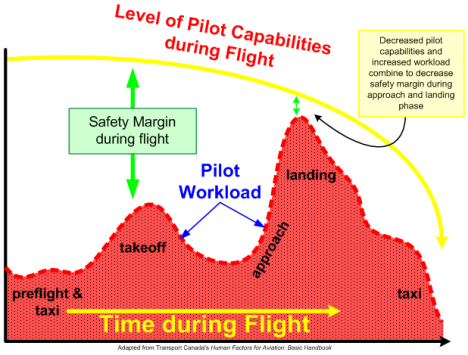
and apply the rule-based solutions (defined by the operational manuals) to reach the expected situations. In case of abnormal flight situations or possible flight conflicts, the operators must derive the solution with their knowledge and practice. This is the knowledge-based level.

The operators, as pilots working capability depends on the loads and the time of working (Figure 3). Of course, the reduction in gap between the pilot capability and workload increases the risk of accidents.

In order to reduce errors generated by operators, understanding and evaluating of derivative factors human decision making has crucial importance. Probably, the most used general model of situation awareness was developed by [6];[7]. Another good model recommended to use to gain the understanding of characterized decision making of aviation operators (pilots and air traffic controllers) is the PEAR model PEAR points out four major factors in human operations [8]:

- People who do the job.
- Environment in which they work.
- Actions they perform.
- Resources necessary to complete the job.

**Figure 3 Level of pilot capabilities during flight**




*Source: Data taken from (Transport Canada, 1997) [9]*

## 3. Subjective Decision Making

There are many references and rules for taking into account the subjective characters of decisions. For example, Hilburn and Jorna [7] analysing the workload had explored both the subjective and objective workload of ATCOs. Another example: the pilot licensing is based on subjective decision of the certified flight examiners [19], however 19 flight

parameters and 17 statistical or mathematical metrics might be applied for objective evaluation of the pilots technical skills [18].

The aircraft control system as the air traffic control system are subjective, endogenous, stochastic and active because the human-operator: pilot or ATCO in loop, who actively generates the control inputs, depending on the situation evaluation and decision making actively. The control origins from inside the system (from operator) that means the system is endogenous. The decision of the operator on per situation dependent on knowledge, experience, skill, current mental, physical condition, and awareness of the situation. Hence this is so called subjective decision mechanism [17].

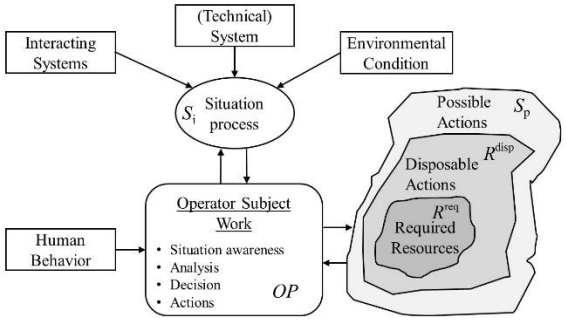
The expected air traffic will be increased quite high in the near future, the NextGen and SESAR (Single European Sky ATM Research) and other international projects funded as a result of this volume increase. One can expect that with a significant increase on air traffic and congestions, the subjective decision making will have more effect on overall flight safety.

Current major ATM projects basically focuses on following terms; (I)Improving the safety, (II) Reducing air traffic management costs, (III)Reducing the environmental impact. Beside the reducing environmental impact the other goals are significantly related with subjective decision making of operators (pilots and air traffic controllers).

Operators decisions depend on their awareness, practice, knowledge, skill of pilot operators. The aircraft control system is stochastic, subjective, nervous (endogenous) and active system. Because the human operator in loop who actively generates the control inputs depending on the situation evaluation and decision making, when his decision comes from his nervous system. Obviously, human operator makes decision on his/her subjective analysis. These subjective analyses contain both active and passive resources. Active resources are known as psychical, psychophysiology, operator's behaviour, possibilities of subjects. While passive ones known as finance, information, materials, information, energy of aircraft (aircraft control system in its physical form) and etc [16].

The subjective character of operator situation awareness and decision making appears by the following ways **Error! Reference source not found.**.

**Figure 4 Operator subjective decision model**




*Source: Redrawn from (Rohacs, Rohacs, & Jankovics, 2016) [3]*

The Operator (OP) collecting the information about the situation of the (technical) system, $S_i$, that changes depending on the system performance and characteristics, environmental conditions, effects of other interacting systems and realized control (management). The operator after identification and understanding the situation makes a situation awareness, analyses the situation and applicable decision, chooses the decision and applies it. During this decision making, the operator may choose the decision from the set of the possible actions, $S_p$ including all the accessible or possible devices, methods and factors. After it, the operator must identify disposable actions, $R^{disp}$, that might be apply in given situation for controlling the system. Finally, the operator should choose the required actions $R^{req}$, that may move the system to intended condition. Of course, this situation awareness and decision making process realized by operator depends on the operator behaviours, namely on knowledge, skills, practice of operators and its actual mental condition, actual physical, psychological condition. There is the reason why the decision is the subjective decision.

In more general approach, the operator must activate its passive (finance, materials, information, energy) and active (physical, intellectual, psycho-physiological behaviours' possibilities of subjects) resources. Applied physical controls and active resources [10]. The passive resources are the resources of the system (e.g. in case of ATCOs, air transportation system, ATM, services provided), while the active resources are related to the operator (ATCO) itself. The active resources are defined by the operator decisions, which also determine how the passive resources will be used.

In this process the remaining time, time until the last moment, while the decision must be applied plays the most important role. The required decision time is the sum of times of the situation awareness, decision making and actions. The successful decision can be made, if the remaining time would greater than the required time

In future systems the operator subjective decision must be supported. The first step is to develop the methods of investigation and modelling the subjective decision processes. The developing methodology may use in wide area of application, including even the distance control of unmanned aerial vehicles [11].

The Department of Aeronautics, Naval Architecture and Railway vehicles at the Budapest University of Technology and Economics initiated a long term research for investigation of the subjective decision processes. There are several results are published from development of the multi-criteria decision making support tool [12], or management decision support for the small companies [13], through the less-skilled (small and personal aircraft pilots) decision [14];[15] until developing the operator environment [3].

## 4. Conclusion

Human error is not avoidable but it is manageable. Safety awareness would help predict and mitigate the risk of human error. This paper was dealing with the methods of subjective analysis to operator (pilot, air traffic controller) decision for improving the decision making in order to achieve more reliable flight operations, air traffic control.

We have used the methodology of development the operators (human) model for better understanding subjective decision making and supporting operators situation awareness and decision making. We have generalized and improved well known model of operators like Endsley and Rasmussen models. The lecture points out on three specific conclusions: (i) the subjective features of operator' should be taken into account in future operator' decision support developments, (ii) the on board online monitoring the operators' mental conditions must be developed and (iii) the information load must be analysed in development of the future instrumentation of the air transport system.

The developed model is based on the information, task, work and mental loads. This model applied in investigations the situation awareness and decision making. The roles of different loads are underlined.

The combination of loads has led to introducing term subjective decision, that means the operators making decision with using their knowledge, skill, experience and personal behaviours. Such situation awareness and decision are recommended to investigate by using the methods of subjective analyses.

## References

[1] Joint. (2011). Concept of operations for the Next Generation Air Transportation System Version 3.2. Washington D.C.: Planning and Development Office (JPDO).

[2] SESAR. (2015). The roadmap for delivering high performing aviation for Europe European ATM Master Plan. Belgium: SESAR Joint Undertaking. doi:10.2829/240873

[3] Rohacs, D., Rohacs, J., & Jankovics, I. (2016, July). Conceptual development of an advanced air traffic controller workstation based on objective workload monitoring and augmented reality. Proceedings of the Institution of Mechanical Engineers (Part G: Journal of Aerospace Engineering Vol. 230), 1747 - 1761.

[4] Rankin, W. (2017, 05 04). http://www.boeing.com. Retrieved from Effects of Reducing Maintanance Errors: http://www.boeing.com/commercial/aeromagazine/articles/qtr_2_07/AERO_Q207_article3.pdf

[5] Rasmussen, J. (1986). Information Processing and Human-Machine Interaction: An Approach to Cognitive Engineering. New York, USA: Elsevier Science Inc.

[6] Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems: Situation awareness (Vol. 37).

[7] Erlbaum. (2001). Hilburn BG and Jorna PGAM (2001) Workload and air traffic control. In: PA Hancock and PA Desmond (eds) Stress workload and fatigue: Theory, research and practice. Hillsdale, NJ.

[8] Johnson, W., & Maddox, M. (2007). A Model to Explain Human Factors. Avionics News, 38-41.

[9] Canada. Transport Canada, A. C. (1997). Human factors for aviation: basic handbook / prepared for Transport Canada; submitted by Air Canada Human Factors Project Team. Ottawa: Transport Canada.

[10] Kasyanov, V. A. (2007). Subjective analysis. Kiev: National Aviation University.

[11] Goncharenko, A. V. (2016). Several models of artificial intelligence elements for airctaft. 2016 4th International Conference on Methods and Systems of Navigation, (pp. 224-227). Kiev. doi:10.1109/MSNMC.2016.7783148

[12] Simongati, G. (2010). Multi-criteria decision making support tool for freight integrators: Selecting the most sustainable alternative. Transport (25:1), 89-97.

[13] Bicsák, G. (2015). Genetic algorithm based time schedule management for small aerospace companies. Repüléstudományi Közlemények(XXVII.:(3)), 221-230.

[14] Rohacs, J. (2010). Safety aspects of the personal air transportation system. 27th International Congress of the Aeronautical sciences, ICAS (International council of the Aeronautical Sciences) (p. 12). Nice: ICAS (International council of the Aeronautical Sciences). Retrieved from http://www.icas.org/ICAS_ARCHIVE/ICAS2010/PAPERS/527.PDF

[15] Jankovics, I., & Nagy, A. (2012). Measurement of Small Aircraft Pilot's Reaction Time Variation With Psychological Load in Flight Simulator In: AIRTEC., 1. 10 p. Frankfurt am Main, Germany.

[16] Rohacs, J. (2012). Subjective Factors in Flight Safety. In R. Agarwal, Recent Advances in Aircraft Technology (pp. 263-286). Rijeka: InTech Education and Publishing.

[17] Rohacs, J., & Kasyanov, V. A. (2011). Pilot subjective decisions in aircraft active control system. Journal of theoretical and applied mechanics (49), 175-186.

[18] Johnson, W., & Maddox, M. (2007). A Model to Explain Human Factors. Avionics News, 38-41.

[19] Hitchcock, L. B.-B. (2016). Pilot performance, in "Handbook of Aviation Human Factors" (ed. by Wise, J. A., Hopkin, V. D., Garland, D. J.) (2nd ed.).