System supporting the operators supervising with vehicle and transport control

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Abstract: With the rapid development of technologies, deployment of the micro sensors and actuators, using the new info communication and embedded systems, widely applied automation, the role of vehicle drivers and transport controllers is transitioning from active control to passive supervising. This lecture (i) develops a supervisor model in situation awareness and subjective decision making, (ii) defines the information, task, work and mental loads of operator – supervisors, (iii) tries to divide the situation awareness, decision making as conflict detection and resolution into the groups managed by autonomy system, automated man – machine system and human managing actions. The paper discusses the basic possibilities how the highly automated and autonomous systems must be managed by supervisors.

1. INTRODUCTION

Our era is characterized by rapid, even better to say revolutionary rapid technology development that results in the use of a series of new disruptive technologies in vehicle and transport system control. The deployment of the distributed wide set of micro sensors and actuators, new info communication and embedded systems and new highly automated and autonomous control systems (control with vehicles and transportation systems) are being developed. The widely applied automation initiates change in the role of vehicle drivers and transport controllers that transition from active control to passive managing with controlling systems, namely control the vehicles and transport systems. This passive management means the vehicle drivers and transport system controllers give inputs for the systems, monitor the operational processes and – in case of emergency situation – may manage the system operation or even may take over the control and after situation awareness – analysis - decision may control the systems. Such process might be called as the vehicle drivers and transport system controllers as passive operators supervise the operation of the systems.

In case of passive managing, supervising with systems, the subjective performance of the operators may play a determining role in successful operation of the systems.

This lecture (i) develops a supervisor model in situation awareness and subjective decision making, (ii) defines the information, task, work and mental loads of operator – supervisors, (iii) tries to divide the situation awareness, decision making as conflict detection and resolution into the groups managed by autonomy system, automated man – machine system and human managing actions. The basic possibilities how the highly automated and autonomous systems must be managed by supervisors will be discussed.

The lecture demonstrates the possible application of the operator models and subjective decision system that have been developed in the last decades (Rohacs, Kasyanov, 2011; Rohacs, 2012; Rohacs, Rohacs and Jankovics, 2016; Tekbas, Kale, 2017)

2. CHANGES IN OPERATORS' ROLE

The revolutionary new technologies have dramatic influence on the development of the car drivers (operators) support as set of sub-systems and system elements. (Fig.1).

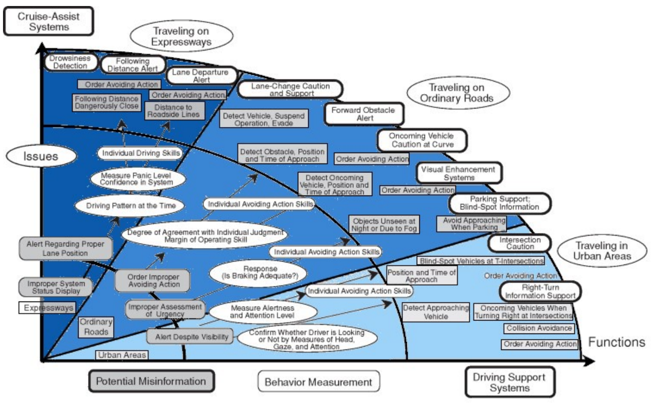

Fig. 1. Driving support devices and human-machine interface issues (it is redrawn after (Doi, 2006))

At the same time, the replacement of the existing vehicle driver instrumentation by future solutions may cause disharmony in drivers (customers), developers and researchers expectations (Tekbas, Kale, 2017). On one hand, the drivers would like to have interesting and nice instrumentations (Fig. 2.a). On the other hand, the future car developers may think about the highly automated and even autonomous vehicle that need minimized instrumentations that even might be better to name only as entertainment. The researchers vision to developing more and more special solutions, devices for increasing the drivers' situation awareness and decision support (as for example night synthetic vision system, see Fig. 2.b).


a.)


b.)

Fig. 2. Car future driver environments: a.) future instrumentation (BMW, 2017), b.) night synthetic vision system (Spotlight, 2017)

The future operator supporting systems will contain;

- sophisticated info-communication systems,
- monitoring the operator loads and,
- supporting the situation awareness and decision making.
- simultaneously tweaking the necessary vehicle units to support response time of driver (adjusting suspensions, torque vectoring and etc.)

The first, the info-communication system provides information about the operational condition of the vehicle. The second, the monitoring the driver loads containing three branches;

- Situation Awareness
    - Physiological measurement
    - Cognitive measurement
    - Proximity detection
    - Characteristics of perception and sensitivity
- Decision-Making and Response Selection
    - Stopping and passing decisions
    - Dilemma measurement
    - Mental workload
    - Driving psychology analysis
- Operation and Execution
    - Analyzing emergency operating behavior
    - Analyzing braking behavior
    - Analyzing follow-up behavior
    - Physical workload

Finally, the situation awareness and decision making is the major task of the operators describing by the well-known and probably most used model of Endsley (1995). It is a rather complex process too, that might be solved on different levels (Rasmussden, 1986). The first level, is the skill-based control that is applied by the operators when the situation is normal and the operator can easily recognize the situations and can work ''automatically''. At the second level, the driver must recognize and identify the situation and apply the necessary solutions to reach the expected situations. In case of abnormal situations or possible road conflicts, the drivers must derive the solution with their knowledge and practice. This is the knowledge-based level.

The technology developments initiate the transition from these human – operator centric models to human load models in which the role of human personal behaviors, knowledge and practice of operators is increasing.

Figure 3. shows the simplified classic model of Endsley (1995) modified to new dynamic transport system monitoring and control. The developed model contains three major new elements (Rohacs, Jankovics and Rohacs, 2016):

- the representation of system factors, based on (i) system functions, (ii) operational characteristics and (iii) operator - system interface (working environment) and included new elements as system operability (interoperability), controlability and automation; system operational intensity and (traffic) complexity, observability and operational (flight) information system; developed working environment to increase the level of situation awareness,
- the situation is evaluating from present situation instead of state of environment as defined by Endsley,
- individual factors includes new elements, as the actual (present) mental condition of operators because in the highly automatred systems the role of psycho-physiological condition of the operators is incresing,

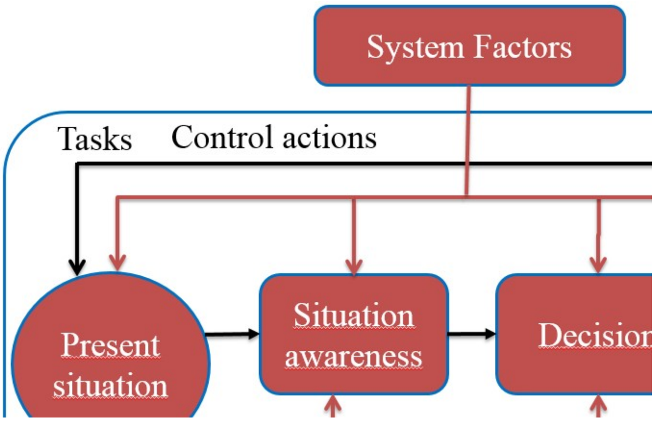

Fig. 3. Simplified model of situation awareness in future dynamic ATM environment

This approach is well usable for transition period from human operated systems, to human supervised system.

By wide deployment of the autonomous system increases the role of system control. Such control like smart transport management requires passive (realized by passive surveillance – radar system and / or by set of sensors integrated into the transport infrastructure) and active (secondary) surveillance system (namely cooperating vehicles).

Therefore, the smart transport in smart city might be managed by use of newly developed air transport management systems, rules and methods, as European (2009) SESAR (Single European Sky ATM Research), the US Next-Gen (Next Generation Air Transportation System (Joint, 2007)), Japanese CARATS (2010) (Collaborative Actions for Renovation of Air Traffic System or the Brasilian SIRIUS (2013) (Impulsionando o Desenvolvimento do ATM Nacional).

3. LOAD MODEL AND SUBJECTIVE DECISION

The operator load can be classified as

- task load that is defined by the planned (driving) tasks should be performed by use of given vehicle in given traffic and environment (infrastructure, weather condition),
- information load induced by quality and quantity of available and supplied information (on vehicle operation, condition of infrastructure, traffic complexity, weather condition) supporting the operators that might be not harmonized and even conflicting and contradictory;
- workload depends on task load and real traffic conditions, traffic complexity, real (not predicted) condition of infrastructure, real weather situations, etc.;
- mental load takes into account the human subjective behaviours including e.g. knowledge, practice, physical, psychological conditions) and it is always associated with workload.

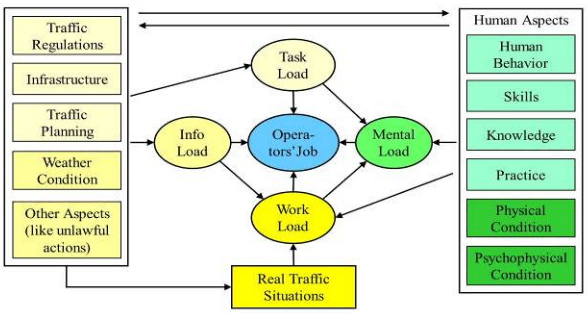

Fig. 4. load model of the operator-supervisors

Principally, the workload is the most known and studied load of vehicle drivers. Task load is associated with workload providing input for that, while as independent load it has not so investigated yet. The mental load of car drivers has been studied for last 20 – 30 years (de Waard, 1996). The info load is relatively new load that becomes relevant because the provided too many information to drivers, to traffic controllers.

The information load may confuse the operators and put them into difficulty to evaluate the right and required information (Ruff, 2002). The workload might be determined from the traffic performances (see for example (Prandini, Putta and Hu, 2011)) or determined from the operator reactions (for instant from the evaluation of the ATCOs (air traffic controllers) voice - see (Hungmuller, Rank and Kubin, 2006)). The mental load is associated with the workload (Metzger, Parasuraman, 2005; Villena, 2013) and it can be determined from the human basic medical parameter, like heart rate, blood pressure (Vogt, Hagemann and Kastner, 2006) or electroencephalogram (*EEG*) (Dasari et al., 2010; Shou, Ding, 2013).

The vehicle operators and traffic system controllers are working in very complex systems providing a lot of information and supporting them by highly automated systems. In such environment the operators make subjective decision. operators are working in very complex environment. The figure 5. shows the general example of such subjective decision (Rohacs, Rohacs and Jankovics, 2016).

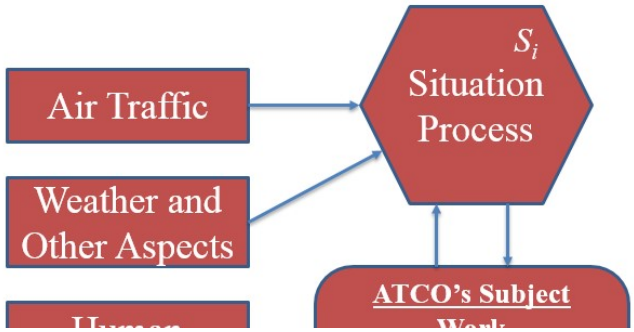

Fig.5. Subjective decision model of ATCOs

The system controllers (ATCOs) must recognize, identify, define and understand the problem and choose the solution from their resources, which makes human controlled active systems endogenous. Resources are methods or technologies that can be applied to solve problems. These could be classified into the so-called (i) passive (finance, materials, information, energy, applied physical controls) and (ii) active (physical, intellectual, psycho-physiological behaviors, possibilities of subjects) resources. The passive resources are therefore the resources of the system (e.g. air transportation system, air traffic management, services provided), while the active resources are related to the ATCO itself. Based on these, decision making is in fact the process of choosing the right resources that leads to an optimal solution.

Subjects (like ATCOs) could develop their active resources (or competences) with theoretical studies and practical lessons. However, the ability of choosing and using the right resources is highly depending on (i) the information support, (ii) the available time, (iii) the real knowledge, (iv) the way of thinking, and (v) the skills of the subject. Such decisions are the results of the subjective analysis.

As shown in the Figure 5, the controller as subject, $\sum '$ must recognize, identify and understand the problem (situation) (S_i) including the expectation about the future states of the system, namely the possible conflicts. Then, from the set of accessible or possible devices, methods and factors (S_p), the operator (controller) must choose the disposable resources (R^{disp}) available to solve the identified problems, and finally decide and apply the required resources (R^{req}) [46, 47, 48, 49]. This is the decision making process. The controllers' decisions naturally depend on their behaviors and loads. The controller should apply the passive and active resources. The active resources are defined by the controller decisions, which also determine how the passive resources will be used.

According to this approach, the remaining time until the conflict and the required time to make a decision and action are the most important subjective factors, which can be optimized by proper anticipations of future system states and by keeping the controller in an optimal mental state.

In fully automated or autonomous systems the drivers or controllers will supervise, only, the vehicle or system and will take part in control in case of emergency situations.

4. DEVELOPING THE WORKING ENVIRONMENT FOR SUPERVISORS

The Department of Aeronautics, Naval Architecture and Railway Vehicles at Budapest University of Technology and Economics (BME) has a long-term program developing skills and competence in operators working simulation, their load management and developing their working environments. The Department has two flight simulators and one ATC/ATM simulation laboratory.

One of the main aim to develop the supervisor' working environment is to collect information on operators' activity to manage their actions. Supervisors would provide better critical information to operators at the emergency time and this information would be used for early warnings for upcoming critical situations or decision assist for ATCOs.

It is needed to support the operators by actual and required information on their requirements and depending on their load conditions. The operator loads are measured by sensors integrated into the operator working environment such as micro sensors in control rules, sticks, cameras, eye tracking control, binocular and so on.

Due to the consequent effects of these developments,

- Reducing operator loads on the subject,
- Managing the operator's actions,
- Increasing situational awareness,
- Better/optimal decision making and increasing the quality of decision
- Increasing operators' effectiveness and productivity
- Increasing safety in critical moments.

Different methods and systems can be built to improve the supervisor' working environment. In this paper the following ideas were defined to measure the operators' condition;

- Integrated micro sensors into the flight simulator (side-stick controller, yoke, mouse)
- Use of eye tracing glass for gaze detection in ATCOs supporting systems

Micro sensors can be used for developing the supervisor' working environment to increase the level of situation awareness. As it is investigated and well known by us that heart rate, skin resistance, body temperature and operator's force on a side-stick (how hard operator hold a control wheel) might be continuously measured by using the micro sensors into the side-stick.

Fig. 6. a.) shows the integrated micro sensor into a side-stick to measure skin resistance and body temperature. For example, if the operator's skin gets wet and sweating, operators might be in a stressful situation, have some private problems or even might have some health problems.

As it can be seen in Fig. 6. b.) that there are two LEDs on the side-stick. One of them is IR LED and the other one is diode LED. Diode LED measures the light. When operator puts his fingers on these led, the light is emitted by the IR LED and lights up the operator' finger. That is the operator' heartbeat. And regarding the operator's fingers movements on the sensors, it can be changed the reflections and also color of the LEDs. And the integrated sensors sense that how this light changes depending on operator's hearth rate. So, it measures the changes in operator' heart rate with this method. And also If it can be shown these hearth rate changes in a software, then we will able to interpret the results on how fast operator' heart is beating.

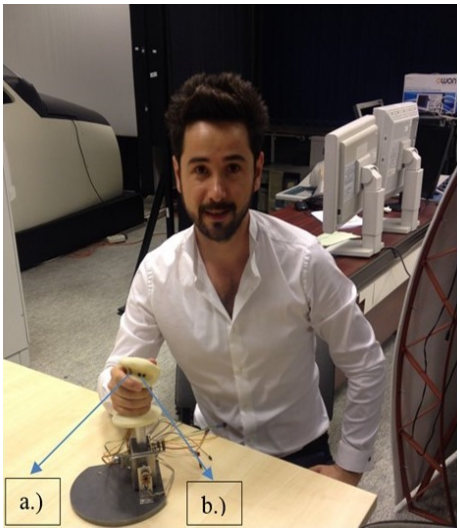

Fig. 6. Integrated micro sensors into a side-stick: a.) micro sensor to measure hearth rate b.) micro sensors to measure skin resistance and body temperature

Also, some micro sensors integrated into the computer mouse by authors such as hearth rate sensor, the skin resistance sensors and accelerometer. This method has been used in the ATC/ATM simulation laboratory at BME. Similarly, these micro sensors are actively used in hospitals to measure patient' heart rate and oxygen level of his/her blood.

The second approach is using of eye tracking system (Al-Rahayfeh, Faezipour, 2013). to measure the operators' condition.

Eye tracking research began over a hundred years ago (for example (Javal,1878/1879)). In aeronautics, the first eye tracking measurements were realized in flight and ATC simulations.

Eye trackers can be built on to capture the eyes' movements, simply by moving eyes up-down or left-right, for different purposes. One of the well-known measurement techniques is using the eye-tracking head gear.

The eye tracing glasses which can be seen in Fig. 7. a.), has been built by authors to collect critical information from operators and it can be used in many different working environments. For example, it is used by authors in flight simulator at BME (Fig. 7. b.).

a.)

b.)

Fig. 7. Eye tracking system and utility a.) eye tracing glasses, b.) use of eye tracing glasses into flight simulator at BME

The eye tracking can be applied for three major tasks:

- training of operators – pilots, ATCOs, (even maintenance staff) for supporting their self-learning and evaluate their working qualities,
- monitoring the operators' activity and mental conditions and
- use of eye tracking in control.

For supporting ATCOs work will be integrated into the load management supporting system, but it will present the information about the objects look at by controllers. Therefore, it will be associated with information support systems, and with the monitoring, detecting and decision support systems, too.

Researches led to the application of eye tracking and motion sensing systems in integrated way in the working environment. A concept of a system based on these sensors was developed and a test system was built which was presented by the Hungaro-Control in the World ATM Congress in 2015.

The eye motion of pilots were measured in two seats fix based flight simulator of a medium size passenger aircraft such as the Boeing 737. Pilots having extensive experience, and beginners, so called less skilled pilots were invited to the simulations.

The pilots realized different tasks. The measured eye motions and visual attentions were rather different depending on the tasks and skill of the pilots (Fig. 8.).

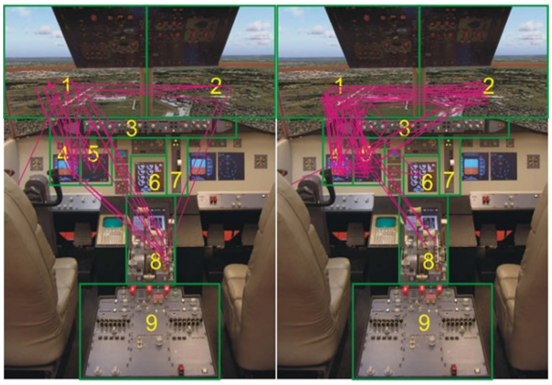

Fig. 8. Eye movements and visual attention measured in flight simulator during take-off (left side) and final approach (right side).

Studies have led to the idea of using the eye tracking in decision support systems. The first developments had been focused on the accuracy of visual attention measurements and developing the supporting ideas. Therefore, a special binocular was developed and applied.

5. LOAD MONITORING AND MANAGING RULES

The task and information loads together with real traffic complete the work load of the operators. And workload depends on real traffic conditions, traffic complexity, real condition of infrastructure, real weather situations, etc.

The actual physical and psycho-physiological condition together are called as mental load. This load depends on human behaviors, skills, knowledge, practice, too. The mental load plays a determining role on the so called subjective situation awareness and decision making of operators.

It can be used for two different type of managements,

- assign a score method - say in [0,1] to all the measurements
- mathematical modelling

First one is when all the measurements will be transfer to the scores. For example, it can be assigned a score on a 0 - 1 scale for each load measurement. (Fig. 9.) And each element has weighting coefficients.

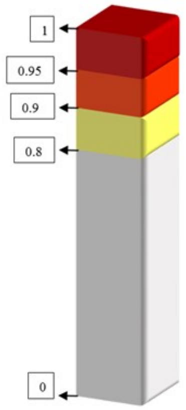

Fig. 9. Demonstration of the load model on a 0 - 1 scale

Score should be 0 if there is a very normal task of load measurement and score should be 1 if the loud may cause serious accident.

As shown in Fig. 4. there are four types of loads i.e. information load, task load, work load and mental load.

The task load is generated by the number and hardness of tasks to be solved. It depends on whether condition, infrastructure condition, traffic regulation and planning, and traffic complexity.

According to recommended scaling model (Fig. 9.), if the task is driving straight in a normal weather condition and not in a traffic at peak times, this task would get 0.1 score.

But in a same task, if the weather conditions are heavy rainy/ foggy/stormy and not in a traffic peak times then the weighting coefficient of the task a little bit will increase, and can be 0.2. And if the traffic is at peak times on an operation day, then the score would be 0.3. So, as it can be seen in Table 1, each task has a basic score accordingly to the its characteristics and risk. To calculate total score for a task, it is necessary to add up the related parameters such as given traffic, environment (infrastructure, weather condition) and other loads effects.

Table. 1. Task loads with the weighting coefficients of the mentioned situations

Task load	Basic score	Weather conditions: rainy/foggy /storm	In a high traffic complexity (at peak times)	In a poor infrastructure condition	Being in a hurry or stressful situation
Going out from parking place	0.1	(0.1-0.4)	0.1	0.1	0.1-0.3
Going straight	0.2	(0.1-0.4)	0.1	0.1	0.1-0.3
Approaching junctions	0.3	(0.1-0.4)	0.1	0.1	0.1-0.3
Driving through the cross section	0.35	(0.1-0.4)	0.1	0.1	0.1-0.3
Make an U-turn	0.4	(0.1-0.4)	0.1	0.1	0.1-0.3

As it can be seen (Table 1.) when we make weighting coefficients for the different factors, it is needed to take into account so many criteria such as weather conditions, traffic complexity, infrastructure conditions even the effect of the other loads. For example, while operating the vehicles, on board cameras and displays can provide some information such as actual traffic or weather condition. If the information is wrong then, operator's working condition will be decreased. In case of this situation total score of the task also will be increased.

According to mathematical model, two different rules might be used.

- If one of the operator's load reaches the threshold.
- where is the score,
  - 0.8 warming signal must be generated,
  - 0.9 calling the special attention on continuously monitoring the operating condition,
  - 0 ,95 actions are required;
- combination of at least two loads, namely in case when any two types of load the load coefficients reaches
  - 0.7 - warning
  - 0.8 monitoring and
  - 0.9 – action required. If at least two tasks reach 0.7 level at the same time.

The metrics (Driver, 2006) and transformation of the measurements to the scores, as well as the definition of the warning levels need further studies and might be defined depending on the type of vehicles its operational condition and environment and driver skills. The management can be developed by use of more sophisticated methods, like Markov decision support.

6. CONCLUSION

This lecture introduces the methods of subjective analysis into the driver situation awareness – analysis – decision – action process. A new improved driver work model was developed by adding the further system and drivers' individual factors to the conventionally used model. This model based on the drivers' subjective decisions.

There was investigated and created drivers' load model including the information, task, load and mental loads.

There were shortly described some results of study and developments of sensors for operators load measuring and estimation. These sensors and sensors available on the market might be integrated into the operators working environment. There were prepared special control stick, control mouse, and eye tracking control that were used in test operator simulators at the department of Aeronautics, Naval Architecture and Railway Vehicles, at the Budapest University of Technology and Economics.

The studies have leaded to recommendation to use the load monitoring and load management to drivers' support system.

REFERENCES

Al-Rahayfeh, A., Faezipour, M. (2013). Eye Tracking and Head Movement Detection. A State-of-Art Survey. IEEE Journal of Translational Engineering in Health and Medicine. 2013;1:2100212. doi:10.1109/JTEHM.2013.2289879.

BMW (2017) vision future luxury integrates augmented reality display, http://www.architectureforfuture.com/bmw-vision-future-luxury-integrates-augmented-reality-display/ (downloaded at May, 23, 2017)

CARATS (2010) - Collaborative Actions for Renovation of Air Traffic System. Long-term vision for the future air traffic system. Changes to intelligent air traffic systems. Study Group for the Future Air Traffic Systems. 2010. p. 56., http://www.mlit.go.jp/common/000128185.pdf (accessed 10.03.2015.)

Dasari, D., (et al., 2010) Crowe, C., Ling, C., Zhu, M., Ding, L. EEG Pattern Analysis for Physiological Indicators of Mental Fatigue in Simulated Air Traffic Control Tasks. Proceedings of the Human Factors and Ergonomics Society Annual Meeting September 2010 54: 205-209,

de Waard, D. (1996) The Measurement of Drivers' Mental Workload, thesis, Published by The Traffic Research Centre VSC, University of Groningen, p. 135.

Doi, S. (2006). Technological Development of Driving Support Systems Based on Human Behavioural Characteristics, IATSS Research (IATSS - International Association of Traffic and Safety Sciences), Vol. 30. Issue 2. 2006, pp. 19-28

Driver (2006) workload metrics project, Task 2. Final report, US department of Transportation, National Highway Traffic Safety Association, DOT HS810 635, Nov. 2006, p. 460, https://trid.trb.org/view.aspx?id=855927 (donwloaded at 16 of August, 2017)

Endsley, M. R. (1995) Toward a theory of situation awareness in dynamic systems. Human Factors 1995; 37: 32–64.

Freight (2017) transport statistics, http://ec.europa.eu/eurostat/statistics-explained/index.php/Freight_transport_statistics, (downloaded at 18 of August, 2017)

Hangmuller, M, Rank, E., Kubin, G. (2006) Evaluation of the human voice for indications of workload induced stress in the aviation environment. EUROCONTROL, Brussels 2006. p. 89.

Javal, E. (1878). Essai sur la physiologie de la lecture. Annales d'Oculistique, 79, 97-117, 155-167, 240-274; 80 (1879), 61-73, 72-81, 157-162, 159-170, 242-253.

Joint (2007) Planning and Development Office (JPDO). Concept of operations for the Next Generation Air Transportation System Version 2.0. JPDO. Washington DC. 2007, p. 219.

Metzger, U., Parasuraman, R. (2005) Automation in Future Air Traffic Management: Effects of Decision Aid Reliability on Controller Performance and Mental Workload. Human Factors, 2005. Vol. 47. No. 1., 35 - 49.

Prandini, M., Putta, V., Hu, J. (2011) Air traffic complexity in advanced automated Air Traffic Management systems. 9th Innovative Research Workshop and Exhibition. EUROCONTROL, 2011. , pp. 3 - 10. https://engineering.purdue.edu/~jianghai/Publication/INO2010_ATM_Complexity.pdf (ACCESSED 22.08.2015)

Rasmussen J. (1986) Information processing and human machine interaction: An approach to cognitive engineering. New York: Elsevier Sciences Inc., 1986, p.230.

Rohacs, D., Jankovics, I., Rohacs, J. (2016) Development of an advanced ATCO workstation, 30th ICAS (International Council of the Aeronautical Sciences) Congress, Daejon, Korea, sept. 25 - 30, Paper ICAS 2016_0662, p. 10, ISBN: 978-3-932182-85-3

Rohacs, D., Rohacs, J., & Jankovics, I. (2016) 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

Rohacs, J. (2012) Subjective factors in flight safety Chapter 6 in book " Recent Advances in Aircraft Technology" (ed. Ramesh Agarwal), ISBN 978-953-51-0150-5, Intech, 263-286

Rohacs, J., Kasyanov, V. A. (2011) Pilot subjective decisions in aircraft active control system, Journal of Theoretical and Applied Mechanics, 49, 1, pp. 175-186, 2011

Ruff, J.(2002) Information Overload: Causes, Symptoms and Solutions. Learning Innovations Laboratories, Harvard Graduate School of Education, 2002, http://www.newsmaster.be/flow/dw/ciel/2011/aout11/infooverloadbrief.pdf (accessed 10.03.2015.)

Shou, G., Ding, L. (2013) Frontal theta EEG dynamics in a real-world air traffic control task. 35th Annual Conference of the IEEE Annual Conference of Engineering in Medicine and Biology Society, 2013. 5594 - 5597, http://www.ncbi.nlm.nih.gov/pubmed/24111005#

SIRIUS (2013) Brasil - Impulsionando o Desenvolvimento do ATM Nacional A aviocao do future jo comecou. 2013. http://www.decea.gov.br/sirius/ (accessed 10.03.2015.)

Spotlight (2017) on Technology: Night Vision Safety Technology from AutoLiv Can Help You See Better at Night!, http://blog.truecar.com/wp-content/uploads/2014/01/BMW_Night_Vision_w_heads_up_display.jpg, (downloaded at May, 23, 2017)

Tekbas, M. B., Kale, U. (2017) Subjective decision of car drivers, Proceedings of 21st International Scientific Conference. Transport Means 2017.

Villena, J., (et al., 2013) Acevedo, J. M., Cruz, J. A., Le Gal, S. Is it possible to observe air traffic controller mental workload?, 28th EAAP (European Associastion for Aviation Psychology) Conference, The future of aviation psychology,, enabling operational improvements and business requirements in aviation, 27 - 31 October

Valencia, Span, https://apcae.files.wordpress.com/2009/05/aviation-psychology.pdf (accessed at 27 September, 2013).

Vogt, J. Hagemann, T. Kastner, M. (2006) The impact of workload on heart rate and blood pressure in en-route and tower air traffic control. Journal of psychophysiology, Vol. 20, No. 4, 2006, p. 297-314.