# Developing the air traffic controllers' decision supporting system

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## 1. INTRODUCTION

The central deterministic elements of the aircraft and air traffic control systems are the human controllers (pilots or air traffic controllers) who are the subjects – operators. Such systems are called as active endogenous subjective systems, because (i) the actively used control inputs (ii) origin from inside elements (pilots) of the system as (iii) results of air traffic controllers' (operators') subjective decisions. The decisions depend on situation awareness, knowledge, practice and skills of controllers. They may make decisions in situations characterized by a lack of information, human robust behaviours and their individual possibilities. In most important (emergency situations or traffic complexity) cases, they must generate their decision during limited time. These peculiarities as subjective factors have direct influences on the system characteristics, system quality and safety.

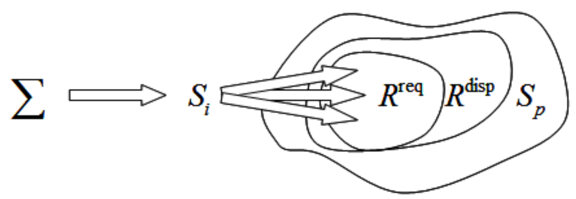


**Figure 1: Controller decision - action process [4]**

As shown on the Figure 1, the controller as subject, $\Sigma$, must identify and understand the problem (situation), ($S_i$), then from the set of accessible or possible devices, methods and factors ($S_p$), must choose the disposable resources ( $R^{disp}$ ) available to solve the identified problems, and finally must decide and apply the required resources ( $R^{req}$ ). The controller should apply the passive and active resources. The active resources are defined by the controller decision on how the passive resources will be used. According to this approach, the remaining time until the conflict and the required time to make decision and action are the most powerful subjective factors.

The situation awareness - decision masking - control action processes depend on (i) "physical" situation (aircraft technical, functional condition and flight condition and air traffic complexity), (ii) controllers' (physical, intellectual, mental) conditions, knowledge and working abilities, and (iii) decision supports. The decision supports must provide the information to controllers about the controlled system conditions, their (controllers) mental conditions and possible results of applicable decisions.

The first high level integrated task and job analysis of air traffic controllers including the cognitive aspects was initiated by EUROCONTROL in 1998. Such approach must be integrated with the a benefits-driven, decision support system developing by MIT for qualitatively and quantitatively iterating upon a decision support system (including the human-machine interface, operational procedures, and operational training) to achieve quantifiable operational benefit [3] [5].

Systems that start taking into account the pilot mental state are also under development [1] [2], in order to improve the safety of small aircraft.

The paper describes the decision support system (DSS) developing by authors together the HungaroControl. The system includes (i) improved displaying the flight and traffic information, (ii) a set of (MEMS based) sensors integrated into the controller working environment and used for measuring the controllers actual workload and mental conditions, (iii) data analyser (providing information about the control system conditions, determined traffic complexity, and controllers' workload, mental conditions), (iv) predicted constrains (like time remains to making the required actions) and (v) possible solution analyser (simulating the issues from possible control actions).

Tests are performed in flight- and air traffic control simulators equipped with elements of developing system.

## 2. HARDWARE

For the decision support system (DSS), several hardware can be developed, which are suitable to be used for measuring some physiological parameter of air traffic controller. Based on some of these parameters, the actual mental condition can be estimated, which means, it is possible to determine if the controller is tired, overloaded or nervous at the moment.

The developed hardware is one of the countless possibilities that are available. It is based on the idea, that the controller uses (keeping in his hand) the mouse of the workstation very frequently during his work time.


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The hardware developed consists of as follows:

- Commercial mouse with built-in 3 axis MEMS accelerometer, optical heart rate sensor and skin resistance and temperature sensor.
- Data acquisition board (DAQ) with signal conditioners, A/D converters, microcontroller, etc. Interfaced to PC via USB port.
- PC software to process and display the results and control the measurement.

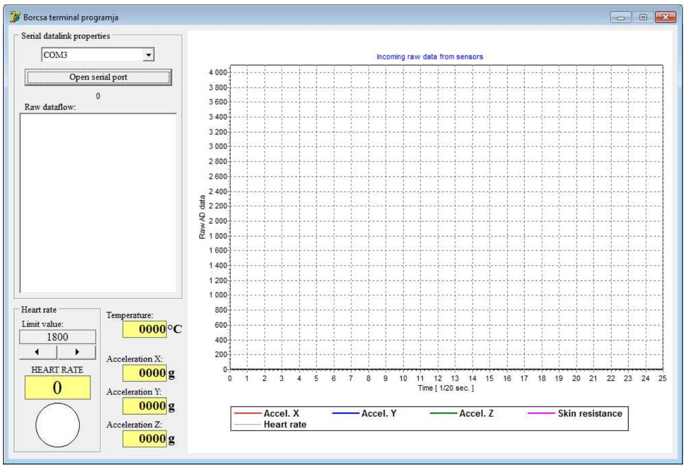


**Figure 2: User interface of the custom PC software**

On Figure 2, the user interface of the PC software developed can be seen. On the right side, the time history of the current raw measured values can be seen, while on the left side, the settings of the COM port and the calculated values are shown.

A commercial mouse was modified in order to make it suitable for accepting custom sensors. The optical heart rate sensor has been positioned on the right side of the mouse, on the place of the right thumb. The sensor consists of a infrared led and transistor pair, which, with the corresponding electronic, can sense the blood pressure variation in the thumb, if it is positioned correctly.

The system general layout can be seen on Figure 3. The mouse original USB connection is separated from the DAQ system, therefore it is not necessary to modify anything (hardware or software) in the ATC workstation. The measured data are feeded into a separated PC via USB connector.

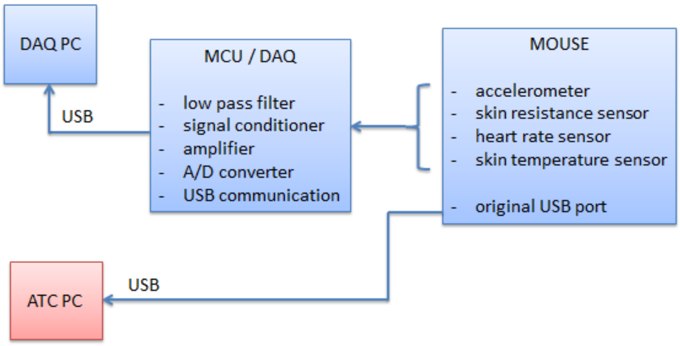


**Figure 3: General layout of DSS developed**

On Figure 4 the system integrated into an air traffic controller workstation is shown.

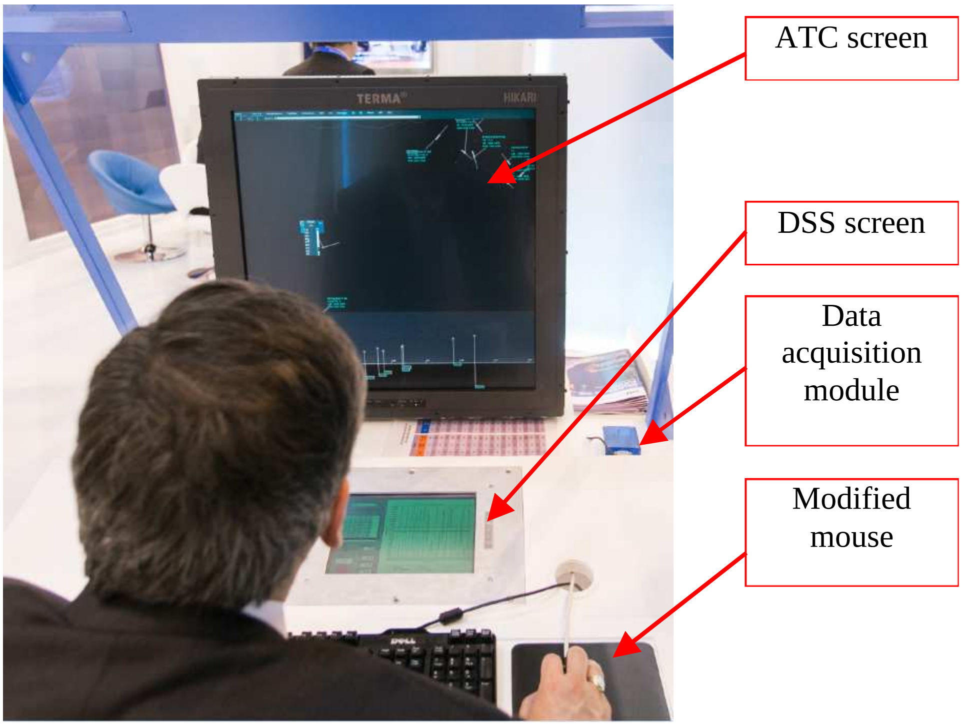


**Figure 4: Decision support subsystem integrated into controller's workstation**

The system has been tested many times in flight- and air traffic control simulators. The results shows, that the heart-rate sensor sometimes gives false values, which must be neglected later in the further developments. Better pulse detection mechanism must be used in order to make it a really robust system. The other sensors, like the accelerometer or the skin resistance sensor are performed well, it is very easy for example to sense and record how many times the user grab the mouse and how long he doing activity with it. These can be important values, when the workload is wanted to be determined.

A risk assessment would be also done, which with the simulation results should clearly demonstrate, and quantify the envisioned benefits, and show whether the real introduction of the concept is cost-effective, and safe.

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