2011

Selection Requirements to Work in Future ATM Systems

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Different findings concerning staff selection requirements for future Air Traffic Management (ATM) resulting from empirical studies and expert judgement are summarised. The biggest impacts are foreseen for ATCO's, commercial pilots, ATM technical staff and a/c maintenance staff, mainly related to advanced ATM concept features. An empirical study involving ATCOs and pilots encompassing workshops and simulations studying elements of a free flight scenario revealed significant changes in ability requirements for ATCOs and pilots. They indicate higher ability requirements for pilots in future ATM systems and only small changes for air traffic controllers. Pilot and air traffic controller profiles are likely to assimilate with regard to cognitive abilities. 'Operational Monitoring' is expected to become a core requirement for future ATM systems. A definition and a respective requirements analysis scale are proposed.

Improvements in air traffic management (ATM) and aircraft systems as well as organisational structures have become one of the key challenges of aviation in 21st century. In Europe, the Single European Sky (SES) initiative aims at enhancing capacity and safety as well as reducing cost and impact on environment. Although the European ATM Master Plan resulting from SESAR, which can be seen as the European equivalent to the U.S. NextGen Programme, widely relies on automation, the Human is expected to remain a central part of the future ATM system. The SESAR concept is based on the idea of a business trajectory being carefully planned and finally executed in a complex interaction between all affected partners, with the primary objective to meet the requirements of airspace users. Information processing and decision-making will be strongly supported by automation tools, often integrating data and systems from different partners (e.g. airline operations centres, cockpit, control centres and towers, meteorological services etc.) During the SESAR Definition Phase, the Human Performance implications of the SESAR Concept of Operations were analysed by means of a preliminary Human Factors Case (Eurocontrol, 2007), staffing prediction models and change and transition models (SESAR 2007a).

Results show that many operational improvement steps will require an adaptation or even development of standards and regulations related to operational staff training and competence verification. Far reaching consequences were identified especially for Air Traffic Controllers, pilots, airline operations centre staff and technical staff installing and maintaining air and ground equipment (about 200.000 staff, SESAR, 2007b,c). Generally, the consequences of

future ATM systems and procedures for recruitment and training requirements were found to be sometimes under-, sometimes overestimated by operational experts. Since degraded mode operations and unplanned circumstances will still require Human analysis, decision making and action implementation, the basic ability requirements for e.g. ATCOs can be expected to include about today's requirements profile (Eißfeldt & Heintz, 2002). However, for the more advanced operational features larger changes in ability requirements are considered most likely (SESAR, 2007, a, c).

However, it is obvious that impacts of future systems and procedures can only be determined when systematically examined and embedded in simulation studies. The provision of a standard methodology to achieve this will therefore be one element of the future SESAR Human Performance R&D, including structures to ensure its application in the context of development and validation activities in the framework of a European Joint Undertaking, the SESAR JU (SESAR JU, 2009). At the same time, research on impacts on recruitment and training of operational aviation staff has been continued with a relation to SESAR concepts.

The key question of the DLR project 'Aviator 2030' dealt with changes that will concern pilots and air traffic controllers introducing SES. Based on domain experts' point of view, future ATM scenarios were developed. Key aspects key were tested in two simulation studies to identify potential changes in ability requirements for pilots and air traffic controllers prospectively.

Method

A multi method approach was chosen in order to fully cover the sequence of analysis from the operational concept to changes in ability requirements and tests.

Based on domain experts' points of view, anticipated changes in the ATM system were described using a special workshop technique taken from sociological research. The 'Future Workshop' concept was used for the first time in a high-tech environment such as aviation. A set of workshops with pilots and air traffic controllers successfully described scenarios of future ATM, providing a valid basis for further research. A detailed description of the layout and the outcome of the workshops is provided by Bruder, Jörn & Eißfeldt (2008).

A standard tool for job analysis (F-JAS, Fleishman 1992a,b,c) was tailored to aviation-related research by integrating aviation anchors for the current job conditions of air traffic controllers and pilots. In addition, new scales were developed in a similar style to measure requirements not covered in the original material. Applying the F-JAS Aviator 2030 with aviation anchors allowed for an interpretation of whether job incumbents anticipated an increase or a decrease in ability requirements in future ATM systems (Eißfeldt, 2009).

A low-fidelity integrated simulation platform (AviaSim) was developed following a bottom-up approach by combining two off-the-shelf simulators to meet the requirements of high realism, low cost, high adaptability, and full controllability for experimental purposes. It included a short-term conflict alert (STCA), mid-term conflict detection aids, and interactive labels for data ink communication on the ATC side as well as a data link window and a traffic visualization system (Cockpit Display of Traffic Information, CDTI) on the pilot side. In a linked simulation, the transfer of control between air and ground as well as airborne self-separation in Free Flight Airspace, was examined (Eißfeldt et al., 2009; Hörmann et al., 2009).

Results

Exemplary Findings on Changes in Pilot and ATCO Requirements Profiles

Following the Avia Sim Scenario, pilots and ATCOs again rated the amount of the required level of abilities. Figure 1 lists the top ten ability requirements as rated in the AviaSim study for the future scenario. The numbers in brackets refer to the ranking position for the baseline scenario and are well in line with other applications of the F-JAS (e.g., Goeters et al 2004).

On the controllers side the positioning of 'time sharing' at the bottom of the top ten list is remarkable as for air traffic controllers this has been the top rated ability requirement in all studies of current ATC so far. For pilots this scale has moved upwards a bit in the free flight scenarios. A common upward trend can be noted for a variety of abilities: 'perceptual speed', 'speech recognition', 'stress resistance', 'decision making' and 'problem sensitivity' all are becoming more relevant for both professions with the free flight scenario. Pilots and air traffic controllers share 8 of the 10 top future rankings (cf. Figure 1) underlining the notion of profiles assimilating in free flight scenarios. The abilities not in common are: 'selective attention' and 'resilience' rated high for ATC but not for pilots, whereas 'spatial orientation' and 'auditory attention' are among the top ten for pilots but not for ATC. If both lists were aggregated into one 'Aviator Free Flight Profile' according to their rankings, 'problem sensitivity' would come first followed by 'decision making' and 'vigilance' and 'visualization'.

ATC future	Cockpit future
1. Problem Sensitivity (2)	1. Spatial Orientation (5)
2. Decision Making (3)	2. Vigilance (2)
3. Selective Attention (14)	3. Visualization (7)
4. Stress Resistance (9)	4. Problem Sensitivity (12)
5. Speech Recognition (15)	5. Decision Making (9)
6. Resilience (4)	6. Time Sharing (10)
7. Vigilance (5)	7. Speech Recognition (8)
8. Visualization (6)	8. Stress Resistance (11)
9. Perceptual Speed (16)	9. Auditory Attention (1)
10. Time Sharing (1)	10. Perceptual Speed (15)

Figure 1

The top ten ability requirements as rated in the AviaSim Free Flight study for the future scenario. The numbers in brackets refer to the ranking position in the baseline scenario.

Emerging Ability Requirements for Future ATM Systems: Operational Monitoring

Due to the level of automation as envisaged in the future ATM operational concepts, the Aviator 2030 research revealed one specific requirement for pilots and ATCOs to become a critical ability clearly going beyond

today's ability requirements. Due to the increase of system based planning and, in consequence, decision making with regard to flight trajectories, the need to effectively monitor the system was found to become much more important. At the same time, the necessity for the operator to take over control under certain circumstances (e.g. handover between ground controlled and free flight mode of operations, non standard operations) is likely to remain critical even in very advanced stages of ATM evolution. Consequently, this ability requirement was further examined and finally defined following the F-JAS format (Fleishman, 1992, a, b, c; Figure 2) in order to enable measuring the ability requirement in future studies.

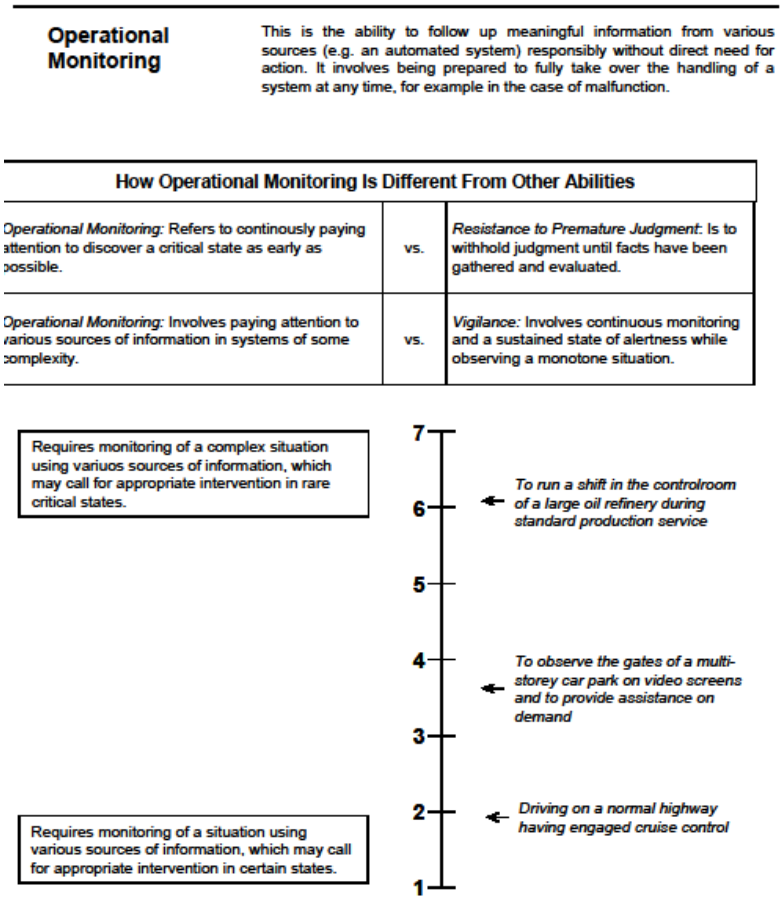

Figure 2

Proposed research ability requirement scale on "Operational Monitoring" following the format of the Fleishman Job Analysis Survey F-JAS.

The resulting behavior-anchored rating-scale is named ‘Operational Monitoring’ (Figure 2). It is considered to be marked by some of the ability requirements rated highest by pilots and air traffic controllers for the future scenario: problem sensitivity, situation awareness, decision making and vigilance. Its ends are defined by a description of an extreme degree of the ability. The behavioral anchors are typical task examples for a high/ middle/ low amount of requirement of the ability. Their position on the scale was determined through an expert rating with participants familiar with the format.

Discussion

The findings underline the importance of empirical research involving job incumbents when determining the consequences of future ATM concepts, systems and procedures for selection requirements of operational staff. Structured, facilitated workshops with job holders as well as the inclusion of standardized job analysis tools into validation or other simulation activities promise to be effective means to provide evidence for this frequently discussed issue.

Significant effects were found especially for advanced features. For example, ‘having a picture’ of relevant elements of air traffic is an ability requirement for current ATCOs. During free-flight operations pilots also had to ‘have a picture’ of the surrounding air-traffic. One can consider that the importance of ‘visualization’ capabilities for pilots may change fundamentally with the introduction of airborne-separation procedures. This new ability is not reflected in today’s selection profiles of pilots. It can be assumed that different ability levels concerning ‘visualization’ exist within the present pilot population, as this requirement is not directly tested in many ab-initio pilot selection systems. It will be interesting to see how effective pilot training for self-separation can compensate for these differences in the future.

Pilots and ATCOs in the future will have to take over “manual” control in various non-standard circumstances. The general ability to follow up meaningful information from automated systems without direct need for action will be a prerequisite to show a good performance in these non-standard situations. This shift in job requirements to supervisory control has been identified as a key human-factors issue in advanced ATM systems. One open question here is if this will bring major changes in the ability profiles used for future selection. In this context “Operational Monitoring” may emerge as a useful construct. The value of the new scale will be explored in recent German and European studies on advanced and future ATM systems (e.g. with a newly introduced en route ATM system in Germany).

References

Bruder, C., Jörn, L., & Eißfeldt, H. (2008). When pilots and air-traffic controllers discuss their future. In *Proceedings of the 28th EAAP Conference: The future of aviation psychology* (pp. 354-358). Valencia: EAAP.

Eißfeldt, H. (2009). Aviator 2030 - Ability requirements in future ATM Systems. *In Proceedings of the 15th International Symposium on Aviation Psychology* (pp. 112-117). Dayton, OH: Wright State University.

Eißfeldt, H. & Heintz, A. (2002). Ability requirements for DFS controllers - current and future. In H. Eißfeldt, M. C. Heil & D. Broach (Eds.), *Staffing the ATM system - the selection of air traffic controllers* (pp. 13-24). Aldershot: Ashgate.

Eißfeldt, H., Grasshoff, D., Hasse, C., Hoermann, H.-J., Schulze Kissing, D., Stern, C., Wenzel, J. & Zierke, O. (2009).

Aviator 2030 - Ability Requirements in Future ATM Systems II: Simulations and Experiments. In *DLR Forschungsbericht 2009-28*. Köln: DLR.

EUROCONTROL (2007). *The Human Factors Case. Guidance for Human Factors integration*. Ed. 2.0, 29-06-2007. Brussels: Eurocontrol.

Fleishman, E. A. & Reilly, M. (1992a). *Fleishman Job Analysis Survey (F-JAS) Administrator´s Guide*. Potomac, Maryland: Management Research Institute.

Fleishman, E. A. (1992b). *Fleishman Job Analysis Survey (F-JAS) Rating Scale Booklet*. Potomac, Maryland: Management Research Institute, Inc.

Fleishman, E. A. & Reilly, M. (1992c). *Handbook of Human Abilities. Definitions, Measurements, and Job Task Requirements*. Potomac, Maryland: Management Research Institute.

Goeters, K.-M., Maschke, P., & Eißfeldt, H. (2004). Ability requirements in core aviation professions: Job analysis of airline pilots and air-traffic controllers. In K.-M. Goeters (Ed.), *Aviation Psychology: Practice and Research* (pp. 99-109). Aldershot: Ashgate.

Hörmann, H. J., Schulze Kissing, D. & Zierke, O. (2009). Determining Job Requirements for the next Aviator Generation. In *Proceedings of the 15th International Symposium on Aviation Psychology* (pp. 118-123). Dayton, OH: Wright State University.

SESAR (2007a). The ATM Target Concept (Rep. No. DLM-0612-001-02-00a). Brussels: SESAR Consortium.

SESAR (2007b). Human Resources. Task 1.7.1/2/3 – Milestone 3 (Rep. No. DLT-0612-17x-00-12). Brussels: SESAR Consortium.

SESAR (2007c). WP 1.7 - D4. Human Resources. (Rep. No. DLW-0706-017-01-00). Brussels: SESAR Consortium. Retrieved from *http://www.sesar-consortium.aero*.

SESAR (2007d). SESAR Master Plan. (Rep. No. DLM-0710-001-02-00). Brussels: SESAR Consortium. Retrieved from *http://www.sesar-consortium.aero*.

SESAR JU (2009). Statement of Work WP 16 Transversal Aspects. Unpublished. Brussels: SESAR JU.