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Shifts in ability requirements as perceived among aviation operators

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Abstract

Comparing today's control rooms or cockpits to those of about 30 years ago clearly shows huge differences in hard- and software, making changes in psychological requirements more than reasonable. To identify changes in ability requirements for operators in future aviation is of some concern when learning about solutions envisaged with large scale programs like NextGen or SESAR. However, as systems evolve step by step and sometimes without much notice, it might be that in retrospect requirement changes are assessed as being only of minor magnitude, whereas prospective ratings tend to over-interpret changes as they might be perceived as endangering one's competence and routines. In this study, it is reported what more than 300 air traffic controllers and pilots described as perceived changes in ability requirements when comparing today's aircraft or system with the one they have been trained for initially. Results were showing different pictures for the professions compared; however operational monitoring, information ordering, selective attention, time sharing and vigilance were always among the requirements with the highest perceived changes since initial training. Results will help to increase the understanding of past changes in ability requirements as perceived by job incumbents.

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1. Introduction

Aviation is among the most prominenteconomic sectors concerning introduction of new technology and applications. Typically these are designed to enable the human operator to perform his/her tasks more efficient and at the best possible safety standard. Since long this has raised questions about potential changes regarding the set of

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ability requirements needed to perform the job of a pilot or air traffic controller with newly introduced tools and procedures. With experienced job holders such introduction requires detailed training on the background of acquired skills at the time of deployment, whereas for the selection of candidates due to the lag between selection and becoming fully qualified, it is best to consider requirements some time ahead.

To describe potential changes in job requirements in aviation with regard to selection procedures has led to different approaches in aviation psychology. For air traffic control foreseen changes in ability requirements have been described from purely theoretical background[1,2], from interviewing experienced controllers[3], cognitive walkthroughs [4], future workshops with pilots and controllers together [5], or even large scale simulations[6]and experiments[7].Different results have been achieved. Besides assumptions on a general increase or decrease in cognitive and social/interactive requirements with future ATM systems, some predictions were more precise, resulting sometimes in controversial assumptions e.g. on the future relevance of time-sharing or memory.

For the first time now a sample of job holders in aviation was asked to rate a set of ability requirements to indicate if and how the level of requirement in their job has changed from the time they have been trained initially to the current job. Provided the ever changing nature of aviation jobs, results can show where the core aspects of change are seen by subject matters retrospectively, and thus allow a better projectioninto the future.

1.1. Background

During the SESAR (Single European Sky Aviation Research) definition phase the need to adequately exploit human performance in ATM when introducing advanced levels of automation was one of the issues considered as a potential showstopper for the ATM Target Concept. In its development phase SESAR produces in numerous work packages the required new generation of technological systems, components and operational procedures as defined in the ATM Master Plan and Work Programme. In SJU (Sesar Joint Undertaking) WP 16.04.03 the task was to describe the impact of future systems and procedures on selection, training, competence and staffing including advanced automation. To do so, proactive tools have been developed helping to describe such impact as early as possible, taking into account the time span between identification of changing ability requirements and deployment of fully licensed operators meeting such needs. The tool concerned with impacts on ability requirements is called SELAT - SELection requirements proactive Analysis Tool. The aim of the SELAT is to support the mandatory human performance assessment process in the SJU that all operational improvements have to perform. To do so it achieves the earliest possible detection of needed change of ability competence profile of human operators, with reference to the technological development. This would enable higher probability of a) continuous high safety standards of operations b) high success rate in training, by selection of the best suitable abilities among aviation candidates c) optimized training for current operators, minimizing the risk for human errors due to change in ability requirements.

2. Method

To depict ability requirements of aviation operators in the current European ATM system the Fleishman Job Analysis Survey [8] was made use of. The F-JAS is a survey measuring human abilities, providing detailed definitions and anchored rating scales for more than 70 scales covering the domains of cognitive, psychomotor, physical and sensory abilities as well as social/interactive abilities. With the F-JAS job incumbents are asked to use a 1 to 7 scale to"rate the task on the level of the ability required, not the difficulty, time spent or importance of the ability"[9]. To find out whether this tool was useful for developing the SELAT, a baseline study was conducted.

For the SELAT baseline study described a special version of the F-JAS has been developed, including not only a subset of the original scales but also additional scales developed at DLR German Aerospace Center. A total of 59 scales were listed in the booklet.A detailed checklist was provided to enable participants to work the material individually, taking them through the procedure step by step. The material was in plain English, data collection was fully anonymous but asking for some background variables like age, gender, position and special function (e.g. coach / check captain) and years of experience with the current system or the job overall. Major aspect of the study was to collect data on ability requirements for the actual work conditions of pilots and air traffic controllers (ATCOs) to provide a baseline for further applications. The main question was whether results for different

professional groups were fully comparable across Europe and thus would allow a one-time measurement approach with the SELAT, providing anchors at the scales reflecting the current conditions of a job. The alternative approach was a two-time measurement in a pre- and post-design, reflecting first the conditions of the daily job and second the rating after some experience with the new tool or procedure for instance in validation trials. As it turned out large differences in results for the same profession across and even within organizations were revealed thus the concept of anchored scales was not further followed for the SELAT [10].

To simulate the repeated application of the scales in a pre/post-design resulting already in the baseline study, a second set of ratings for the same ability requirements was collected. The leading question to be answered in the retrospective part of the study was: Please indicate on a five-point scale reaching from '- -' to '++'for which abilities you consider changes in ability requirements when comparing todays a/c or system with the one you have been trained for initially. This will help us understanding past changes in ability requirements.Marking '++' indicates that to your impression this ability has become significantly more required with the actual a/c or system compared to the former one. If you consider an ability requirement equal for actual and former a/c or system, please mark 'o'.These retrospective data from more than 300 job incumbents from all across Europe will be reported here.

2.1. Data

The data were collected among SESAR partners mainly in 2013. Originally data collection was planned to be conducted in groups in the presence of an instructor, however it was soon revealed that for pilots and air traffic controllers it was almost impossible to schedule such events in an efficient way. Thus a checklist procedure was developed allowing subjects to provide their ratings individually. Participation was voluntarily and fully anonymous. For every airline or air navigation service provider (ANSP) at least one focal point was assigned who distributed the material locally and offered to collect and hand it back if required.However every participant could also send back the filled-inmaterial individually using a postal service free-of charge.The material consisted in a scale booklet (40 pages), a checklistand an answer sheet (4 pages) for the two sequences. The whole procedure was planned to last between 60 and 90 minutes.

Starting off slowly with only one ANSP and one airline participating, the response in the field grew remarkably ending with 110 pilots from 4 major European airlines and 227 air traffic controllers from 5 ANSPs in the North, Center and South of Europe. In addition also air traffic safety electronic personnelATSEPs were tried to be included as this profession becomes more and more relevant in modern ATM, however due to the inhomogeneity of this group the data are not reflected here.

The basic sample characteristics for N = 337 participants are presented for the professional groups separately:

- *Air Traffic Controller:* N = 227; 71% male, mean age: 38.7; working position: 46% ACC, 32 % TWR, 22% UAC; time since first licence: 14.2 years; experience with current ATM system:Mean 58.2 months; describing their current system as Traditional (1) versus Advanced (11): 7.8.
- *Airlinepilots:* N = 110, 100% male; mean age:41.2; aircraft: 54% Airbus, 42% Boeing, 4 % other; time since first licence: 16.8 years; experience with this fleet: Mean 73.9 months; describing their current system as Traditional (1) versus Advanced (11): 8.2.

3. Results

In general most of the ability scales received retrospective ratings indicating equal or somewhat higher relevance compared to the time of training. Only two scales received mean ratings indicating a decrease of relevance over time: mathematical reasoning and number facility.

Table 1 shows for the sample of 337 aviation operators means and standard deviation of the15 ability requirements rated as having the highest increase in relevance when comparing the actual job with the one at time of initial training. The marks have been recoded 1 (- -) –5 (++)to allow for statistical analysiswith1 meaning 'ability has become significantly less required' and 5 meaning 'ability has become significantly more required'.

Table 1. Perceived increase in ability requirements since initial training – Top 15 / N = 337.

Scale name	Mean	Std.Dev.
Operational Monitoring	3.57	.92
Openness to Experience	3.48	.78
Time Sharing	3.46	.82
Visual Color Discrimination	3.44	.80
Information Ordering	3.43	.84
Behavior Flexibility	3.42	.73
Coordination	3.42	.73
Coaching	3.41	.74
Selective Attention	3.40	.80
Self Control	3.39	.72
Speed of Closure	3.39	.82
Vigilance	3.38	.82
Flexibility of Closure	3.33	.75
Perceptual Speed	3.33	.85
Problem Sensitivity	3.32	.86

The highest increase in relevance since initial training was revealed for operational monitoring, a scale developed by the department of aviation and space psychology at DLR as result of prior research in the Aviator project [11].This scale was constructed following the format of the F-JAS in a combination of theoretical aspects and empirical findings following the same methodological path as described by Fleishman andQuaintance[12]. Operational monitoring is defined as 'the ability to follow up meaningful information from various sources (e.g. an automated system) responsibly without direct need for action. It involves being prepared to fully take over the handling of a system at any time, for example in the case of malfunction.' The full scale is depicted in Annex A.

Figure 1 shows the distribution for operational monitoring. While 36.5% of aviation operators indicated that they had not experienced requirement changes for operational monitoring, 35.6% reported some and another 16.9% indicated significant increase. Thus over half of the sample has perceived an increase for operational monitoring. However, 11% reported a decrease for this requirement, with only 1.2% stating this decrease to be significant.

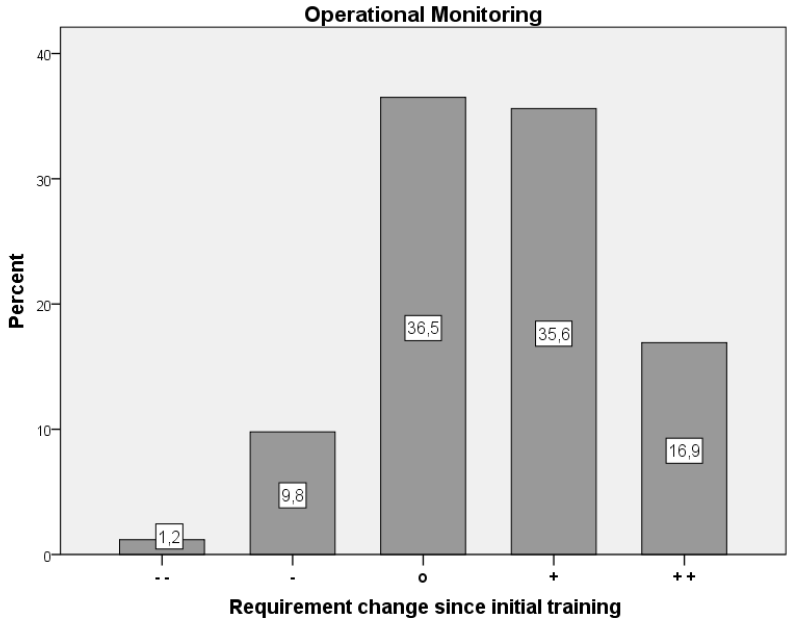

Fig. 1.Distribution of perceived changes in operational monitoring. N = 337.

Comparing the mean values of air traffic controllers (3.58) and pilots (3.56) for operational monitoring leads to very similar results. Applying Mann-Whitney-U-test shows that also the distribution for both samples is equal (p>.05). Extrapolating this findingsoperational monitoring can be hypothesized to be a central aspect also when it comes to requirement changes for aviation operatorsin the future [13].

Further cognitive abilities assessed as more required are the ability to correctly follow a rule or set of rules in order to arrange things or actions in a certain order (information ordering, 3.43), the ability to quickly make sense of information that at first seems to be without meaning or organization (speed of closure, 3.39), and the ability to identify a known pattern from the background material (flexibility of closure, 3.33). Moreover, pilots and air traffic controllers perceived an increase in relevance in the ability to concentrate on a task without getting distracted (selective attention, 3.40)also over a longer period of time although active intervention will rarely be necessary (vigilance, 3.38). They also considered a moderate increase in the ability to shift back and forth between two or more sources of information (time sharing, 3.46), the ability to compare letters, numbers, objects, pictures, or patterns, both quickly and accurately (perceptual speed, 3.33), and the ability to identify and communicate when something is wrong or is likely to go wrong (problem sensitivity, 3.32).

As most participants were experienced job incumbents, they found that the ability to help develop the talents and skills of others (coaching, 3.41) became more required during their career. It is also not surprising that with the introduction of new technology and procedures after initial training more acceptance of new ideas and environments (openness to experience, 3.48) and more flexibility to adapt to changing circumstances (behavior flexibility, 3.42) was required. In addition, the social/interactive aspects of structuring work plans and activities (coordination, 3.42) and remaining calm and levelheaded in difficult or stressful situations (self control, 3.39) were ratedas more required compared to initial training. According to the sensory abilities, operators perceived an increase in relevance in the capacity to match or discriminate between colors (visual color discrimination, 3.44).

The Mann-Whitney-U-test shows that for 4 out of the Top 15 abilities both professions assessed the change in requirements significantly different: Pilots perceived a higher increase in relevance for information ordering ($p < .05$) and problem sensitivity ($p < .05$) compared to air traffic controllers. Also for self control, pilots assessed the change in relevance as higher ($p<.05$). The increase for visual color discrimination was perceived higher by air traffic controllers($p<.05$).

4. Discussion

For the first time a sample of job holders in aviation was asked to rate for a set of ability requirements to indicate if and how the level of requirement in their job has changed from the time they have been trained initially to the current job. Results were showing an increase in relevance for some abilities when comparing the actual job with the one at time of initial training. Both professions, air traffic controllers and pilots, perceived operational monitoring as the ability with the highest increase in relevance. With the intention to deploy more advanced automation in the aviation environment in the future, this finding encouragesfurtherresearch into operational monitoring regarding selectionand training[14].

Comparing both professions, some changes were perceived as higher for pilots or air traffic controllers. However, operational monitoring, information ordering, selective attention, time sharing and vigilance were always among the requirements with the highest perceived changes since initial training.

It has to be taken into consideration that on average the level of perceived changes abilities are only low to moderate. As systems evolve step by step and sometimes without much notice, it might be that in retrospect requirement changes are assessed as being only of minor magnitude, while prospective ratings tend to over-interpret changes as they might be perceived as endangering one’s competence and routines. Provided the ever changing nature of aviation jobs, results can show where the core aspects of change are seen by subject matters retrospectively, and thus allow a better projection into the future.

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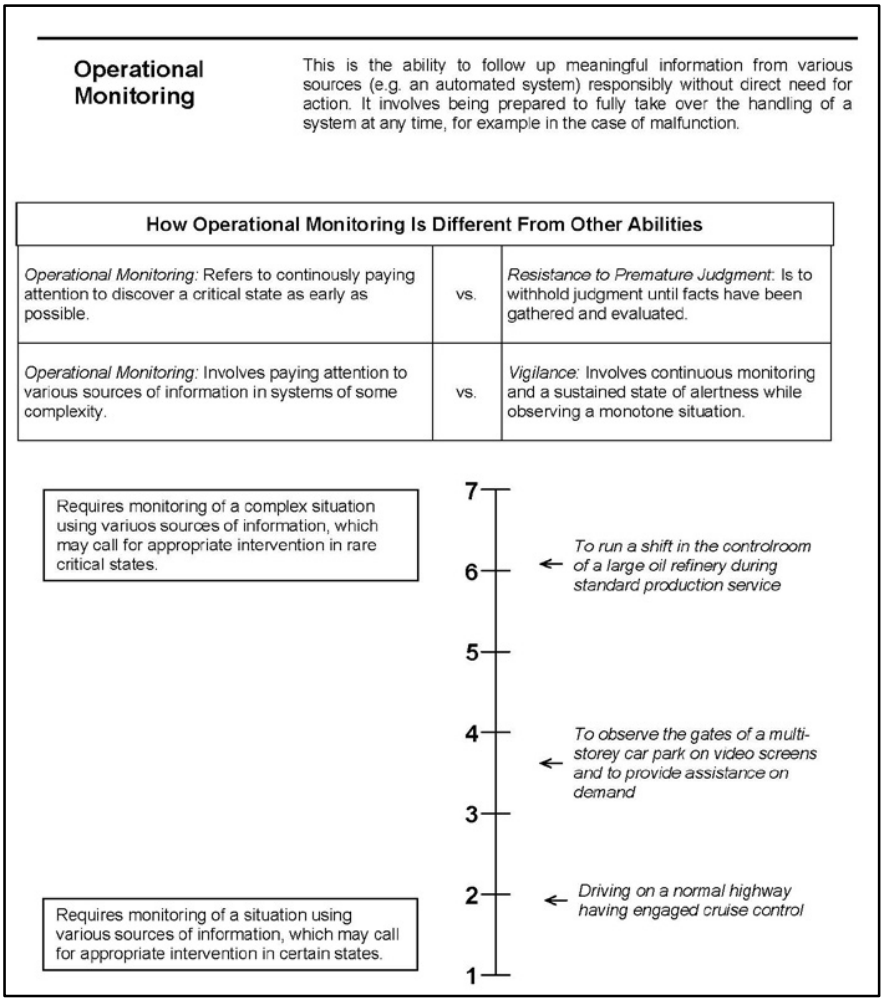
Appendix A. Scale: Operational Monitoring



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