Paper presented at the 15th International Symposium of Aviation Psychology. Dayton/OH, April 27-30, 2009.

# DETERMINING JOB REQUIREMENTS FOR THE NEXT AVIATOR GENERATION

Hans-Juergen Hoermann
German Aerospace Center (DLR)
Hamburg, Germany

Dirk Schulze-Kissing & Oliver Zierke
German Aerospace Center (DLR)
Hamburg, Germany

The aviation industry is envisioning a tremendous growth of air traffic within the next two decades. New technologies and operational concepts will be the key enablers to accommodate the increasing amount of movements in a safe, efficient and environment friendly manner. Current working concepts reach from improved interoperability of national ATM systems, via satellite based navigation, collaborative decision making, and self separation of aircraft up to fully automated air-ground-space systems. It can be expected that the introduction of such concepts will have a significant impact on the working conditions and job requirements of future air traffic controllers and pilots, who were selected on traditional job profiles reflecting the current and past operational settings. Our paper is presenting elements of a prospective job analysis of future aviators assigned to specific operational tasks within the future air transport system. Results will be based on reviews of available international concept papers, conducted future workshops with present job holders and low fidelity simulation runs of collaborative air traffic control and aircraft separation tasks. Relevant en-route and arrival scenarios will be discussed and presented at the symposium with some preliminary data of the initial tryout studies.

One important basis of a fair and efficient selection system is the adequate identification of job requirements. However, in times of rapidly developing working conditions, job profiles of knowledge, skills, abilities and other characteristics have an increasing short half-life period. The classical selection rationale that job requirements should match a person’s individual pattern of stable aptitudes and interests will become perishable because of significant environmental influences. The drivers of that change are economical, technological and societal in nature (Anderson & Herriot, 1997). Such changes will lead to altered sets of typical job tasks, procedures and resources, which may or may not be congruent with the selection methods used to predict the job holders’ success at the time of hiring. In some cases, staff members might even have to be retrained or reassigned to different tasks. This will bear equal challenges for experts in selection as well as in training.

The aviation system is facing tremendous challenges in the coming decades due to the economic needs to expand transportation capacities by a factor 2x or beyond while maintaining the same or better safety levels (Ky & Miaillier, 2006; Krois, McCloy & Piccione, 2007). Such growth will be enabled by new technologies and operational concepts, which will significantly affect the work roles and tasks of all human actors in the future air transport system. Work roles may become more interchangeable, flexible, and proactive. For example, human operators could control aircraft from the ground or air traffic controllers might give instructions to aircraft clusters instead of single aircraft while spacing and separation could be assured by pilots in the cockpit. A new job profile might develop, for which we use the term *Aviator*. This paper is part of the project called *AVIATOR 2030* (Eissfeldt, 2006), which intends to elaborate tools and methods for a prospective analysis of job requirements and work roles in future commercial aviation. Future workshops and simulation are the main approaches applied in this project. While the paper of Eissfeldt et al. (see Symposium Proceedings) describes the results of the future workshops, this paper will provide an outline of the derived scenarios, which will be implemented in a simulation environment called *AviaSim* in order to investigate potential new work roles of pilots and controllers.

## New Concepts for the Air Transport System within NextGen and SESAR

Current developments in the aviation system are driven in the US and in Europe by two large-scale industry-government programs called NextGen and SESAR. SESAR is Europe's *Single European Sky Air traffic Research* system. NextGen is the US' *Next Generation Air Transport System*. Both programs are aiming to prepare the future air transport system for the increased demands in the years 2020 and beyond. The common vision is to integrate and implement new technologies and operational concepts that will boost performance of the air traffic management system (ATM) on a sustainable basis. Both, SESAR and NextGen combine increased automation with new procedures to achieve safety, economic, capacity, environmental, and security benefits. The programs will be aligned with each other to establish common standards for technical equipment and interoperability (JPDO, 2007; SESAR, 2007).

A key component is the cooperative ATM-model (C-ATM), where aircraft are constantly sharing their position data (from navigational satellites), flight path intent, and other relevant aircraft parameters with each other and with ATC. Automatic Dependent Surveillance Broadcast, known as ADS-B is one of the technological preconditions to determine navigational data at a much higher degree of precision. This system can be used to transmit with high accuracy the same traffic information to pilots and air traffic controllers (ATCOs) and hence assure safe aircraft separation even if minima are reduced in high density airspace or at the airport. The new paradigm for planning and executing system operations will be the aircraft’s 4D-trajectories: a 4D-trajectory is the aircraft path in three spatial dimensions related to time, from gate-to-gate. SESAR’s ATM target concept is based on a further number of key features (SESAR, 2007):

- Trajectory management with minimized constraints by airspace design or pre-defined routes
- Collaborative planning continuously reflected in the Networks Operations Plan to ensure strategic de-conflicting even where resources are constrained
- Capacity gains by integration of airport operations and greater coordination between the stakeholders
- New separation modes supported by ATCOs and airborne separation systems will minimize potential conflicts and interventions
- System wide information management (SWIM), which integrates all ATM operational relevant data and links all relevant users into collaborative decision making (CDM) processes

- Humans will be central as managers and decision-makers even though advanced levels of automation support will be required to exploit the complexity.

The nature of roles and tasks for human actors within the future system will necessarily change. This will affect equipment design, staff selection, training (especially for unusual situations and degraded mode of operations), competence requirements and relevant regulations. For example, SWIM will cause a shift from mutually exchanging information to publishing, broadcasting, and goal-directed retrieval and usage of information.

## *AviaSim* – A New Simulation Platform with Multiple Actors

Future workshops were conducted with a number of experienced ATCOs of the Deutsche Flugsicherung (DFS) and airline pilots of Deutsche Lufthansa (DLH). As described in the paper by Eissfeldt (2009), the workshop participants generated several future scenario elements such as trajectory negotiation, tactical flight planning, self-separation, working in distributed teams, or teaming with automation. On the basis of these workshop results and the review of NextGen's and SESAR's future operational concepts, a simulation platform called *AviaSim* has been developed by the authors, which should allow to investigate processes of the tactical decision making, task allocation, attention, monitoring, and information management of human actors working together collaboratively in a distributed team environment.

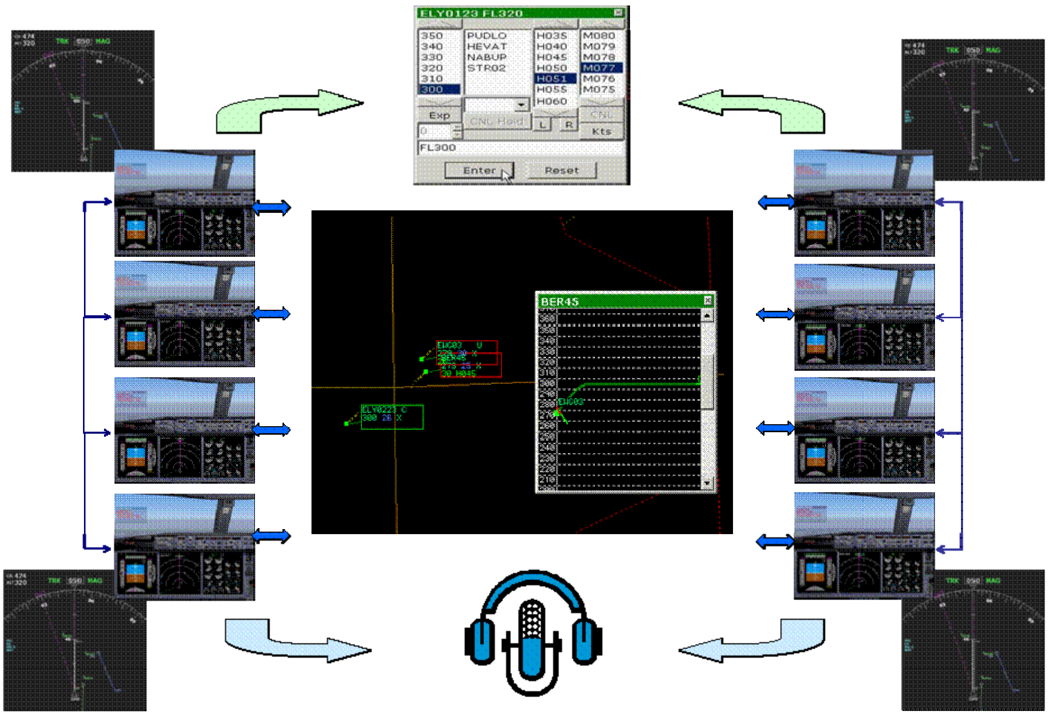


Figure 1. *AviaSim simulation platform with a networked configuration of eight flight simulators and one air traffic control simulator. Workplaces are equipped with standard technology and additional decision support systems. Communication is via data link and VOIP (Hoermann, Schulze-Kissing & Zierke, 2008)*

With open local area network architecture, AviaSim is currently configured for up to nine aviator workplaces: one for an air traffic controller and eight for pilots. Additional traffic can be generated with pre-determined flight plans per experimental script files. Each workplace has the standard equipment with additional automatic assistance functionality to support tactical decision making and continuous monitoring tasks. Figure 1 displays a configuration with traffic information displays and collision warning functionality. Communication processes are facilitated through VOIP and advanced by data link channels. This configuration serves primarily the simulation of en-route scenarios. However, with different support systems such as airport moving maps or arrival/departure managers we can also simulate with AviaSim traffic situations on ground or during departure and arrival. The type of aircraft also permits to introduce military traffic and uninhabited aerial systems.

## Development of a Potential Future Scenario

The choice of a potential future scenario was guided by a number of project-specific criteria and constraints:

- Realistic simulation of the working environment
- Reflecting results of the future workshops
- Consideration of required expertise of the subjects
- Air-ground simulation of the collaboration between multiple actors with distributed roles
- Facilitating control of experimental factors and measurement of a variety of relevant dimensions, including hard data, observation, subjective rating and eye-point of gaze
- Low fidelity simulation platform with open architecture.

The main purpose of the scenario development is to create an environment, in which it is possible to investigate work processes of aviators in the future air transport system. However, the technology development has not yet progressed so far that specific descriptions would be publicly available so that operational procedures could be elaborated. Therefore, our scenarios just have a certain probability of being realistic. In order to maximize this probability, it was essential to review current proposals of SESAR and NextGen for concepts of operation as well as to conduct the workshops with present jobholders. As a result of this, the focus of our initial scenario scripts is on how to define the functionality of future inborard/onground human to human communication interfaces as well as how to integrate new automation systems in the future work processes. The collaboration between distributed human and automatic team players during operational decision making processes from gate-to-gate is a main facet of the future air transport system, which we intend to investigate (see Figure 2).

The general task is to plan and execute effective separation of traffic by complying with the needs of the user while assuring separation minima. The authority for separation control should be transferred between ATCOs and pilots during the scenario. The different human actors will cooperate with particular assistance systems which can be attached or detached to the workplace (*Concept of Control Sharing*). They can choose to communicate with each other per data link or per voice transmission in a dyadic or in a partyline manner. The airspace is sectored into managed and unmanaged areas separated by transition layers. Following specific handover procedures, separation authority will be transferred from ground to air or back from air to ground upon transitions between managed and unmanaged sectors (*Concept of Control Transfer*). When an aircraft is in self-separation mode, it will have to follow a certain set of rules to prevent the risk of loss of separation. This en-route scenario challenges the crews' abilities of planning ahead, situation awareness, communication, information management and decision making as well as their attitudes towards *Compliance to Rules* and *Trust in Automation.*

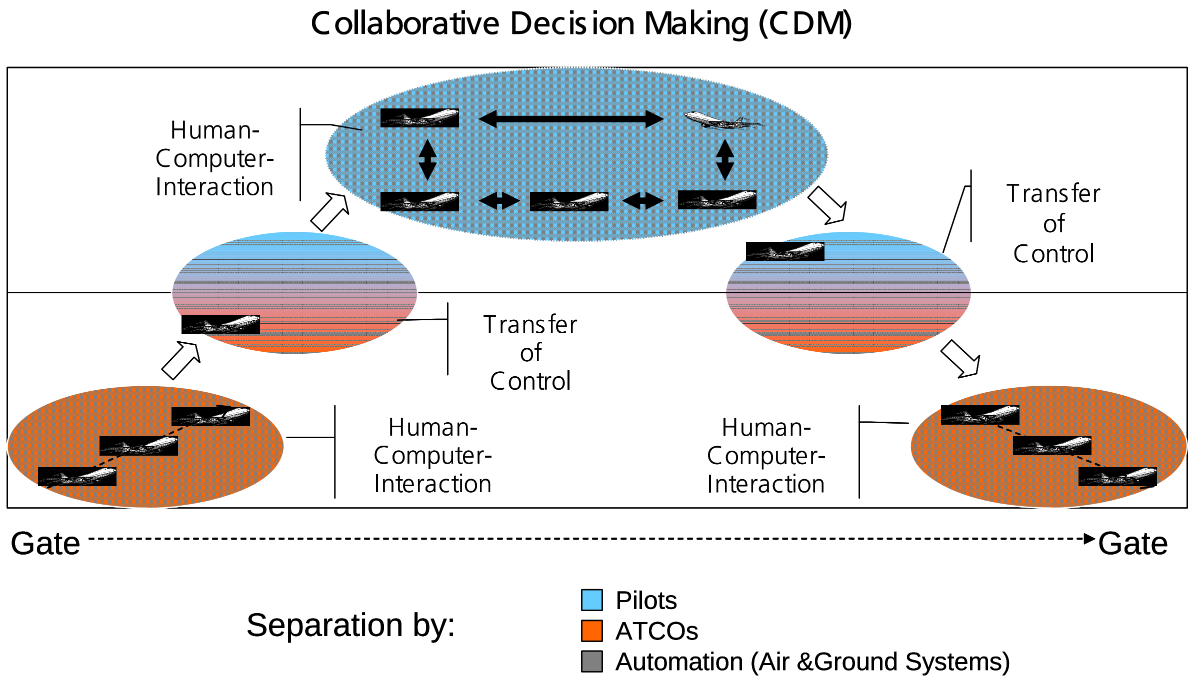


Figure 2. *Control Sharing and Control Transfer for separation tasks in future gate-to-gate operations (Hoermann, Schulze-Kissing & Zierke, 2008)*

It can be expected that such handover situations of authority carry a slightly increased risk of misunderstanding. Therefore, we expect flexibility of attention, communication, foresight and shared situation awareness of all actors to become critical factors of system performance. During self-separation, the ATCO can shift certain degrees of attention to secondary tasks. Eye-point-of-gaze measurement will be applied to record monitoring behavior. Being displayed on a different screen, secondary cognitive and perceptual tasks can also be inserted into the cockpit environment to gain some information on the workload, attention control, planning and monitoring behavior of the pilots.

In summary, task performance in the described en-route scenario should be relatively independent of the degree of subjects' technical knowledge and expertise. However, they will of course have to be current license holders. It is further intended to create a normal operations scenario without a significant amount of technical failures. The focus will be the behavior of the human actors. The determination of basic job requirements will not be linked to emergency situations in this phase of the project.

## Outlook

At the time of writing this paper, the project is preparing for first tryout studies and data collection phases. The AviaSim platform is already equipped and checked with all technical features described above. Up to 20 subjects will be recruited from DFS and DLH to activate the system and to participate in the real-time simulation of authority and control sharing and transfer in the future aviation system. It is envisioned to apply a customized version of Fleishman's Job Analysis Survey as described by Eissfeldt (2009) to collect information about the cognitive task requirements. In addition, a number of performance indicators will be collected. In future, we intend to use the AviaSim platform for cognitive task analyses of aviators beyond the en-route scenario. Arrival and departure scenarios with respective assistance systems have already been drafted and will be followed by surface movements at airfields. Assistance systems with higher levels of intelligence are also being designed. The open system architecture offers plenty degrees of freedom for expanding the equipment parallel to definition and implementation phases of NextGen and SESAR.

## References

Anderson, N. & Herriot, P. (1997). *International handbook of selection and assessment*. West Sussex/UK: Wiley.

Eissfeldt, H. (2006). *Projektplan „Aviator 2030"*. Hamburg/Germany: DLR ME-PS.

Eissfeldt, H. (2009). Aviator 2030 – Determining ability requirements in future ATM systems. *International Symposium on Aviation Psychology*. April 27-30, Dayton/OH.

Hoermann, H.J., Schulze-Kissing, D. & Zierke, O. (2008). Kooperation und Verantwortung im zukuenftigen ATM-System. Paper presented at the 4th AVIATOR2030 Progress Meeting. DLR: Hamburg/Germany: August, 18th, 2008.

JPDO (2007). *Concepts of operations for the next generation air transportation system* (Version 2.0). Joint Planning and Development Office. http://www.jpdo.gov/ .

Ky & Miaillier (2006). SESAR: towards the new generation of air traffic management systems in Europe. *Quarterly Issue of the ATCA Journal of Air Traffic Control*.

Krois, McCloy & Piccione (2007). Research portfolio for the Next Generation Air Transportation System (NextGen). *International Symposium on Aviation Psychology*. April 23-26, Dayton/OH.

SESAR (2007). *The ATM target concept - D3*. SESAR Definition Phase – Deliverable 3. http://www.sesar-consortium.aero/ .