

A Cockpit Point of View on "Human Factors" for a Changing ATM Environment

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ABSTRACT

The vision of SESAR is to integrate and implement new technologies to improve air traffic management (ATM) performance. Enhanced automation and new separation modes characterize the future concept of operations, where the role of the human operator will remain central by integrating more managing and decision-making functions. The expected changes represent challenges for the human actors in the aircraft and on ground and must be taken into account during the development phase. Integrating the human in the ATM system development starting from the early design phase is a key factor for future acceptability. This paper describes the adaptation of currently applied Cockpit Human Factors processes in order to be able to design the aircraft for the future ATM environment. Starting with the Airbus experience in successfully integrating Human Factors (HF) in the design and certification of aircraft, factors are described that identify how human actors can be integrated during the system engineering process when taking an air/ground perspective. For aircraft, the real added value of HF has been shown in being able to identify the real and relevant HF issues and to permanently adapt the methods to design and demonstrate efficient, easy to use, and safe aircraft. Building new technologies in aircraft for the future ATM requires not only to strive for a Human Factors Integration focusing on systems and Human-Machine Interfaces (HMI) but also integrating concepts of inter- and intra-organizational human cooperation on the level of an operational concept. Lessons learnt will be developed by combining principles of a human-centered approach and system engineering processes to support designing aircraft for a future ATM environment in a coherent and efficient manner. Examples such as 4D operations will be used to demonstrate facilitators or showstoppers for successful air/ground Human Factors integration from an aircraft manufacturer perspective.

INTRODUCTION

The current level of European ATM performance was identified as being insufficient to support future traffic growth and users' needs. The first deliverable of the SESAR Definition phase [1] describes some of today's ATM characteristics such as capacity limitations, focus on tactical control, no adaptability of delays, and fragmentation. To enhance ATM performance, the Single European Sky Aviation Research (SESAR) program was launched with the objective to develop the future ATM environment and achieve key performance objectives by increasing the safety level by 10, efficiency and ATM capacity by 3, and by reducing cost by 2. For this purpose, the ongoing SESAR development phase has the objective to produce new operational procedures, new technologies and preindustrial components according to the European Master Plan [2]. Enhanced automation and new separation modes are key elements for performance improvements. Additional changes cover the implementation of improved monitoring and conflict tools, improved safety net systems, improved navigation capability, trajectory management procedures and adapted airspace design, improved predictability, runway capacity enhancement, higher airport utilisation and better scheduling, and network organisation.

The analysis of the current baseline situation reveals remarkable differences between the airborne and ground side: Aircraft development has made a major shift towards automation during the 70ies which is fully exploited by today's airline operations. On ground, the technical equipage level between air traffic control centres is very diverse. To ensure an overall performance increase, changes need to involve the complete ATM environment covering both air- and groundside and making the two parts of the ATM system function together through a real air/ground integration. From commercial aircraft perspective, the future challenge will be

to integrate an increased number of low cost airlines and to adapt ATM management rules and airport infrastructure to better correspond to specific airline needs. Consequently, the objective of an aircraft manufacturer is to optimise aircraft design for use of the aircraft in the future ATM environment by providing functionalities that are easy to use, safe, and efficient.

Airbus as manufacturer of transport aircraft takes part in the definition of the next ATM generation. This generation will be characterised by more interaction and cooperation between aircraft and the ground. The goal is to ensure that future aircraft capabilities match the future operational concept and that the future operational concept makes the best use of the future aircraft capabilities by synchronising Air and Ground development and deployment. To ensure that aircraft can fly in different worldwide contexts, SESAR is part of the Target Global Interoperability within the ICAO framework and collaboration is established in particular with the US NextGen program.

Human Performance (HP) is a key component in SESAR, and the role of the human was identified as being central within the future operational concept. The evolution of ATM is however based on a certain repartition of roles and responsibilities between human actors and machines different to today. Hence, one task of Human Performance experts will be to ensure that the roles allocated to the human, i.e. the pilots, controllers and others human actors, will make sense from a human perspective. These roles have to be playable, performing, easy to learn, interesting and attractive. Consequently, HP will deal with Human-Human-Machine performance in terms of a positive contribution to the SESAR concept as well as human errors management. The problem is however that from a human perspective, whatever the role assigned to the human, it is very dependent of its implementation: the task definition, the work organization, the technical solutions (e.g. Human Machine interface, systems logics), the context of use (e.g. time constraints, weather conditions, terrains and obstacles), working conditions and the human conditions (e.g. internal factors such as fatigue, experience, memory capacity and external factors such as training or staffing).

As a consequence, HP is a transverse activity and has to be studied in many areas of SESAR. The integration of HP in the lifecycle of a complex system aims at reducing the risk associated to the human vulnerabilities and increasing the performance of the global Human(s)-Machine(s) system(s) taking into account the benefits of human capability. Within the SESAR program, HP studies are part of operational projects to challenge the concept definition as well as of technical projects to support the design of technical solutions and to contribute to their validation. HP studies are conducted at different stages of concept and product maturity. The main driver of the HP approach is to offer the means to understand

the HP issues related to innovations. To discover the areas of complexity from the end-users point of view permits to set the adequate requirements to develop the most suitable socio-technical solution.

AN AIRBORNE VISION TOWARDS HF INTEGRATION IN ATM

Anticipating the future is one of the main drivers of any business activity. The Aircraft manufacturer does not escape from that. For this reason, the Airbus Human Factors team builds SESAR activities in the perspective of the next two to three decades. Some characteristics of aviation are recalled in order to understand the Airbus drivers:

- Aircraft design cycle and in service operations are cycles of very long duration. One aircraft type is flying around 25 to 35 years. The A320 family was launched in 1988 and is still fully efficient. Functions can be updated to adapt the aircraft to the aviation context (i.e., continuous safety enhancement, efficiency optimization, cost reduction, new operations). The A320 cockpit philosophy is the underlying philosophy for A330, A340, A380, and A350, that are all part of the same family. This means that a manufacturer is managing its fleet by updating the aircraft and ensuring that the family concept is not affected. Consequently, evolutions are required to be fully manageable by the crews, easy to learn and to use.
- Changes are done for the benefits of Safety, Airlines and ATM performance, and are managed by the manufacturers as a set of modifications. The scope of modifications is broad as they may be related to the different crew tasks (i.e., fly, navigate, manage the system, communicate and manage the mission) or to functional or technological improvements (e.g. replacement of CRT by LCD displays). Therefore, the modifications are not focused only on ATM management functions, even if today the ATM evolution is a worldwide open marketplace where SESAR, NEXT GEN and perhaps other world region initiatives prepare the ATM of the future. Furthermore it is quite obvious to observe that most commonly, the modifications are not directly requested by the end-users (pilots or air traffic controllers).

These considerations are made to introduce the paramount influence of Human Factors to integrate at best these sets of modifications as the way to take into account the end-users considerations (human capacities and vulnerabilities). SESAR is in charge of developing the basis for the packages of new European ATM functions. They will have to be integrated into all the other aircraft functions including Next Gen functions, and are targeted for in-service aircraft as well as program under development and research programs. The objective of Airbus is not to create a new cockpit for ATM evolutions but to work on smooth evolutions of existing cockpits. The consequence is that the evolutions are made

with limited change of architecture and cockpit concepts for in-service aircraft.

Accordingly, a second objective of Airbus is that all new ATM functions will be certifiable on in-service aircraft and on new aircraft. This certification also covers Human Factors regulation in use since 2000 and applicable to the A380 and recent aircraft as well as to the major modifications on previous designs.

What is the impact of these considerations from a human point of view? First, the interaction between pilots and ATM functions should be designed to be fully in line with the cockpit philosophy of the targeted cockpit (such as A320, A330, A380, and A350) regarding topics such as control and display arrangement, color coding, information management, interaction, automation philosophy. The analysis of this interaction should however not only be looking at Airbus cockpit but also take a broader view. A minimum of standardization between cockpits all over the world is a positive contributive factor for the pilots who operate aircraft coming from different manufacturers during their professional carrier. The fewer the differences, the better the “cognitive economy” regarding mental demand or use of routines for pilots in case of transition between aircraft and during operations. Moreover, the cockpits are designed and certified to comply with HF criteria as “easy to use, clear and non ambiguous information”, “adequate level of situational awareness” and “manageable human errors”. Regarding the impact on workload, it is not sufficient to demonstrate that the new functions will be acceptable in terms of workload, which means that they will not exceed the acceptable level of workload according to regulations. An important objective for Airbus is that the new functions to be used by the crew will not increase the workload in a significant way, especially during the flight phases of taxi, take off, climb, descent, approach, and landing. In the same spirit, the pilots are trained and qualified for the current functions and it is not expected that the new ATM function will require significant additional competences and training.

In order to have a chance to cope with the objectives above, the human centered design approach is central and will have to be strong enough to produce adequate guidelines to the design team in a very pragmatic way. Airbus already has an efficient Human Factors Design Process as integrated part of its engineering process. It has been developed during the A380 development and improved along the various applications. A large effort was involved to train all the staff involved in designing cockpit, procedure and pilots training programs, to become familiar with this process. The final objective is to keep this process to develop all new functions including ATM ones with the necessary adaptations to be able to build an efficient HP process able to integrate Air and Ground considerations. The following chapters detail these aspects.

THE CURRENT STATUS ON AIRBORNE HF INTEGRATION

WHAT TO ADDRESS - HF INTEGRATION WITH REGARD TO THE PRODUCT

Amalberti [3] defined the role and the position of Human Factors to “... examine the human role in a system or application (e.g., hardware, software, procedure, facility, document, other entity) and how the human is integrated into the design. Human factors apply knowledge of how humans function in terms of perception, cognition, and biomechanics to the design of tools, products, and systems that are conducive to human task performance and protective of human health and safety.” Airbus has proposed a similar statement: “The Human Factors discipline aims at optimizing the relationship between the aircraft end-users and their operational tasks, including Human-machine interaction and communication between individuals. This optimization is processed by a systematic consideration of human sciences within the framework of systems engineering.” [4] These human factors address several aspects of human at work:

- The working environment in the cockpit (physical ergonomics, comfort, adaptation against the environmental conditions);
- The interaction between the pilots and the systems which is reduced to the interaction through a control device cursor and through a keyboard, and to the manipulation of input devices (order, mini-sticks, buttons, rotactors);
- The teamwork and its activities of communication and cooperation: two persons in the cockpit to whom it is necessary to add the staff of the cabin;
- Procedures, roles and responsibilities: the task allocation between the pilots and the systems, task allocation between the human beings such as between pilots and controllers;
- The organization of the work: the pilots mainly work in shift schedules during most their professional activity. The management of fatigue is a major subject which should not be neglected for the long range operations but which is also relevant for medium-range aircraft because pilots can chain flight legs with variable rest periods;
- The qualification and the training of the pilots: pilots are highly qualified and trained staff. The cost of their qualification and training is significant, which the companies would like to reduce.