

Human Factors Computer Based Training in Air Traffic Control

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Summary

In the last years, in order to improve safety and help accidents prevention, human factors issues have been introduced into training programmes in aviation. In particular, as recommended and supported by different institutions, such as Eurocontrol, FAA, JAA and ICAO, further studies and research on the use of specific tools supporting human factors training in Air Traffic Control are needed.

Moreover, the increasing effort to introduce human factors to people working in complex systems, such as pilots and air traffic controllers, leads to the problem of how to integrate human factors training with technical aspects, which are already taught through traditional training courses.

This paper presents the development of a human factors Computer Based Training (CBT)* and its integration with an existing, classical technical training for air traffic controllers at the Italian Agency for Air Navigation Services (ENAV). The paper describes the objectives, the methodological approach and the contents of the human factors CBT and enhances the idea of unifying theory and operational practice.

Introduction

The main objective of the human factors CBT is to develop a didactical tool aimed at making the air traffic controllers aware of human factors and safety issues related to the air traffic control domain. Finally, the overall aim of the human factors CBT is the accident prevention.

As reported in the literature, the human factors concept indicates some aspects of human performance (individual) and human relationships (interaction with others) which may have a bearing on accidents, incidents and their prevention (ICAO, 1984).

In one sense the objective of human factors contributions to air traffic control is the same as that of the air traffic control itself, namely the safe, orderly and expeditious flow of traffic. A secondary but essential human factors objective is to provide air traffic controllers with satisfying jobs and tasks that are well matched with human skills and abilities and performed by a competent and well-motivated workforce (Hopkin, 1995).

Following this approach, the human factor matters embodied in the CBT are, for example, interpersonal communication issue, situation awareness, stress, decision making and co-operation. These matters have been introduced in the CBT with the intention to cover the main safety problem related to human factors in the air traffic control context. These matters have been explained by different examples from the domain, some possible consequences on task performance and through the proposal of simple solutions.

The presentation of human factor matters in the CBT is addressed by both textual information and the use of video and audio reproducing real situations that have occurred. The selected situations are accidents where the Air Traffic Control has played a role in the sequence of the events determining the accident.

The video used reproduces the accident from cockpit scenes. The cockpit scenes are introduced with the additional scope of integration and of completion of the air traffic controllers task's view of a co-operative system, such as the aviation system.

An important way to cope with co-operative systems is through the shared knowledge of the issues related to the management of the ATC task and of the pilot task, as well as of the capacity of the system that both use. To maintain the safety as well as the fluidity of the traffic flow and of the communication exchange, an integration between the two worksystems -ATC and cockpit- has to be supported (Amat and Bellorini, 1996). Greater efforts are suggested for introducing, into the air traffic controller and pilot training programs, information on the difficulties encountered while performing their respective tasks.

Moreover, this idea emerged as a need from a past experience by the Joint Research Centre of the European Commission. The experience developed at the Joint Research Centre in the area of human factors training and analysis of complex working environment has been focused in the domain of aviation safety. In particular, two projects have affected the development of the CBT in the ATC domain:

1) The CRM (Crew Resource Management) project was developed to ameliorate non-technical aspects of flight safety, with respect to the understanding and awareness of human factors problems amongst airliner pilots (Kjær-Hansen, 1995). The focus of the project was the development of an innovative CRM training, using the "standard classroom methods" coupled with the results of the analysis of the organisation and the safety attitudes of the airline pilots, and an advanced computer-based multi-media system in specific training sessions. The CRM-JRC for a small charter operator has been completed and currently being adapted and applied for the training the national Italian operator, Alitalia (Amat et al., 1997).

2) A theoretical and applied research study has been performed in collaboration with the Italian National Council of Research in the field of ATC over a period of 4 years. This has dealt with the study of the effects of stress on human operators and machines in complex organisation. The objective was fourfold: to analyse the causes and the consequences of stress on task management, cooperation and communication; to model the relationship between stress, cooperation and communication; to develop requirements and specifications for the design of the interfaces of ATC systems in cooperative work; to use the results for human factors training courses (Bellorini and Vanderhaegen, 1995).

The Approach

Human factors training is new to many Air Traffic Controllers (ATCOs), and an accurate approach is needed to ensure the maximum efficacy.

The CBT has the main purpose of introducing human factors to the participants at the CBT, namely the ATCOs, and to prepare them to deeper discussions in later class room sessions. Hence, the primary purpose of the CBT is to make the participants receptive to discussions about human factors. To support this development, the CBT should create an interest in the subject by making the participants reflect on a series of general problems in the aviation domain, and specifically in the context of ATC. At such an initial stage of the training program, an important step is to get the participants used to thinking about human factors problems and to express a personal opinion about it. It is hence not the conclusions drawn that are the most important aspect by themselves, but rather the mental processes that the participant has gone through to arrive at these conclusions.

A secondary purpose is to introduce the most basic theoretical framework on human factors, giving brief description of notions like communication, decision making, situation awareness and so on. This serves to prepare the group of participants further to the class room sessions, where these matters will be discussed in more detail.

As human factors training is new to many participants, special care must be taken in the design of the presentation of the subject - it is of major importance not to alienate the participants. The major methodological choice towards this goal has been to base the CBT on the presentation of real accident cases where human factors have played a decisive role in the development of the accident. It automatically provides the presentation with an authentic atmosphere, further underlining the relevance to the participant.

The format of a CBT as the introduction to the matter has been chosen over more traditional forms, such as text or video to gain the benefits of the interactive presentation. Where both text and video are passive media, the CBT can provide a level of interaction where each participant chooses the pace of the presentation, the details to study in further depth or parts to pass by quickly. This format reduces the feeling of being forced through a training course of no interest, as the participant can set his or her own pace. Considering that the main purpose is to create interest in human factors in ATC in general, it cannot be considered "wrong" if a participant focuses on some details at the expense of others, it is more important that he or she is interested in the subject and has thought over some relevant problem fields.

To guide the participants through the subject, and to support the mental processes of thinking over the problems, the participant is asked a series of open questions relating to the accident cases shown in the CBT. These questions are given a broad form in order to allow for the participant's personal interpretation of the situation - in accordance with the philosophy that the mental processes themselves are more important than the conclusion they lead to.

The accident cases are presented following the chronological order of the events leading to the accident, but the free form of interaction allows the participant to go back and see any part of the accident desired. The presentation is divided into events based on the cognitive processes involved, and the questions are related to an event as a whole.

The result of the interactive presentation of real accident cases and the use of open, but guiding questions is that the participant arrives at his or her own analysis of the accident. It follows from the limited material provided that it can not be compared with the official analysis as presented in the accident report, but it provides a good basis for an introduction to human factors.

Structure and Content

The CBT follows a simple structure divided into three modules: 1) an introduction, 2) a central part with the presentation of accident cases with questions to the user and, 3) a conclusion.

This simple and classic structure allows for an easy understanding of the system in a user group not accustomed to CBT.

To give the CBT an easy start, the introduction is totally linear, with the sole possibility of going back in video sequences or to skip parts that are not of interest.

The central part, on the other hand, gives the participant the possibility to explore the information on the accidents, and allow for a relatively free navigation in the material.

Last, the conclusion module, which is quite brief, has a linear structure.

The navigation possibilities of the CBT can be illustrated as shown in figure 1 below.

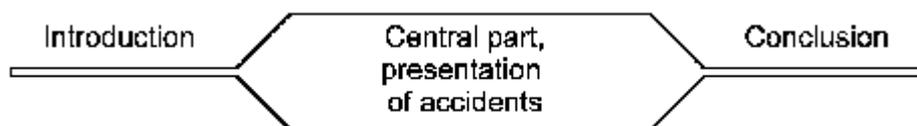


Figure 1. The navigation space of the CBT.

Introduction

The introduction is mainly based on video shots from control rooms and control towers with the purpose of creating confidence in the CBT and a sensation of familiarity with the subject. This is important as human factors have not been taught formally in preceding training programmes, and a certain scepticism from the participants can be expected. The introduction does not have the purpose of teaching actual human factors knowledge.

Central part

The central part of the CBT presents two accident cases through an interactive screen with a time line representing a series of events, each described by a video clip, if available, and textual excerpts from the official accident report. The relevant questions are presented and further theoretical explanations are available for the participant who might desire it. The two accident cases are Kegworth (case 1) and Tenerife (case 2).

Case 1, Kegworth

Kegworth accident happened on January 8, 1989 to a Boeing 737-400 G-OBME. 47 passengers died, 74 suffered serious injury. The cause of the accident was that the operating crew shut down the No2 engine after a fan blade had fractured in the No1 engine. Different factors contributed to the incorrect response of the flight crew such as loss of situation awareness, stress, lack of training and experience and poor communication exchange between the pilots and between the pilots and the cabin crew. Safety recommendations were made during the course of this investigation.

The Kegworth case has been introduced to train the air traffic controllers because of the analogy to problems that the air traffic controllers can encounter during the management of their task. Communication, training and stress are the main issues on human factors that have been illustrated through this accident from the pilot view and experience. These issues well match and complete the air traffic controllers experience and task view.

The Kegworth case is presented through video which shows parts of the communication between ATC and the flight deck and shows the task management on the flight. The report excerpts are used to give information which is not included in the videos, like changes of frequency. Last, information about altitude and heading is provided in textual form.

Case 2, Tenerife

The Tenerife accident happened on March 27, 1977 when KLM flight 4805 and Pan Am flight 1736 collided on the runway of the Tenerife airport with a loss of 583 lives. From the accident analysis it is concluded that the combination of interruption of important routines, a loss of cognitive efficiency and a loss of communication accuracy created an environment for the rapid diffusion of multiple small errors (Weick, 1990).

This case is particularly interesting for the training of air traffic controllers, as the development of the accident and the events leading to it, are heavily correlated with the interaction between the ATC and the two air crews, between the crews and internally to the crews. Radio communication is the single most important means of communication and information interchange between ATC and air crews, and the communication problems seen in the accident at Tenerife are of great relevance to a human factors discussion.

Conclusion

The concluding module is brief and has the main purpose of giving an integrated view of the problems presented and to prepare the participant for the discussion with other participants that follows the CBT.

Development Steps

For the realisation of the CBT, different steps have been followed as described hereafter.

Analysis of the accident reports.

As first step, two accidents are chosen which support the objective of the CBT: the Kegworth and the Tenerife accidents.

The official report from the Air Accidents Investigation Branch of the Kegworth accident has been analysed (1990).

The official report from the Spanish authorities and the ICAO report of the Tenerife accident (1978) have been also analysed. The aim of the analysis of these reports is to find out the main issues involved in the accident related to human factors and safety.

From the reports some important excerpts have been transcribed and considered to be proposed to the air traffic controllers in the CBT. Starting from the transcribed excerpts, each accident has been divided in phases and each phase in events.

From the resulting analysis, the story board can easily be defined, as each event corresponds to one screen, and every event-screen has the same basic lay-out and interaction.

Questions/comments and theoretical framework

The second step for the CBT development has been the definition of questions and comments related to the events of the accident. Questions and comments have been introduced in order to activate the processes of thinking over the events leading to the accident. In certain cases, comments have been introduced to clarify and specify more details of the events. Basically, the questions are a means to reach a theoretical definition of human factors concepts and a means to think about the way the air traffic controllers use the standard phraseology, manage communication, or apply the air traffic control procedures.

At this step a theoretical frame on human factors and safety has been defined in order to share a common language on human factors concepts.

Interface design

The third step is the design of the interface of the CBT.

It is important that the CBT does not give the impression of being neither rigid nor boring, as this could easily prove to be counter productive in respect of the goal of raising the awareness towards human factors issues.

The interface design therefore follows the structure of the CBT, and takes on three different forms for the introduction, the presentation of the accidents and the conclusion.

The introduction, which has the purpose of familiarising the user with the CBT and giving an idea about why human factors training is given, is linear in design, working very much as a video with the sole possibility of going backwards or stepping forwards to avoid it. This part does not require any interaction from the user.

The interface of the central part is designed to suit the purpose of the CBT, in that the presentation of the accidents, leaves the participant free to explore the events leading to the accident while, at the same time, providing a simple and direct path to follow to obtain a chronologically correct presentation of the accident. Experience from similar projects has shown that this approach in practice is used by the participants to go through the event sequence in chronological order initially, to then go back and examine parts of particular interest later - often to answer the questions.

Interface and Interaction

The interface of the central part allows, as explained earlier, for a relatively free navigation. The main window is shown in figure 2, and it contains the most important elements for the presentation.

The timeline is seen to the left, with an excerpt from the accident report to its right. The timeline is itself a navigation instrument, as it allows the participant to go back to earlier events to revisit details or to go forward to the next event.

To right is seen the video window with a video giving a reconstruction of the event and below that is seen a map of the airport with the positions of the involved aircraft.

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