# EFFICIENCY OF A SITUATION AWARENESS TRAINING MODULE IN INITIAL PILOT TRAINING

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We designed a specific SA training module and tested whether it would enhance the SA competency of pilot trainees during initial training. Twelve pilot trainees took part to the empirical phase of the study. They were pseudo-randomly assigned to two conditions, the experimental group (*n*=6) who received the SA training module and the control group (*n*=6) who did not receive any specific SA training. All pilot trainees were assessed during a flight simulator session in order to evaluate objectively their levels of SA (SAGAT, Situation Awareness Global Assessment Technique, Endsley, 1995). Results highlighted that the SA levels were globally high and homogeneous for the experimental group (range of percentage of maximum SAGAT score= [79.3% ; 87.5%]), whereas the control group's scores varied more widely (SAGAT range = [57.5% ; 87.5%]). Moreover, a qualitative analysis revealed specific strategies used by those pilot trainees who had highest levels of SA.

## Introduction

"Being aware of what is happening around you and understanding what information means to you now and in the future" has been named *situation awareness* (Endsley & Jones, 2012, p.13). Situation awareness (SA) has emerged since the 1980s as an important construct in human factors and applied ergonomics and is still the focus of research studies in various domains (e.g., Cordon, Mestre, & Walliser, 2017 in seafaring ; Afkari, Bednarik, Mäkelä, & Eivazi, 2016 in surgery ; Lu, Coster, & de Winter, 2017 in driving). The most widely cited definition is the one of Endlsey (1995b): "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". In the field of aviation, SA has been recognized as a critical component. Indeed, an investigation of flight accidents between 1989 and 1992 (Endsley, 1995a) revealed that among the 17 accidents mainly attributed to human error, SA was the most prevalent factor in 15 of them (i.e., 88%). Another study published by the Flight Safety Foundation (Khatwa & Roelen, 1998/1999) focused on 156 CFIT accidents between 1988 and

1994. This study highlighted that 45% of accidents in which flight crew errors occurred involved a SA error.

Given the importance of SA, several researchers have tested the development of training approaches for improving it. For instance, Strater et al. (2004) tested a PC-based tool to improve SA of naval cadets. They developed two modules, one module which teached time management and task prioritization (“SA Planner”) and another which focused on general strategies aimed at improving SA (“SA Trainer”). In order to assess the efficacy of their “Infantery SA trainer” (ISAT), they compared trained and untrained cadets on SA assessment and performance. They obtained mixed results and could only conclude on “tentative indications of training effects” (p. 671). Bolstad, Endsley, Costello, and Howell (2010) tested the efficacy of six different computer-based training modules (checklist completion, air traffic control comprehension, psychomotor skills, attention sharing and contingency planning) on general aviation pilots. They concluded that “no evidence was found to show that improvements in the basic and cognitive skills trained by the modules translated to improved flight skills performance”. For airline pilots, a training programme for SA has been developed and tested by a european consortium (Hoermann, 2003) in the ESSAI (Enhanced Safety through Situation Awareness Integration in training) project. Eight crews received the ESSAI training and a control group of eight crews did not. Results revealed SA improvement and better performances during a simulator session for the trained group.

To our knowledge, no air training organization has designed a training program oriented towards SA, which would strengthen this competency during the ab-initio pilot training. The present study aimed at developing and testing a specific SA training module that would improve SA of ab-initio students during their pilot initial training.

## Method

### Participants

Twelve student pilots of the ENAC (Ecole Nationale de l’Aviation Civile, France), the a french national civil flight training organization, were recruited to perform the experiment. They had all completed a 18-week module of visual flight rules (VFR) training and were following completing a single engine instrument flight rating (IFR) module. They were pseudo randomly assigned to two conditions. Indeed, they were located at two different flight training centers, Carcassonne (*n*=8) and Grenoble (*n*=4). Student pilots from Carcassonne were at week #22 (131,25 flight hours on average) and those from Grenoble were at week #30 (194,25 flight hours on average) of the training syllabus. In order to control the flight training experience variable, each experimental group was composed of two student pilots from Carcassonne and four student pilots from Grenoble. Otherwise, pilot students were randomly assigned to each experimental condition. All participants were volunteers and provided written consent.

### SAGAT questionnaire

A SAGAT questionnaire was designed in order to assess the level of situation awareness of the participants at three moments of the simulated flight. The questionnaire consisted of eight items assessing the three levels of situation awareness defined by Endsley (three items of level 1, three items of level 2 and two items of level 3).The accuracy and relevance of each item was assessed by the first author of the present paper, also flight instructor, on a five-points scale. Thus, SAGAT scores could range from 0 to 40.

**Procedure**

Participants of the control condition performed a simulated flight on a certified FNPT-II flight simulator of the Socata TB20 aircraft. After 30 min of explanations and briefing, participants performed a one-hour simulated flight. The scenario started in flight at flight level 110 over the Geneva Lake heading to Lyon St Exupery. The flight preparation proposed two alternate airports with good weather conditions, Saint Etienne and Grenoble. Weather at destination was sufficient enough for a non-precision approach (cloud base 400ft). No technical failures were scheduled during this simulator session but several and continous environmental changes like wind changes, airport constraints. At three times the simulation was freezed and the participant answered to the SAGAT questionnaire in order to evaluate their assessment of the new environment. At the end of the simulation, participants were debriefed during 20 min. Participants of the control group did not receive any specific training on SA (the concept was only introduced during their initial theoritical training).

Participants of the experimental condition received a specific training module the day before they performed the same simulated flight as the control group. This training module consisted of five hours of training: theoretical presentation of SA and related concepts (e.g., mental workload, mental schemas,…), discussions about case studies based on real incidents and familiarization with a self SA-assessment tool assessing subjectively the three levels of SA (this tool will not be detailed here because it will be presented in another paper). Participants of the experimental condition performed the same simulated flight as the control group. However, during the simulated flight, they also had to fill the self SA assessment tool before each SAGAT questionnaire.

## Results

**SAGAT scores**

Given the small sample size of each group, we performed no statistical test to compare the two groups (see Table 1 for summary statistics). However, a qualitative analysis of the data highlighted that the SAGAT scores of the experimental group were globally higher than those of the control group (see Figure 1). More precisely, SAGAT scores of the experimental group were high and more homogeneous (all between 79.3% and 88.3%) than those of the control group (between 57.5% and 87.5%). Interestingly, the lowest SAGAT scores (less than 60%) were only found in the control group.

Table 1.
*Descriptive statistics of SAGAT scores for each experimental group (EXP=experimental; CTL=control).*

| Group | *n* | *mean (%)* | *sd* | *min (%)* | *max (%)* |
|---|---|---|---|---|---|
| CTL | 6 | 29.1 (72.7%) | 5.4 | 23.0 (57.5%) | 35.0 (87.5%) |
| EXP | 6 | 34.1 (85.3%) | 1.3 | 31.7 (79.3%) | 35.3 (88.3%) |

*Note.* Maximum score of SAGAT was 40. Numbers in parentheses represent percentages of this maximum score.

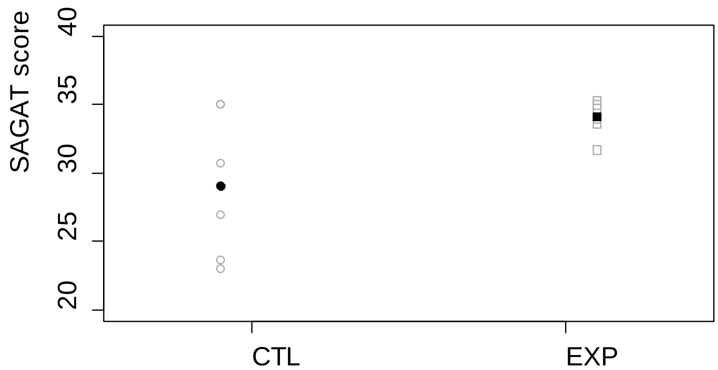


*Figure 1*. Means (black filled) and raw data (not filled) of total SAGAT scores for each group (control and experimental). SAGAT scores could range from 0 to 40.

## Qualitative analysis

A qualitative analysis of the decisions made by each participant of each group revealed that all pilot students of the experimental group (6/6) made safer decisions based on a relevant information collection and comprehension. On the contrary, in the control group, two pilot students out of six uncorrectly assessed different airport weather conditions and had a wrong environment understanding leading for example to too steep approaches. Interestingly, these two “poorer” pilot students were at the week#22 stage of their training. Pilots of the control group at week#30 performed qualitatively as good as those of the experimental group.

# Discussion

The present study aimed at testing the efficacy of a SA training module designed for pilot students during basic flight training on light aircraft. An experimental group who completed the 5-hours specific SA training module was compared to a control group who did not follow this training module. The two groups were compared on the basis of a simulated flight with assessment of their SA level through SAGAT queries. Results highlighted that pilot students of the experimental group had globally higher and more homogeneous SAGAT scores than those of the control group. A qualitative analysis of their flight performances suggested that experimental group pilots were better than the control group ’at understanding a constant evolving situation and adapting strategies in accordance to it.

However, several limitations of this study need to be adressed. Firstly, a larger sample size would be needed to confirm these results and to allow generalisation. Secondly, the SA training module seemed to improve flight performance only for pilot students at an early stage of the IFR training module (week#22). Clearly, one can assume that some pilot students are more able to generate high levels of SA without any specific training. For instance, Endlsey and Bolstad (1994) found that the best fighter pilots had SA scores that were 10 times better than those with the lowest SA and they did not get any specific SA training. However, the question is whether pilot students who would have difficulties in improving their SA on their own would benefit from a specific SA training module. Thirdly, the level of difficulty used for the flight scenario may have a large impact on the results of studies aimed at testing the efficacy of a SA training module. Indeed, maybe the flight scenario used in this study was too easy for pilot students at a more advanced stage of the IFR training module (week#30), and no differences between experimental groups could be observed.

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