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TRAINING FOR SITUATION AWARENESS

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Need for Situation Awareness Training in Aviation

In the aviation domain, maintaining a high level of situation awareness is one of the most critical and challenging features of a pilot's job. Problems with SA were found to be the leading causal factor in a review of military aviation mishaps (Hartel, Smith, & Prince, 1991). In a study of accidents among major airlines, 88% of those involving human error could be attributed to problems with situation awareness as opposed to problems with decision making or flight skills (Endsley, 1995b). Although similar studies have not been performed for general aviation accidents, SA is reported to be considerable challenge in this population as well, particularly as general aviation pilots are frequently less experienced and less current than operators for major airlines (Hunter, 1995).

Due to the important role that SA plays in the pilot decision making process and its substantial role in aviation accidents and incidents, the development and validation of methods for training to improve SA in aircraft pilots is a subject that is beginning to receive focus in the operational and human factors communities. SA training can be focused at improving individual SA or at improving SA at the team level. Each approach should be considered as complimentary, and potentially useful as additions to activities directed at improving SA through system design. As a practical matter pilots will always need to learn to develop the best SA possible with whatever system they are flying.

Situation Awareness Challenges and Skills

One way of identifying methods for improving SA is to examine in what ways SA errors occur. A second method is to identify the ways in which pilots successfully develop and maintain SA as compared to pilots who do a poorer job at these tasks. A number of studies have been performed pertinent to these issues.

Errors in SA

An analysis of SA Errors in aviation was conducted (Jones & Endsley, 1996) using reports from NASA's Aviation Safety Reporting System (ASRS) using an SA error taxonomy based on a model of SA (Endsley, 1995c), Table 1. Gibson, Orasanu, Villeda and Nygren (1997) also performed a study of SA errors based on ASRS reports. They found problems with workload/distraction (86%), communications/coordination (74%), improper procedures (54%), time pressure (45%), equipment problems (43%), weather (32%), unfamiliarity (31%), fatigue (18%), night conditions (12%), emotion (7%) and other factors (37%). Consequences of loss of SA resulted in altitude deviations (26%), violations of FAR (25%), heading deviations (23%), traffic conflicts (21%), and non-adherence to published procedures (19%). Dangerous situations were found to result from 61% of the cases. Clearly loss of SA should be taken seriously in aviation.

Table 1 Causal Factors related to Errors in Situation Awareness (Endsley & Jones, 1996)

Loss of Level 1 SA – Failure to correctly perceive the situation (76.3%)

- <u>Information not available (11.6%)</u>
  - system & design failures
  - failure of communication
  - failure of crew to perform needed tasks
- <u>Information difficult to detect (11.6%)</u>
  - Poor runway markings
  - poor lighting
  - noise in the cockpit.
- <u>Information not observed (37.2%)</u>
  - Omission from scan
  - attentional narrowing
  - task related distractions
  - other distractions
  - workload
- <u>Misperception of information (8.7%)</u>
  - Prior expectations
- <u>Memory error (11.1%)</u>
  - Disruptions in routine
  - high workload
  - distractions

Loss of Level 2 SA – Failure to correctly comprehend the situation (20.3%)

- <u>Lack of/incomplete mental model (3.5%)</u>
  - Automated systems
  - unfamiliar airspace
- <u>Incorrect mental model (6.4%)</u>
  - Mismatching information to expectations of model or model of usual system
- <u>Over-reliance on defaults values in the mental model (4.7%)</u>
  - General expectations of system behavior

Loss of Level 3 SA – Failure to correctly project situation (3.4%)

- <u>Lack of/incomplete mental model (.4%)</u>
- Over-projection of current trends (1.1%)
- Other (1.9%)

Comparisons of Pilots

Several other researchers have investigated the differences in SA between pilots who perform well and pilots who do not. Prince and Salas (1998) studied the situation assessment behaviors of GA pilots (means experience level = 720 hours), airline plots (mean experience level = 6,036 hours), and commercial airline check airmen (mean experience level = 12,370 hours). They found several key differences with experience level.

(1) Increasing levels of preflight preparation - GA pilots talked about personal preparation before the flight, while line pilots also emphasized knowing the equipment and its limits and briefing for the flight. Check airman focused on planning and preparation specific to the flight and gathered as much information as possible about the conditions and flight elements (e.g. weather, ATC, airport status) in order to prepare in advance.

(2) More focus on understanding and projection – GA pilots described themselves as passive recipients of information with an emphasis on information in the immediate environment (Level 1 SA). Line pilots dealt more at the level of comprehension (Level 2 SA) and emphasized their active role in seeking out information. Check airmen were more likely to deal with Level 3 SA, seeking to be proactive. They dealt with large numbers of details and the complex relationships between factors in this process.

In conducting critical incident reviews with pilots they identified four major actions that are important for team SA in commercial pilots: (1) identifying problems or potential problems, (2) demonstrating knowledge of the actions of others, (3) keeping up with flight details, and (4) verbalizing actions and intentions. Prince, Salas and Stout (1995) found that those aircrews who performed better on an objective measure of SA demonstrated more actions in these areas. They seemed to solve problems faster and recognized problem situations developing.

Orasanu and Fischer (1997) studied the characteristics of commercial aircrews in making various types of decisions through an analysis of ASRS data and observations from simulator studies. They found that in making go/no-go decisions about an approach, the better performing crews attended to more to cues signaling deteriorating weather and sought out weather updates allowing them to plan for a missed approach in advance. When studying a choice type task which involved picking an alternate airport, however, the better performing crews took longer. They were much more attuned to the constraints imposed by a hydraulic failure and reviewed other alternates in light of the constraints. They gathered more information allowing them to make a better decision, whereas poorer performing crews went right to evaluating options. Analysis of a hydraulic failure, which represented a scheduling type task, showed the better performing crews taking active steps to manage what would become a high workload task. They planned in advance for actions that would occur in the high workload periods and thus were more effective in these situations.

From this research, Orasanu and Fischer have focused on a two step decision model: situation assessment and action selection. Time availability, risk level and problem definition are indicated as critical components of the situation assessment phase. Situation ambiguity and the availability of responses were hypothesized to be critical factors dictating the difficulty of the decision. When cognitive demands are greater, the higher performing crews managed their effort by performing actions that would buy them extra time (e.g. holding) and by shifting responsibilities among the crew. Good situation assessment, contingency planning and task management were highlighted as critical behaviors associated with success. Less effective pilots appeared to apply the same strategies in all cases rather than matching their strategy to the situation.

In examining accident reports, Orasanu, Dismukes and Fischer (1993) also report that pilots who had accidents tended to interpret cues inappropriately and often under-estimated the risk associated with a problem and over-estimated their ability to handle dangerous situations. Wiggens, Connan and Morris (1995) found that general aviation pilots who performed poorly in deciding to continue into inclement weather were poorly gauged in terms of matching their skill level to the situation. "In the absence of extensive task-related experience, pilots are more inclined to rely on their self-perceived risk-taking behavior than their self-perceived ability to resolve various decisions." The more experienced pilots demonstrated behaviors that were much more related to perceptions of their own ability. It would appear that inexperienced pilots may be deficient in their ability to properly assess risk and capabilities (Level 2 SA) from the situational cues at hand.

In studies of individual differences in SA abilities, Endsley and Bolstad (1994) found that military pilots with better SA were better at attention sharing, pattern matching, spatial abilities and perceptual speed. O'Hare (1997) also found evidence that elite pilots (defined as consistently superior in gliding competitions) performed better on a divided attention task purported to measure SA. Gugerty and Tirre (1997) found evidence that people with better SA performed better on measures of working memory, visual processing, temporal processing and time-sharing ability. While some of these characteristics may not be trainable, at least attention sharing has shown some indication that it can be improved through training (Damos & Wickens, 1980). Reducing loads on working memory may also help.

Target Areas for Improving Individual Pilot SA

From these various studies several key factors can be identified that indicate where individual pilot SA can be improved.

Task Management

Interruptions, task related distractions, other non-task related distractions and overall workload pose a high threat to SA. Good task management strategies appear critical for dealing with these problems. Schutte and Trujillo (1996) found that the best performing crews in non-normal situations were those whose task management strategies were based on the perceived severity of the tasks and situations. Those who used an event/interrupt driven strategy (dealing with each interruption as it came up) and those who used a procedural based strategy performed more poorly. The ability to accurately assess the importance and severity of events and tasks is an important component of Level 2 SA. This understanding also allows pilots to actively manage their task and information flow so as not to end up in situations in which they are overloaded and miss critical information.

Development of Comprehension (Level 2 SA)

In addition to problems with properly assessing the importance or severity of tasks and events, pilots will also perform poorly if they are unable to properly gauge the temporal aspects of the situation, the risk levels involved and both personal and system capabilities for dealing with situations. Simmel and Shelton (1987), in analyzing accident reports, note that accurately determining the consequences of non-routine events appeared to be the problem for the pilots. Each of these factors (timing, risk, capabilities, consequences and severity) are major components of Level 2 SA for pilots (Endsley, Farley, Jones, Midkiff, & Hansman, 1998). The research suggests that more inexperienced pilots are less able to make these important assessments, remaining more focused at Level 1.

Projection (Level 3 SA) and Planning

Amalberti and Deblon (1992) found that a significant portion of experienced pilots' time was spent in anticipating possible future occurrences. This gives them the knowledge (and time) necessary to decide on the most favorable course of action to meet their objectives. Experienced pilots also appear to spend significant time in pre-flight planning and data gathering and engage in active contingency planning in flight. Each of these actions serves to reduce workload in critical events. Using projection skills (Level 3 SA) these pilots are able to actively seek important information in advance of a known immediate need for it and plan for various contingencies. Not all planning is equally effective, however. Taylor, Endsley and Henderson (1996) found that teams who viewed only one plan were particularly susceptible to Level 2 SA errors, failing to recognize cues that things were not going according to plan. Actively planning for various contingencies and not just the expected in flight is critical.

Information Seeking and Self-Checking Activities

Pilots with high levels of SA actively seek out critical information. They are quicker to notice trends and react to events because of this. Furthermore, it has been noted that these pilots are good at checking the validity of their own situation assessments, either with more information or with others (Taylor, et al., 1996). This strategy was found to be effective in dealing with false expectations and incorrect mental models. Other researchers have also suggested a "Devil's Advocate" strategy where people are encouraged to challenge their interpretations of situations (Klein, 1995; Orasanu, 1995).

Training to Improve the SA of Individuals

Relatively few programs have attempted to specifically train SA to-date. Most work has been directed towards design and automation issues and the more fundamental research issues regarding what to train discussed above, although there are a few exceptions. Many major airlines, for example, have recently introduced short training courses on SA that mainly serve to acquaint pilots with what SA is and some of the factors that can impact it. While these type of SA awareness courses may be helpful and are certainly a good first step for airlines to undertake, no validation work has been done as to their effectiveness.

Effective improvement of SA through training approaches will most likely be achieved by improving the skills and knowledge bases that are critical for achieving good SA in flight. Some basic approaches to training individual SA have been outlined by Endsley (1989) to include higher order cognitive skills training, intensive pre-flight briefings, the use of structured feedback, and SA-oriented training programs.

Higher order cognitive skills training

Training programs devoted specifically to teaching higher order cognitive skills related to SA would include programs for teaching attention sharing, task management, contingency planning, information seeking/filtering, self-checking and other meta-skills identified through research to be important for SA would fall into this category. Most of these skills have been identified as being important for achieving and maintaining good SA in flight. Training that is directed at these constituent skills associated with SA should therefore be explored as methods of helping pilots perfect their capabilities in these areas.

Intensive pre-flight briefings

As the acquisition and interpretation of information is highly influenced by expectations, pre-flight briefing is critical. Prince and Salas (1998) found that the issues focused on in the pre-flight preparation varied considerably for pilots of different experience levels. The idea behind intensive pre-flight briefings is to use multi-media tools to help pilots develop a clear picture of their flight: where the hazard areas are, where the weather is, what a new airport's approach pattern looks like. By being able to 'fly-through" the flight in advance, pilots can develop a better mental picture of the environment. This can be extremely helpful when flying into a new airport; for instance, being able to picture where to look for needed cues and runway configurations. But more importantly, such a tool could be incorporated within a contingency planning assistant, prompting pilots to look for potential hazards, such as deteriorating weather conditions, heavy air traffic or in-flight mechanical failures, and developing appropriate contingency plans.

SA-oriented training programs

Current training programs could be greatly enhanced by incorporating training that specifically focuses on the development of pilot SA. Current initial training for pilots focuses primarily on the basic skills of flying the aircraft. At some point after the psychomotor skills and basics of flight have been mastered, a training regime focused on SA and decision making in flight would be of the most benefit. This type of training would focus on developing the schema and mental models that allow experienced pilots to have a much better understanding of the importance, consequences, timing, risk levels and capabilities associated with different events and options. This type of training would specifically focus on creating Level 2 and 3 SA from the basic information available in flight.

It also would help to train pilots in the critical cues that signify prototypical classes of situations. More experienced pilots know where to look for cues and understand the significance of these cues when they occur. Kass, Herschler and Companion (1990) showed success with training subjects to recognize critical cues in a simulated battlefield environment. Other research, however, has shown that the cues attended to in early training can largely affect what is attended to later on (Doane, Alderton, Sohn, & Pellegrino, 1996). It is therefore important that a broad range of representative sets of situational cues be included when training pilots in this way.

Structured Feedback

Feedback is critical to the learning process. In order to improve SA, pilots need to receive feedback on the quality of their SA. For example, inexperienced pilots may fail to appreciate the severity of deteriorating weather because unless they have an accident, or at least a bad scare, they may have come through similar weather in the past just by luck. Unfortunately, this result also reinforces poor assessments. Due to the probabilistic link between SA and outcome, it is difficult for pilots to develop a good gauge of their own SA in normal flight. Feedback on SA can be used to help train SA, however, through the Situation Awareness Global Assessment Technique (SAGAT), a measure of SA developed for design evaluation (Endsley, 1995a). SAGAT uses freezes in the flight simulation to query pilots about important aspects of their SA. The accuracy of the pilot's perceptions are then compared to the real situation to provide an objective and direct measure of pilot SA. This technique could be adapted for a training application by providing feedback to the pilot on how accurate he or she was on the responses given. For instance: "You thought you were here when actually you are there. You have traffic at one O'clock, but were unaware of it. You are actually very close to stall speed." This type of technique could be integrated with the higher-order cognitive skills training and SA-oriented training programs to help pilots fine-tune their information acquisition strategies and schema.

Validation of Training Techniques

Each of these approaches shows promise for improving pilots' ability to develop and maintain SA during flight. Most importantly, these techniques, or others developed for training SA, should be carefully tested and evaluated. Control groups should be employed to determine whether SA training concepts discussed result in significant changes in pilots' ability to acquire and maintain SA in challenging aviation environments. SA measurement techniques discussed in this book should be applicable to such an endeavor, just as they are to the evaluation of changes in the system design. The measurement of SA in evaluating training techniques should provide both greater sensitivity in the analysis of the effectiveness of the techniques (as sensitive performance measures may be difficult to obtain), and will allow a determination of whether the techniques examined actually effected SA, or potentially effected pilot performance through some other mechanism. This is an important issue which tends to get neglected in SA research. In addition, the degree to which trained skills transfer to improved performance on the flight deck should be measured.

Training to Improve the SA of Teams

In addition to efforts directed at improving the SA of individuals, there is considerable interest in improving the SA of teams. This approach has the advantage of enhancing recovery from SA losses. Taking the view that SA problems may be inevitable, good team processes may help pilots recognize SA problems and take steps to deal with them. Prince and Salas (Chapter 14) deal extensively with the issue of training team SA in pilots. Many their strategies are focused on the communications and coordination of the aircrew and feature Crew Resource Management principles.

In another domain, Endsley and Robertson (in press) conducted a three year study to develop, implement and evaluate a program for enhancing team SA in aircraft maintenance technicians.

Team SA Training Course Development

The Team SA Training Course was developed based on an analysis of SA requirements and problems in aviation maintenance teams (Endsley & Robertson, 1996a; Endsley & Robertson, 1996b). The analysis investigated situation awareness across multiple teams involved in aircraft maintenance. It identified several teams within the aviation maintenance setting, each of which involved leads and supervisors as well as line personnel: aircraft maintenance technicians (AMT), stores, maintenance control, maintenance operations control, aircraft-on-ground, inspection and planning. The analysis produced a delineation of situation awareness requirements for each of these groups and an understanding of the way in which each group interacts with the others to achieve SA pertinent to their specific goals. SA appears to be crucial to the ability of each group to perform tasks (as each task is interdependent on other tasks being performed by other team members), their ability to make correct assessments (e.g. whether a detected problem should be fixed now or later (placarded)), and their ability to correctly project into the future to make good decisions (e.g. time required to perform task, availability of parts, etc...). As a part of the analysis, certain shortcomings, both in the technologies employed and in the organizational/ personnel system, were identified that may compromise team SA in the maintenance environment.

From the analysis, five major areas for improving SA in aviation maintenance were identified.

(1) It found that there were significant differences in the perceptions and understanding of situations between teams that were related to differences in the mental models held in these different teams. The same information would be interpreted quite differently by different teams leading to significant misunderstandings and system inefficiencies.

(2) It noted problems with not verbalizing the information that went into a given decision (the rationale and supporting situation information). Only the decision would be communicated between teams. This contributed to sub-optimal decisions in many cases as good solutions often required the pooling of information across multiple teams.

(3) A problem with lack of feedback in the system also was present. The results of a given decision would not be shared back across teams to the team initiating an action. This contributed to the inability of people to develop robust mental models.

(4) The importance of teamwork and the need to use shift meetings to establish both shared goals and a shared understanding of the situation was noted. The conduct of shift meetings for accomplishing these objectives was found to be highly variable in this environment.

(5) Finally, several problems that can reduce situation awareness in individuals were also noted in this domain, including task-related and other distractions, negative effects of noise and poor lighting, vigilance, and memory issues.

The Team SA Training Course was developed to address these five SA Training goals and objectives. In addition, the course also provided a review of Maintenance Resource Management (MRM) principles which are considered to be prior knowledge requirements for the trainees. The Team SA Training Course was designed to be presented as an eight-hour classroom delivery course. The course was designed to be presented to personnel from across all maintenance operations departments (also called technical operations in some airlines). The course is best taught to a class composed of a mixed cross section from different maintenance operations organizations (e.g. stores, AMTs, inspectors, maintenance operations control, etc..) This is because the course focuses on helping to reduce the gaps and miscommunications that can occur between these different groups and it was anticipated that much of the course's benefit would come from the interaction that occurs when trainees share different viewpoints and information in going through the exercises.

The instructional strategy used for the course features adult inquiry and discovery learning. This allows a high level of interaction and participation amongst the trainees creating an experiential learning process. The Team SA Training Course strongly encourages participation in problem solving, discussion groups and responding to open ended questions, thus promoting the acquisition and processing of information.

Evaluation

For its initial evaluation, the Team SA Training Course was delivered by a major airline at four of its large maintenance bases. Most of the maintenance organization personnel in the airline had already received MRM training which is considered to be a precursor to the Team SA Training Course. The course was delivered over a two day period by this airline. (It was expanded from the original eight-hour course design by this airline to allow for more group exercises, interaction and case studies.)

Seventy-two people from nine different maintenance locations attended the training sessions at which the evaluation took place. Participation in the course was voluntary and participation in the course evaluation was also voluntary and confidential. Participants were present from a full cross-section of shifts. The majority of the participants were male (86%), however, 14% of the participants were female. The participants came from a wide range of technical operations departments and job titles. The most frequent job title was that of line mechanic (AMT), followed by leads and supervisors. A good cross sections of other organizations within the Technical Operations Group were also represented, including inspection, planning, and documentation support personnel. Attendees were very experienced at their jobs (mean = 10.41 years) and within the organization (mean = 12.16 years).

The Team SA training evaluation process consisted of three levels: Value and usefulness of the training, pre/post training measures, and changes in behavior on the job. A questionnaires was administered immediately following the course to get participant’s subjective opinions on the value and usefulness of the course. In addition, the amount of learning in attitudes and behaviors related to SA was also measured. An evaluation form was provided immediately prior to the training to assess knowledge and behaviors of the trainees related to SA. It was administered again immediately following the course to measure changes in attitudes and self-reported intentions to change behavior as a result of the training. The form was administered again one month later to assess changes in behavior on the job.

Value and Usefulness

The post-training course evaluation was used to measure the level of usefulness and perceived value of the course. Course participants scored each subsection of the course on a five-point scale which ranged from 1-waste of time to 5-extremely useful. On average, they rated each of the topics as "very useful" (mean scores between 3.5 to 4.7). In addition to rating topics in the course, participants also answered several questions related to the course as a whole, shown in Figure 1. The mean rating for the course overall was 4.3, corresponding to better than "very useful". A whopping 89% of the participants viewed the course as either "very useful" or "extremely useful, representing a high level of enthusiasm for the course. There were no low ratings of the course as a whole. Over 94% of the participants felt the course was either "very useful" or "extremely useful" for increasing aviation safety and teamwork effectiveness (mean rating of 4.4). Over 89% felt the course would be either very or extremely useful to others (mean rating of 4.3). When asked to what degree the course would affect their behavior on the job, 83% felt they would make a "moderate change" or a "large change", as shown in Figure 2.

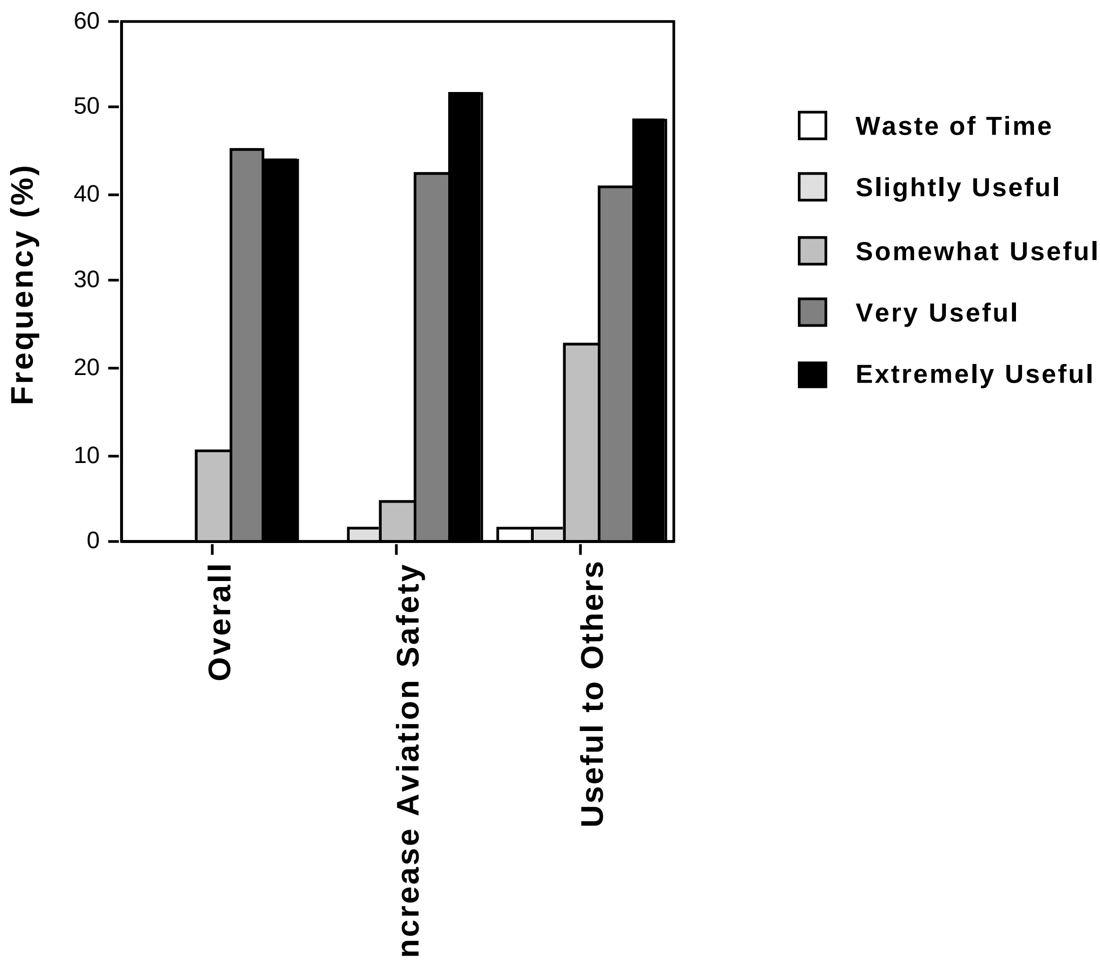

Figure 1 Team training course evaluation (from Endsley & Robertson, in press)

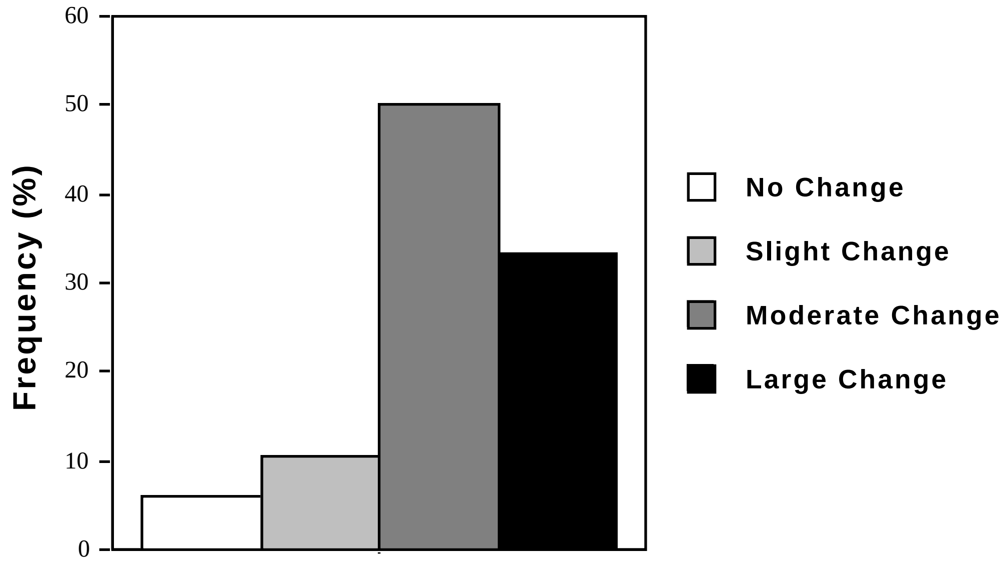

Figure 2. Perceived effect of course on behavior (from Endsley & Robertson, in press)

<u>Changes in behavior & attitudes</u>.

The mean change in the post-test compared to the pre-test on each behavior described in the pre/post self-reported SA behavioral measure form was also assessed. A factor analysis on the questionnaire revealed a moderate degree of homogeneity. That is, responses on the items were somewhat interrelated, however no large groupings of related factors were revealed to explain a large portion of the variance. (Only one factor accounted for more than 10% of the variance, with most accounting for less than 5%). The questionnaire was therefore treated as a set of independent items. Changes on each item were compared for each subject using a paired comparison analysis (pre-test to post-test).

The Wilcoxon non-parametric statistical analysis revealed that attitudes and self-reported behaviors changed significantly on seven of the 33 items ($p<.05$). Participants reported after the training they would be more likely to keep others up-to-date with their status as they go along in doing their jobs (an increase of 15%). They also were slightly more likely to report that they would try to keep up with what activities others were working on over the course of the shift (an increase of 10%). Both of these items relate to improved situation awareness across the team.

Participants reported they would be more likely to try to understand others' viewpoints when engaged in a disagreement with other departments (an increase of 15%). This relates to an effort to develop better shared mental models regarding other departments. In addition, participants reported changes in several behaviors related to improved communications and teamwork. They were more likely to report improved written communication when sending an aircraft with a MEL to another station (an increase of 21%). Participants were more likely to report that they would make sure to pass on information about an aircraft and work status to the next station (an increase of 13%). They were also more likely to report making sure all problems and activities are discussed during shift meetings (an increase of 11%), and encouraging others to speak up during shift meetings to voice concerns or problems (an increase of 12%).

These differences between the pre-test and post-test measures on SA related behaviors and attitudes indicates that in addition to participants responding positively to the course, they reported actual changes in behaviors they would make on the job as a result of the course, thus improving SA on the job both between and within maintenance teams.

Changes on the job

In order to assess whether participants actually made the intended changes in their job behaviors following the course, the same form was again administered one month following the course. At the time of this analysis, the participants of only one course had been on the job for a full month after the training session. Of these participants (17), six responses were available for this analysis (representing a return rate of 35% which is typical of mail-in questionnaires). A paired comparison of responses on each item between the post-test questionnaire and the one-month questionnaire was made using the Wilcoxon test. This analysis revealed no changes on any of the test items at a .05 level of significance. Therefore, it would appear that the behaviors participants reported they would engage in following the training were carried out in practice, at least for this small sample.

Summary

Overall the SA Team Training Course was highly successful. The course content associated with all of the major training objectives was rated very highly with the vast majority of participants rating each area as “very useful” or “extremely useful”. The course was viewed as between “very useful” and “extremely useful” overall, for increasing aviation safety and in terms of usefulness to others. The majority of participants felt that the course would result in making changes in their behaviors on the job. The results of the follow-up questionnaire, administered one month after the training course, supported these intentions. The self-reported behavior follow-up questionnaire showed that participants were making the changes they had intended to make following the training.

The evaluation represents only an initial evaluation of the Team SA Training Course in its prototype implementation phase based on the responses of an initial group of course participants. To further validate these findings, continued evaluation is needed with succeeding groups of trainees in the course. In addition, more follow-up research is needed to validate the results of the on-the-job behavior changes and the degree to which the training impacts critical maintenance performance measures at the airline. These activities are in process Despite these limitations, this example shows a process by which team training courses can be developed for different domains. The preliminary results at least indicate that there may be considerable value in pursuing courses such as these.

Conclusions

This chapter attempts to build on existing research to scientifically explore potential techniques for training SA. As good SA is at the heart of good decision making and performance in aviation, training focused at improving SA should be highly effective at reducing the level of accidents and incidents in aviation. Research designed to explore this possibility has only recently been undertaken. Much work is still needed to determine whether programs built from these research findings will bring fruition. It is possible that the development of situation awareness in a given domain requires the skills and knowledge bases acquired only through trial and error learning. It is also highly possible, however, that training programs directed at enhancing the most fundamental cognitive skills and at boot-strapping the acquisition of needed knowledge bases can improve on the hit-or-miss processes currently in play.

While most efforts at training SA have been directed at the pilot community, SA training may be a viable approach for other communities as well. While it is likely that the issues confronting personnel may be rather different form those found in aviation, some of the approaches outlined here for improving SA at the individual or team level may also be applicable to other domains. Considerable research is needed, however, to determine the sources of SA differences between high and low SA individuals in these other domains and the skills and strategies that may be appropriate for maintaining high SA. Within aviation, we are only just beginning to explore the ways in which individuals and teams develop and maintain SA within the challenging operational environment. Far more research is needed in this area.

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