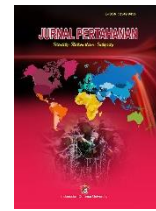




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### **SPATIAL DISORIENTATION TRAINING TO SUPPORT FLYING SAFETY IN INDONESIAN AIR FORCE**

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#### **Abstract**

The magnitude of aircraft accidents due to the spatial disorientation (SD) experienced by the aircrew has encouraged efforts to provide optimum training to prevent and minimize those unexpected accidents. In their publication, USAF has stated that SD had caused 15-69% of their aircraft fatal accidents. This study aims to determine the extent of which the SD training program in Aerophysiological Indoctrination and exercise (ILA) of the Indonesian Air Force has been carried out effectively, making it useful for the crew to prevent accidents. The main focus of the study is to analyze the willingness of aircraft crew; leadership support policy, simulator tool condition, and qualification of instructors. This research designed to use a qualitative descriptive approach. Data collections obtained through depth interviews involving Indonesian Air Force aircrews, aviation health experts, instructors officer of Health Service of Indonesian Air Force, and also through the search of publication and related documents. The results show that there are still many aspects required more attention from the Indonesian Air Force authorities; insufficient simulator facilities that are too old and out of Job, inadequate software as the basis of the implementation of the training program, the limited .qualifications of training instructors, and lack of support from higher commands.

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## INTRODUCTION

Human nature has born as land creatures so that every time they try to explore the sky there will be body physiological disturbances. Mismatch of the body-sensor system perceived and the actual situation experienced, known as spatial disorientation (SD) The SD phenomenon defined by Benson as a disturbance of the physiological function experienced by aircrew as an inability to recognize their position, direction, motion, and attitude of himself or his aircraft (Benson, 1988). Accordingly, they will need the help of the instrument. SD that can't be immediately recognized and anticipated will soon make the aircrew lose their control to the plane and followed by a fatal accident (Newman, 2007).

SD has commonly known as the major cause of aviation accidents. There were studies conducted by some air force institutions around the world in terms of its prevalence and its contribution to aircraft mishaps. In general, the results show that SD has considered as main contributed by about six percent to 32 percent of a major accident and about 15 percent to 69 percent of fatal crashes. U.S. Air Force study examining the SD phenomenon from approximately 15 years of accident data found that SD accounted for 11 percent of USAF accidents and 69 percent of casualties during the period 1990 to 2004 (Lyons et al., 2006). In Indonesia, there were also several instances of accidents that allegedly occurred Due to SD. Two of them were the Adam Air PK-KKW plane crash with flight number DHI 574, which crashed on Makasar Strait water on January 1, 2007, and Lion Air PK-LKS aircraft with LNI 904 flight number, which fell in the waters at the end of the airport runway Ngurah Rai Bali on 13th April 2013 (National Transportation Safety Committee, 2008; National Transportation Safety Committee, 2014).

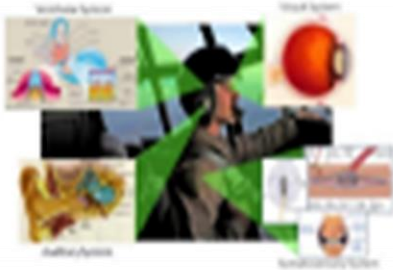
To provide the suitable knowledge and expertise of SD coping for our aircrews, the

Indonesian Air Force (TNI AU) has conducted an SD training program that is incorporated in Aeromedical Indoctrination and Training activities (ILA). The training was held at the Institute of Aviation and Space Health (*Lekespra*) dr. Saryanto using the Basic Orientation Trainer (BOT) simulator (Mabes TNI AU, 2013). This training aimed: 1) Imitating some sort of SD that may be experienced by the pilot (especially the vestibular type), 2) Train the aircrew the best way to deal with SD, and 3) Emphasize the importance of trusting the instruments. Even today, it is so difficult to eliminate the incidence of mishaps due to SD, that's why proper indoctrinations must be perfectly delivered to the crew so they will always be aware of the dangers.

There are 3 (three) sensory systems play important role in the body balance function and trigger the occurrence of SD, the vision system (eye), vestibule system (organ balance in the middle ear), and proprioceptive system (skin and its tactile organ). These three systems work to maintain body balance. In the event of a discrepancy between one or more of these systems, it will lead to an illusion that is inconsistent with actual reality. Sensory systems that are most likely to be relied on in the ground environment are the eyes. However, in aviation, the function of the eye may be deceptive. For instance, the oculokinetic Illusion leads the crew to see the nose moves up as the plane takes the take-off motion, while in fact, it doesn't. This illusion occurs due to physiological mismatches of vision systems and proprioceptive systems influenced by the acceleration of the moving forward aircraft.

We may divide the types of illusions into 2 (two) large groups, which one is caused by the vision system and the other by the vestibular system. Both of them have almost similar risks and require professional handling.

Illusions due to the visual system occurs since humans rely heavily on visual stimuli



**Figure 1.** Integration three sensory systems of body balance function

*Source:* Woodrow, 2001

to describe the surrounding environment. Therefore, when faced with various movements and accelerations along with the unique visual perspective and weak lighting encountered in flight, a pilot cannot be expected to get a correct understanding of the geographic locations, his position and position of the aircraft, the direction, the altitude, and the speed of the aircraft. Instrument panels in the aircraft have been designed in such a way to help pilots maintain an awareness of the aircraft position and movements. Nevertheless, human vision remains vulnerable to understanding this illusion. Some examples are: 1) Light confusions, 2) Wrong vertical and horizontal guidance, 3) Relative movement or linear section, 4) Autokinesis, 5) Glare in the highlands, 6) Haze and fog, 7) Space myopia blank visual fields, 8) Runway problem approach and 9) Night landing (Woodrow & Webb, 2001).

The vestibular system illusion experienced since in a natural way the human vestibular system has evolved to work only in the land or ground environment. It will, therefore, tends to provide misleading information to the brain during flight. Semicircle channel response may be inappropriate during usual! angular acceleration in flight or otolith organs can not distinguish between gravitational forces and linear acceleration. Some examples of illusions in this group include: 1) Somatogyral illusion, 2) Nistagmus, 3) The Leans, 4) Graveyard spin, 5) Graveyard

spiral, 6) Coriolis illusion, 7) Occulogyral illusion, 8) Chromatographic illusion, 9) Occulographic illusion, 10) Pitch up or pitch down illusion, 11) Irregularities illusion and 12) Elevator illusion (Woodrow & Webb, 2001).

SD training for TNI AU crews has been conducted several decades ago using the Basic Orientation Trainer simulator. But nowadays it hasn't complied anymore with their modern jet aircrafts operations. It is felt that the simulation technology made and performed by this aerophysiology tool simulator is outdated due to the age of the tool, so it is allegedly not effective enough in providing an understanding of the real situation to the crews to open the risk of unsafe decision and unsafe action during the mission. Besides, because of difficulties SD topics discussion, it appears that this training has been very rarely done again due to the absence of aviation health experts who can give depth and detail explanations of this phenomenon, by the physics and physiology point of view.

Another problem arise was the lack of aircrews participation willingness so it gives a contribution to developing inefficient training. It appears that crews are reluctant to undergo the SD training program due to various reasons. One of the most common reasons is that they don't like being treated as 'new kid on the block and they can't see the relationship between the program and their daily routine flying activities.

Other topics of this discussion come from a regulatory point of view. there are still many shortcomings in the detailed explanation of the training implementation procedure. We cannot even find professionally separated job descriptions between Aerophysiology Simulator Operator, Training Instructors, and Aviation Medicine Experts. The undivided job descriptions make the authority overlap between them and make it worse that they start to rely on each other, both on the maintenance of the simulator and the

implementation of the training itself.

To describe the whole situation of the SD training program we must consider all the aspects causing the problems. We were quite aware that failure in the implementation of this training will eliminate the importance of Situational Awareness that can be obtained from this program. Therefore, by referring to the situation, the researcher conducts research and analyzes the implementation of the SD training, so that the effectiveness of the program can be achieved to support safe and good mission performance of the aircrews.

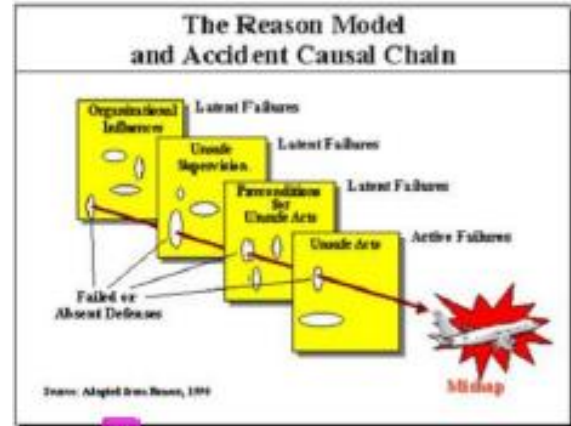


**Figure 2.** Basic Orientation Trainer Simulator  
Lakespra Saryarito  
*Source:* Authors, 2020

Achievement of aviation safety is a great aiming of TNI AU due to valuable assets of personnel and defense equipment for the readiness protecting the sovereignty of the state in the air. There is a motto: "The sky is vast, but there is no room for error", so the culture of safety must be empowered in earnest, not at random or simply meeting the requirements of the rule, In another word, there must be strict commitments from the top leadership, namely the Chief of Staff of the TNI AU regarding the importance of flight safety, and make it down flowing into the implementing staff in the air squadrons.

As James Reason demands that accidents could always be prevented if the management can recognize the possible hazard of human error at each stage of work or mission, those reasons management,

such as TNI AU, is required to make every effort necessary to protect its employees and shall be obligated to carry out any necessary measures to prevent the flying accident.



**Figure 3.** Swiss Cheese Model by James Reason  
*Source:* Reason, 1990

This research attempts to observe, evaluate, give ideas to improve the SD training implementation effectiveness to avoid situations that could endanger aircrews and mission. Nevertheless, it must be understood that the achievement of flight safety is an end goal fought for by all parties involved, from top management to the lowest rank and the smallest task group participate in the preparation of a flying mission. Even if one of the elements made an error then the opportunity of the accident will be doubled. Based on the backgrounds, then we have the following problem formulation:

- a. How has the SD training been carried out according to the applicable rules?
- b. How far are the effectiveness and relevance of the SD training in supporting the Air Force's flying safety?
- c. What is the alternative solution necessary if SD training was ineffective?

## RESEARCH METHOD

### Research Framework

The framework of thought that guides researchers in conducting research can be explained as follows:

- a. Input Analysis. It includes phenomenons of aircraft accidents with suspected causes of SD, and a significant gap between implementation of the ideal SD training has been done since several years ago and current conditions.
- b. Process Analysis. It was done by using the Qualitative Analysis Method. This method is used to determine the aspects that affect the implementation of SD training.
- c. Output Analysis. We put all data analysis in the conclusion and suggestions regarding the effectiveness of SD training implementation.
- d. Outcomes Analysis. The recommendation will be prepared based on the conclusions and suggestions

### Research Design

Qualitative research methods used in this research to analyze the topics. This design is deliberately chosen because we believe this method is the best way to examine a natural object condition as expected in this topic. Final data analysis of qualitative research found to be inductive and the results emphasis more on the meaning than generalization (Sugiono, 2015). So, we feel that this design is more suitable than quantitative research methods.

### Subject

We have selected subjects with best and longest experiences related to SD training in TNI AU, which includes: a) Military aircrews, b) Aerophysiology Simulator Operator, c) Aviation Medicine Experts work at the Aerophysiology Department of Lakespra Saryanto, and d) TNI AU Department of Health officials directly related to the implementation policy of this training. All subjects were treated as colleagues in which they are not only asked may choose direction and their way to present the information during interviews (Sutopo, 2006).

They were one TNI AU Department of

Health official with the rank of First Marshal, two aviation medicine expert with the rank of Lieutenant Colonel and Major, two military aircrews with the rank of Major and one Aerophysiology Simulator Operator with the rank of Warrant Officer.

### Data Collection Technique

Data collection techniques used in this research are:

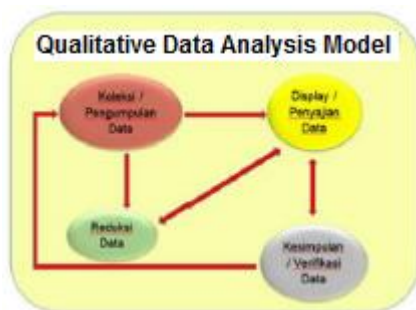
- a) Observation. We used an open observation method where we gathered with all parties involved in the SD training program and also explained meticulously the research procedures so that they all know the whole activities from the beginning to the end. But surely sometime we will disguise some important parts of the observation to protect data secrecy.
- b) Interviews, we conducted an unstructured interview method in this study so we could obtain more in-depth pieces of information. Nevertheless, the interviews could be well controlled because we already set the extracting information guidance, in the form of outlines of questions asked.
- c) Triangulation, this study used data triangulation and methodological triangulation techniques. In data triangulation techniques, which can also be referred to as source triangulation, researchers have attempted to use various sources. While the technique triangulation researchers, researchers collect the results of both in the form of data and conclusions about a particular section or any of them to be tested by other researchers (Sutopo, 2006).

### Data Analysis Technique

We already started data analysis even before entering the field, continued during the process of collecting data and post data collection. Furthermore, the analysis is done with these three main ways, a) Data Reduction, where we summarize, choose



the main things, and focus on the things that are important to look for the theme and pattern, so it will provide a clearer picture and make it easier to do further data collection and search if necessary. b) Display data, conducted in the form of narrative text descriptions. By displaying the data, it would be easier to understand what just happen and then we can plan the work based on what has been understood. c) Conclusion Drawing, we raised valid and consistent evidence to obtain a credible conclusion. The data analysis model can be seen in Figure 4.



**Figure 4.** Qualitative Data Analysis Model  
*Source:* Sugiono, 2015

## RESULT AND DISCUSSION

Research on SD in Indonesia is still very rare, partly due to a lack of understanding of this phenomenon, Meanwhile, in other developed countries even they have tried efforts to prevent and reduce the number of accidents caused by SD, but a big amount of accidents still exist, Experts at USAF Fight Safety Center in 2010 continue to remind that the only way to save lives from of this killer phenomenon threat is to avoid and prevent the SD occurrence (Sugiono, 2015).

This research is expected to provide an overview of all aviation institutions Indonesia about the effectiveness of prevention efforts that we have done while making improvements in the future. Some of the basic things sought in this research are the knowledge, understanding, and opinions of the personnel involved in the

implementation of the SD training. For that reason, we have asked flight crew informants to what extent they understand the phenomenon of SD and how they think it can affect their performance on their flying duties, their opinions about the training done so far, and their suggestions about efforts that can be done to improve the effectiveness of this training.

### Conformity Training with Rules

The SD training is scheduled for the crew along with the ILA program, which is every 2 years for combat pilots, and every 3 years for crew and helicopter crews. It is a pity that according to the interview results obtained information the flight crew rarely received the SD training as it should. The rarity of the SD training is because the Basic Orientation Trainer (BOT) simulator was no longer operatable which makes the training can not be done optimally.

Another factor causing the absence of SD training is because the Technical Guidance which is the reference of its implementation has not been prepared in detail so that there is a difference of understanding and the level of knowledge possessed by the flight crews with the Aerophysiology Simulator Operators and the Training Instructors assisting during the training (Mabes TNI AU, 2013). For example, the objective to be achieved in the Technical Guidelines is to train the flight crew to cope with SD by imitating several kinds of SD. So, the instructor will simply play the gondola and mention the illusion that may occur. Yet what the crew wanted to be a detailed explanation of how the SD illusion might happen so they could easily understand it. However, due to the in-depth understanding of the mechanism of the occurrence of SD requires knowledge of physics and body physiology is quite complicated so that not even all Aerophysiology Simulator Operators and Training Instructors have that understanding. Additionally, the

Aerophysiology Simulator Operators and Training Instructors only knew the SD theoretically and rarely experienced the SD events as perceived by the crew, so their understanding would be even shallower.

The next shortcoming in the Technical Guide to this SD training is the criteria and grouping of training materials tailored to the manned type of aircraft and the nature of the SD most likely to be experienced. So, it should not be that all types of SD exposed but only those that have the suitability and importance for the type of aircraft.

### **Training Program Effectiveness**

This research notes that through participation in training that has been done so far, almost all informants already have a fairly, good knowledge and understanding and uniformity of perception about the purpose of the SD training implementation. However, some problems arise in the field, although in reality, the flight crew had experienced SD not all of them able to recognize it. This is partly due to the very rare implementation of SD training due to the Basic Orientation Trainer (BOT) simulator is not able to be operated again optimally which makes the training cannot be done optimally. It also obtained information that due to the characteristics of BOT training, the crew thought that the training was just a joke and did not get benefit from the training. As it is known that in BOT training, the crew is inserted in a pitch-black gondola and rotated around the center of the gondola while being asked to feel the perceptual errors of body position and the gondola that is experienced due to the absence of the instrument (Woodrow & Webb, 2001). Therefore, instructors are required to provide explanations to the flight crew about the phenomenon experienced and the consequences so that they can understand the SD phenomenon well. It is a pity that the Aviation Medicine Experts who accompany the flight crew are often less

able to provide the participants with the desired explanation. Therefore, the flight crew became reluctant to carry out this SD training because they could not benefit from the implementation.

The flight crew also judged that the Training Instructors were not very clear about aviation medicine applications in the real world of aviation, which ultimately reduced the quality of material delivery, transfer of knowledge, and awareness building of the SD training materials. This may be due to the inexperience of the instructors. Although Aviation Medicine Experts serving at the Aerophysiology Department have already served in the air squadron, their understanding usually will be more fixed on the aircraft type owned by the air squadron.

Thus, it can be seen through this research that until now the implementation of the SD training program has not been effective and relevant to the needs of the flight crew in supporting the safety of flying in the implementation of daily tasks.

### **Alternative Solutions**

It was found that generally the flight crew who had attended the previous SD training and also had enough flying experience, will be able to recognize the SD event they experienced and can immediately perform their recovery action correctly. The action is carried out by fully trusting the aircraft flight instruments to determine the position of the aircraft, thereby avoiding the occurrence of unwanted accidents. Instinctively and supported by the learning experience in the simulator, the absorption of the results of the flight health briefing, as well as the flying experience, they will immediately surrender and fully trust the aircraft instrument even though often the instruments indicated are inconsistent with their feelings. However, similar awareness can not be observed among the beginner crew, so more research is needed.

To reactivate the training program and

increase the participation of the flight crew towards the SD training, the Aviation Medicine Experts stated that it is necessary to add the tools of Advance Orientation Trainer (AOT) simulator as well as continuing education support to improve and also maintain the knowledge and skills of instructors and experts aviation health that manages the SD training program. One way that can be done is the provision of opportunities for instructors in the Department of Aerophysiology to add knowledge and insight regularly will be very useful. These activities can be done either by following scientific events or working visits to air squadrons, to reduce concerns to the quality of instructors as delivered by the crew. And finally, with the new simulator and qualified instructors, it is expected that the crew has an interest in participating in the training because they feel the need to understand the phenomenon of SD by using simulator facilities similar to their daily work environment.

Related to the proposed procurement of the AOT simulator as an alternative solution, it will need a strategy in taking a more tactical and realistic step to determine the simulator model to be purchased. Although the proposed procurement must go through the procedures set by the top management, it would be better to send some aviation medicine experts to visit friendly countries that have used certain types of simulators, as well as to learn to assess their feasibility in terms of operational and maintenance (Department of Acceleration Physiology, 2006). By being able to get an overview of some types of simulators that have been operated by other countries, we will be able to compare and obtain an insight to pick up the best simulator for us.

Another important thing, basically SD training must be undertaken by a crew because any type of aircraft must have the same possibility to experience the phenomenon. This characteristic was

different from the training type of other simulators. For example, Human Centrifuge that simulates G-Force when performing certain maneuvers that can only be done by the fighter aircraft crews. Aircraft and helicopter crew members also have the same chance to lose their position at altitude, while experiencing SD like fighter crews, although they are not doing the extreme maneuver. So, aircrews who had experienced a state of confusion due to SD will know the importance of this training. And they will always try to increase their situational awareness of SD. One more thing behind these expectations is to revise and refine the Technical Guidelines and Standard Operating Procedure as the basis for the implementation of the training. By detailing the technical implementation of the SD training as expected along with will, its supporting rules, it is believed to be very useful for the implementation of training and application in the field when the crew is undergoing a real flying task.

## **CONCLUSIONS, RECOMMENDATION, AND LIMITATION**

SD training is such an effort to help the crew achieve, good performance to perform their flight duties. However, there are still some factors that make this program far from optimum. The factors are rules that are out of date, the simulator was too old, the licensing procedures, the reluctance of the aircrew to participate, and also the lack of qualified instructors.

This study shows that our SD training still not effective because there are still many aspects that need the attention of all the authorities in TNI AU. To overcome the problems found, it is necessary to have the same word and vision of all the authorities in TNI AU to obtain optimal benefits from the implementation of this program. Appropriate measures to be part of this problem-solving effort include improving the value and quality of aerophysiology training, provision



of a new SD simulator, capacity building of trainers and simulator operators, as well as increased interest, knowledge, and skills of aviation medicine experts in Lakespra.

SD training is part of a bigger program to build aircrews situational awareness regarding the impaired physiology of the human body due to aviation. While this research is still focusing on SD, other studies are still required to examine the extent to which these pieces of training are still carried out optimally and can be expected to achieve the expected objectives. As the age of the simulator increases, the danger during training increase severalfold, requiring a review of the extent to which a new simulator tool is required and we can suggest a possible temporary suspension of training so all aircrew to be transferred to other training centers abroad.

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