Original Research

Indian Air Force and US Air Force Spatial Disorientation Countermeasure Training: A Comparison

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Abstract

Introduction: Spatial Disorientation (SD) has contributed to numerous aviation mishaps around the world and continues to cause substantial losses of men and material. Physiological training and knowledge of a good instrument cross-check are the main weapons against SD at the disposal of the flight surgeon and the pilot. Various countries across the globe follow SD training programme which are tailor made to suit their own specific requirements.

Aim: This paper aims to compare the current SD countermeasure training practices in the IAF and the USAF.

Materials and Methods: A literature search of scientific articles pertaining to USAF and IAF practices of physiological training of aircrew was carried out. In additional, official US and Indian policies on aircrew physiological training were studies and a comparative analysis of current policies and practices was carried out.

Results: The IAF pilots are exposed to dedicated instructions on SD during all stages of flying training, followed by regular reinforcement of the same by the flight surgeons in operational units. The IAF installed the Airfox® SD Simulator at the Institute of Aerospace Medicine in 2004, followed by two more similar simulators at No. 1 & 2 AMTC in 2009. This simulator is now utilities for SD training of ab initio and operational pilots of the IAF as part of the operational training in aerospace medicine (OPTRAM) course. In the USAF, initial SD training is conducted during the pilot trainee's undergraduate flight training programme, officially called the Specialised Undergraduate Pilot Training (SUPT). A few illusions are demonstrated on the Barany Chair. Refresher training for USAF pilots is done annually and every five years, both of which have a one hours brief SD. There is no simulator based SD countermeasure training for pilots.

Conclusion: The USAF SD training programme is rudimentary at best. On the other hand, the IAF has a highly effective programme. The USAF needs to boost its SD training programme at the earliest. The IAF needs to capitalize on the benefits accrued from its programme. The tempo of SD training needs to be maintained.

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Introduction

The process of evolution on the Earth over millions of years saw living beings transform from aquatic to terrestrial and even arboreal creatures and aerial ones. However, physiologically human beings were forever destined to remain on terra firma. Keeping in view this phylogenetic heritage, it is obvious that exposure to the aerial environment creates a mismatch between the demands of this new environment and the humans' innate limited capability to orient themselves in this unfamiliar environment. This mismatch manifests itself as spatial disorientation (SD) [1]. SD has contributed to numerous aviation mishaps around the world. Although the exact incidence varies between different countries, SD continues to cause substantial losses of men and material [2, 3, 4].

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Gibb suggested that SD contributes to at least 25-33% of all aircraft mishaps and results in the highest number of fatalities [5]. Proven and suspected cases of aircrew spatial disorientation contributed to 5.79% of total, 6.7% of major and 18.42% of the fatal aviation accidents in the Indian Air Force (IAF) from 1970 through 1990 [3]. Between 1991 and 2000, SD was implicated in 20.2% of Class A mishaps in the United States Air Force (USAF) at a cost of 60 lives and 1.4 billion US dollars [6]. Physiological training and the knowledge of how to do a good instrument cross-check are the main weapons against SD at the disposal of the pilot and the flight surgeon [7]. In a survey conducted in the IAF, 88% of aircrew reported an improvement in their awareness about SD after undergoing simulator based training [8]. Various countries across the globe follow SD training programs which are tailor-made to suit their own specific requirements.

The IAF started SD training for its aircrew way back in the sixties with a link trainer. Later an indigenous machine was made and installed. In the eighties the gimbal mounted tumbling device was built and used for SD training. In the nineties, Agarwal introduced some maneuvers for SD training on the human centrifuge with the latter rotating at a very slow speed ~ 0.2 Gz (Personal communication, April 05, 2013).

In the United States, the use of an SD training device dates back to the US Army Signal Corps. The first device, called the Vertigo Stopper Box, was designed and used in 1929. Ercoline confirmed that the Vertigo Stopper Box (or Ocker Box) was eventually replaced by the Vista Vertigon® when the USAF decided to standardize the training and make SD a part of Consolidated Undergraduate Pilot Training (UPT) in the late 1950's. By the 1960's, all the UPT bases had a version of Vista Vertigon that was used in the physiology portion of the academic training (Personal communication, April 05, 2013).This paper aims to compare the current spatial disorientation countermeasure training practices in the USAF and the IAF.

Materials and Methods

A literature search of scientific articles pertaining to USAF and IAF practices of physiological training of aircrew was carried out. In addition to the fact that the author has been actively involved himself in the SD training of IAF aircrew for a considerable length of time and the author also communicated with people who are/were actively involved with the SD training in both countries. In addition, official US and Indian policies on aircrew physiological training were studied. A comparative analysis of the SD countermeasure training policies and practices of the two was then carried out, suitable conclusions were drawn and recommendations were put forth.

Results

The Indian Air Force has implemented a robust SD countermeasure training program for its aircrew. Historically, SD countermeasure training for IAF pilots was started in 1992 with an academic SD element being included in the pre-existing High-G course and renaming it as the Advanced Fighter Aircrew Indoctrination Course (AFAIC). This evolved gradually to form, what is now known as the OPTRAM course.

The IAF pilots areexposed to dedicated instructions on SD duringthe basic, intermediate and advanced stages offlying training as part of the aviation medicinetraining package. This is followed by a regularreinforcement of these instructions by thesquadron aviation medicine specialist in the field.This training takes the form of periodic lectures on SD and on limitations of the human sensory apparatus. This holds true for all aircrew, irrespective of the aircraft they are current on.

During training of fast jet pilots, the importance of instruments and their scan in maintaining orientation is generally demonstrated in the Unusual Attitude Recovery sortie under the hood in a fighter trainer, as part of the instrument flying (IF) syllabus. This is only carried out in those

fighter aircraft where such a facility exists. The aim, primarily, is to teach aircraft recovery and not the causes or preventive aspects of disorientation [9].

Recognizing the importance of training in combating spatial disorientation and to improve the SD coping skills of its aircrew, the Indian Air Force installed the Airfox® Disorientation Simulator(http://www.amst.co.at/sites/products/diso/diso.html) at the Institute of Aerospace Medicine (IAM) in May 2004. This was followed by two more similar simulators being installed at the No. 1 and No. 2 Aeromedical Training Centres (AMTC) in 2009 (Fig.1). However, this paper does not constitute an endorsement of this equipment by the author. (http://www.amst.co.at/sites/products/diso/diso.html) at the Institute of Aerospace Medicine (IAM) in May 2004. This was followed by two more similar simulators being installed at the No.1 and No.2 Aeromedical Training Centres (AMTC) in 2009 (Fig-1). However, this paper does not constitute an endorsement of this equipment by the author. (http://www.amst.co.at/sites/products/diso/diso.html) at the Institute of Aerospace Medicine (IAM) in May 2004. This was followed by two more similar simulators being installed at the No. 1 and No. 2 Aeromedical Training Centres (AMTC) in 2009 (Fig-1). However, this paper does not constitute an endorsement of this equipment by the author.

Fig-1: Airfox® Spatial Disorientation Simulator

Ground based aerospace physiology training in the IAF is carried out as part of a one week course called Operational training in Aerospace Medicine (OPTRAM) that all aircrew need to undergo periodically. Various OPTRAM courses are tailor made for the intended student population, be it fighter aircrew, transport or helicopter aircrew, or ATC officers.

No. 2 AMTC carries out SD countermeasure training for the ab-initio pilots undergoing basic flying training at the Air Force Academy, enlisted aircrew and Air Traffic Control (ATC) officers. Transport and helicopter pilots undergo SD training at No. 1 AMTC. All trainee and operational fighter aircrew undergo SD training at IAM in conjunction with centrifuge and hypoxia training.

The SD simulators consist of a 6 degree-of-freedom motionsystem with an additional, continuouslyrotating yaw mechanism to generate linear androtational motions. They utilise advanced electroniccontrols, computer-model driven responses andvivid graphic displays to provide safe and realistic disorientation training. The computer generated scenarios can be manipulated from the control desk to simulate IFR flight scenarios including dark night, clouding and other poor visibility conditions. In addition, all three simulators can be configured to a Night Vision Goggle (NVG) compatible status. The facility of a graded increase in the yaw rotation and additional heave motion gives an additional capability of being used for motion sickness desensitization[8].

The Airfox® SD simulator is capable of simulating thirteen common illusions for fighter flying and three additional illusions which are specific for rotary wing aircraft (Table-1). Five of these illusions involve passive operation of the simulator and serve to demonstrate the limitations of the orientational senses. The active illusions involve a closed loop control of the simulator by the pilot/ student.

Table - 1 : Illusions Demonstated on SD Simulator

Passive Illusions	Passive coriolis
	Somatogyral
	Oculogyral
	Nystagmus
	Autokinesis
Active Illusions	Spin recovery
	Leans
	Active coriolis
	Dark night take-off
	Black hole approach
	False horizon (clouds)
	Runway width illusion
	Runway slope illusion
Helicopter Illusions	Flicker vertigo
	Vection (Brownout)
	Vection (Whiteout)

The training on the simulator varies with the particular group undergoing the training. For *ab-initio pilots*, the training is conducted over a period of 01 working day and includes didactic lectures on SD and demonstration of all passive and active daytime illusions for each student individually. This is done to prevent any negative transfer of training since this group is not exposed to night flying during this stage of flying training.

For fighter aircrew, the training involves didactic lectures followed by demonstration of all passive and active illusions in the simulator. In the initial part of the simulator run, all passive illusions are demonstrated to the pilot. Subsequently, after a brief familiarization flight, the pilot flies pre-set profiles on the simulator and goes through all the active illusions. Each aircrew undergoes around 60 minutes of training in the simulator.

Transport and rotary wing pilots undergo training which is similar to the one for fighter aircrew. The simulator cockpit can be configured accordingly to suit the particular type of aircraft. However, some illusions are based on the fast jet configuration alone. Hence, given their inexperience in handling fast jets, the focus is more on demonstration of illusions by the instructor at the control desk rather than on their ability to do so themselves by flying the simulator.

ATC officers go through SD training to increase their awareness about this particular stress associated with aviation, the limitations of the human body's sensory apparatus and their role in assisting the pilots in overcoming SD. Their training involves suitably tailored didactic lectures followed by demonstration of the passive illusions in the simulator. Demonstration of active illusions is purely voluntary depending on the officers' experience in handling an aircraft.

Similar SD training programs are followed by a number of other countries, like the United Kingdom, The Netherlands and Germany, to name a few[10]. Table-2 summarizes the SD training programs followed by different NATO member countries.

The USAF aerospace physiology training program provides USAF aircrew, operational and aeromedical training designed to improve their performance during flight operations. Air Force Instruction (AFI) 11-403, *Aerospace Physiological*

Training Program, provides the policy and guidance for this program. The AFI also meets the standards established by STANAG 3114, *Aeromedical Aspects of Aircrew Training*.

The training program offers training for new aircrew members and refresher training for experienced aircrew members. Spatial disorientation training is offered as part of both the initial and refresher training [11].

In the US Air Force Initial training to counter SD is conducted during the pilot-trainee's undergraduate flight training program. There is a two-hour block of instruction for the T-6 aircraft. There is no special SD training for the T-38. The official name for the flight-training program is Specialized Undergraduate Pilot Training (SUPT). The SUPT syllabus requires that the causes and consequences of SD be introduced during the Aerospace Physiology (AP) section, which is completed early in the year-long program. The entire AP section requires about 50 hours of instruction, which includes a 2 hour block on SD. The syllabus includes demonstration of some illusions to the pilot trainees using the Barany Chair (if available). The illusions demonstrated include the graveyard spiral, coriolis and nystagmus. Each student is given at least one demonstration. However, nystagmus is generally demonstrated on a couple of students only [10, 12, 13].

Currently, there is no specific section of the training syllabus for in-flight SD instruction in the US Air Force.

Refresher training in the USAF occurs in two separate courses, one annually, the other, every five years. The first course, entitled "Instrument Refresher Course," is a day long series of lectures covering primarily instrument flight procedures with a one hour brief on SD. . It is preferably taught by an aero space physiologist. As for the

Table-2: SD Training by Country [10]

Type of SD Training	USAF	US NAVY	RAF	Royal NAVY	Canada	Germany	France	Netherlands
Classroom Based	LS,BC	LS	LS	LS	LS	LS,BC	LS	LS,NVG
Ground Based	BC	MSDD	DISO	DISO	BC, GI	DISO	Centrifuge	BC, DISO, Desdemona
Flight Sim Based	NVG	Nil	Various	Various		Planned	No	No
In-flight Demo Refresher	4 A/C		No	No		Yes	No	No formal process
Training Frequency	5 yrs	4 yrs	5 yrs	4 yrs	5 yrs	4 yrs	5 yrs	4 yrs

LS: Lecture Series BC: Barany Chair NVG: Night Vision Goggles GI: Gyro IPT

MSDD: Multi Station Disorientation Demonstrator

Desdemona: Advanced SD trained capable of multi-axial acceleration coupled with visual and vestibular illusions (M/s AMST, Austria)

five-year recurrence training, there is a block of 45 – 60 minutes of instruction on SD during the aerospace physiology refresher course. It is usually an all day series of lectures. SD may often be a part of this series. If so, it would not be more than an hour. The syllabus included in the module on "Perception and Spatial Disorientation Issues Affecting Human Performance and Situational Awareness", is suitably modified for helicopter and fast jet pilots.

The topics covered include special senses, including anatomy and physiology of the visual, vestibular, and kinesthetic systems, their limitations, and specific visual and vestibular illusions. Night Vision Devices (NVDs) are covered during the visual section. Circumstances that contribute to disorientation and loss of SA and salient mishaps where SD was a major contributor, are also discussed (Table-3) [10].

Discussion

Although the phenomenon of spatial disorientation (SD) has been described and documented by many, both researchers and aircrew, since the earliest days of aviation, a complete understanding of the complex mechanisms and interactions has remained elusive. The economic consequences alone of SD are enormous, both in cost of lost aircraft and cost of training new aircrew.

Curiously, the USAF SD countermeasure training program continues to be rudimentary, while the US Navy carries a relatively much more exhaustive training [14]. An advanced spatial disorientation simulator is already in the final stages of installation at the Naval Aeromedical Research Unit. Although it is primarily intended for research purposes, the importance that the US Navy places on SD, is apparent.

It was confirmed by William Ercoline (personal communication, March 25, 2013) that the USAF trained its aircrew in SD on the Vista Vertigon® till it was removed from service in the mid 1990s due to lack of sustainment, leaving a glaring defect in the training capability. In October 1999, Maj Gen Welser of the Air Force Education and Training Command (AETC) recommended the procurement of 6 Advanced Spatial Orientation Devices (ASDD) for UPT bases to replace the Vista Vertigon®. The requirement remained unfulfilled for lack of funds till September 2011 [15].

In 2005, a technical study carried out by AETC comparing motion based and non-motion based SD training systems concluded that all pilottrainees should experience SD illusions in motion based simulators during UPT. A comparative analysis of various simulators carried out in 2008 concluded that full motion trainers improved the pilots' ability to recognize and respond to SD before experiencing it in the aircraft [15].

Table-3: Syllabus of USAF Refresher Aerospace Physiology Training for SD

Special senses	Anatomy and physiology of visual,vestibular and kinesthetic systemsNightVisionDevices Auditory cuesSpatial disorientation
Circumstances contributing to disorientation and loss of SA	Night Vision Devices Corrective actions to rectify disorientation, once recognized
Salient aircraft accidents and incidents where SD has been implicated	

It is now proposed to procure 5 SD trainers off the shelf for the UPT bases over the next 3-4 years [15]. Once installed, these simulators will provide a quantum leap in the USAF aerospace physiology training program. In addition, these wouldgo a long way in reducing the attrition rates of man and machine due to SD in the USAF.

The USAF is also mulling the idea of installing Automated Ground Collision Avoidance Systems (Auto GCAS) in its entire combat aircraft fleet. However, SD training helps in reinforcing the weak link in the man-machine interface, and hence, still remains an invaluable tool and component of aircrew training.

The IAF needs to capitalize on the benefits accrued from its SD training program. Improvement based on experience and feedback from the aircrew should be a constant endeavour. A vital suggestion that emerged from interaction with qualified flying instructors (QFIs) and flying supervisors is to integrate DISO training with the conventional instrument flying curriculum, with its three components: full panel, limited panel and recovery from unusual attitude. In such a case, DISO training can be redefined, especially for advanced stage trainee pilots as per the suggested format, where once the trainee pilot has been put into an illusionary situation in DISO, he/she must spell out and take correct actions as per his/her training syllabus, under supervision of the available flying instructor (QFI), who must debrief the trainee pilot immediately after the situation. This is for better transfer of simulator based learning for application in actual flight. In addition, during such SD training, psycho physiological monitoring of the trainee pilot may be undertaken to assess the stress levels. This monitoring may be useful for debriefing the 'high strung' pilots or those whose psycho-physiologicalresponses are found to be exaggerated beyond the normal in such situations. This can be a part of debrief by the SD trainer - an Aviation Medicine Specialist. Such an effort is likely to be rewarding since it is aimed at younger, learning trainee pilots, who shall not only be sensitized to SD but shall have feedback about their stress coping strategies. Development and validation of such program shall require team approach between a group of thinking QFIs, SD trainers (specialists in aviation medicine),neuro-physiologists, and cognitive psychologists [16].

A comparison of the SD training in the two organizations shows that the USAF has conspicuously lagged behind the IAF in this vital aspect of aircrew training. The IAF has already started showing the benefits of SD training with an increased awareness among pilots and a reduction in the number of mishaps. In the USAF, although the aircraft mishap rate for every 100,000 flying hours has been steadily declining over the last few years, the rate of accidents attributed to SD has remained relatively constant [17].

There is reasonable evidence to support the premise that ground and simulator based training is one of the most effective ways to prevent spatial disorientation. Due investment of manpower and capital in this vital area would reap dividends in the long run in terms of reduced aircraft mishaps and lost or ineffective aircrew.

Conclusion and Recommendations

The USAF spatial disorientation training program is rudimentary at best. The lack of an effective training program is reflected in the near constant rate of mishaps attributable to SD.

The IAF, on the other hand, has a highly effective SD training program, the benefits of which have started showing in an increased awareness amongst aircrew and a steadily declining rate of mishaps attributable to SD.

The author recommend that the USAF boost its SD training program by inducting disorientation simulators and commence ground and simulator based training for its aircrew at the earliest. This will go a long way in enhancing mission effectiveness and reducing losses of men and machines due to SD.

The IAF needs to capitalize on the benefits accrued from its SD training program. However, there is also a scope for further improvement in the program so as to impart maximum benefit to the aircrew and the organization in terms of reduced attrition of man and machine. It is imperative that the tempo of SD training be maintained and continued emphasis be given to this problem in the coming years.

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