Chapter 2 – APPROACH TO SD TRAINING

2.1 STANDARDIZATION AGREEMENT STANAG 3114

For NATO countries SD training should comply with Standardization Agreement STANAG 3114 Edition 7 as issued in 2003 entitled 'Aeromedical Training of Flight Personnel' [35]. The following extract about SD Training may be derived from this agreement. For the initial training no difference is made for fixed wing and rotary wing aircrew, so that part is presented only once. For the continuation training there is a slight difference in wording, so those sections are both replicated. Of interest is also the statement that "*All flight personnel engaged in flight operations will receive the continuation aeromedical training described in this STANAG at intervals up to 5 years*".

INITIAL AVIATION MEDICINE TRAINING OF FLIGHT PERSONNEL WHO ARE TO OPERATE FIXED WING / ROTARY WING AIRCRAFT

a) Academic Instruction

(19/15) Orientation and Disorientation. The anatomy and physiology of vestibular apparatus. Mechanisms of orientation on the ground and in flight. Spatial disorientation in flight, definition and mechanisms. Common types of disorientation in flight illustrated by examples. Factors leading to disorientation and its avoidance. The management of disorientation.

b) Practical Instruction

(4/2) Experience of Spatial Disorientation. The academic instruction on Spatial Orientation and disorientation should be reinforced by a practical demonstration of the effects of vestibular stimulation using a rotating chair or suitable disorientation device to provide each student with a personal experience of some of the common illusions.

CONTINUATION AVIATION MEDICINE TRAINING OF FLIGHT PERSONNEL WHO ARE TO OPERATE FIXED WING AIRCRAFT

a) Academic Instruction

(5) Spatial Disorientation. Revision of mechanisms underlying disorientation and of management of disorientation in flight. Discussion of recent incidents of disorientation and the lessons to be learnt from them.

b) Practical Instruction

--

CONTINUATION AVIATION MEDICINE TRAINING OF FLIGHT PERSONNEL WHO ARE TO OPERATE ROTARY WING AIRCRAFT

21. Syllabus of the Course. The course is to include the following academic and practical instruction:

d) Spatial Disorientation. Revision of mechanisms underlying disorientation and of management of dis-orientation in flight. Discussion of recent incidents of disorientation and the lessons to be learnt from them.

Comparison with the STANAG Edition 5 of 1970 [1] shows that next to the lectures on the SD mechanisms and demonstration of illusions, now the practical management of SD takes a prominent place. In the draft version of STANAG 3114 Edition 8, instruction and practical experience should comply with

Air Standard 61/117/14 'Ground-based Demonstration of Spatial Disorientation' [31] which has considerable consequences for the continuation training (see also Section 3.5 and 6.3.1.1). Flight safety is also an issue which is taken more and more into account in the academic instruction.

In the following section a survey is provided about the SD training as practiced per 2006 in several countries.

2.2 TRAINING AS IN SEVERAL COUNTRIES AS OF 2006

In line with STANAG 3114 SD training can be divided in *initial* SD training and *continuation* (refresher) SD training. SD training may also be different for *fixed wing* and *rotary wing* aircrew. Finally, each SD training may be divided in *academic* instruction and in *practical* instruction. It is of interest to see how different nations / services have implemented these STANAG regulations. This is summarized in Table 2.1. Although Australia and New Zealand are not member states of NATO, their SD training programs are also incorporated since they belong to the ASCC nations, which are standardizing their SD training programs. In Table 2.1 is displayed what kind of devices are applied (Barany Chair, dedicated motion based SD trainers, full flight simulators), what continuation training interval time is applied, as well as who serve as instructors.

Table 2.1: SD Training by Country

Type of SD Training	USAF	USN	USA	UK ARMY	UK RAF	UK NAVY	Canada	New Zealand
Classroom	LS, BC	LS,	LS	LS	LS	LS	LS	LS
Ground Based	BC	MSDD	BC	DISO	DISO	DISO	BC, GI	BC
Flight Sim Based	NVG	Nil	Nil	Lynx	Various	Various		
In-Flight SD Demo	4 A/C		Yes	Yes	No	No		
In-Flight to Overcome or manage SD	INR	UAT	UAT	UAT	UAT	UAT	No	UAT, Transition IMC - VMC
Refresher Training Frequency	5 yrs	4 yrs	If not fly within 180 days	5 yrs	5 yrs	4 yrs	5 yrs	3 yrs
Training Objectives & effectiveness	USD, Monitor Class A Mishap rate	USD, Written Exam	USD, Written Exam	Written Exam	Written Exam	Written Exam	NFP for refresher, Written exam for beginners	USD, No Eval
Training the Trainees	Flt Surg and Aero Phys	At NOMI, Flt Surg & Aero Phys	USASAM, Flt Surg	Army Spec in Aviat Med	Ex-mil Aircrew & Med Instr	Ex-mil Aircrew & Med Instr	Flt Surg, Aero Techs, BioSci Officers	Flt Surg

NOMI – Naval Operational Medical Institute
LS – Lecture Series
USD – Understanding SD
NVG – Night Vision Goggle
INR – In-Flight Recovery
G – Gyro I
GI – Gyro IPT
BC – Barany Chair
NFP – No Formal Process
V – Vertigon
UAT – Unusual Attitude Recovery Training
MSDD – Multi Station Disorientation Demonstrator

Type of SD Training	Spain	Czechia	Sweden AF/Nav/A	Greece	Italy	Germany	Australia	France	Netherlands
Classroom	LS,	LS	LS	LS	LS	LS, BC	LS,NVG	LS	LS, NVG
Ground Based	BC, GI	GI		DISO	BC, DISO	DISO	BC,GI	Centri fuge	BC, DISO, Desdemona
Flight Sim Based	No	No	UAT	IFR	No	Planned	No	No	No
In-Flight SD Demo	Navy	No	Yes		Yes	Yes	No	No	NFP
In-Flight to Overcome or manage SD	No	UAT	INR	IFR, UAT	NO	UAT, INR	INR	NFP	UAT
Refresher Training Frequency		5 yrs	Not Regulated	3 - 5 yrs	5 yrs	4 yrs	3 yrs	5yrs	4 yrs
Training Objectives & effectiveness	USD, No Eval. Query	NFP	NFP	Pre-exam, USD, LS exam, Eval	USD, written exam	USD, NVG	NFP	USD	USD, NVG,
Training the Trainees	Flt Surg & Av Med Course	Aero Phys	PTO's, IP's, Flt Surg	Flt Surg	Flt Surg & Aero Phys	GAFIAM, Flt Surg, Flt Inst	Flt Surg Av Med Course	AvMed Course	Aero Phys, Av Med Course

NOMI – Naval Operational Medical Institute
LS – Lecture Series
USD – Understanding SD
NVG – Night Vision Goggle
INR – In-Flight Recovery
G – Gyro I
GI – Gyro IPT
BC – Barany Chair
NFP – No Formal Process
V – Vertigon
UAT – Unusual Attitude Recovery Training
MSDD – Multi Station Disorientation Demonstrator

Since nations and services are in many respects hard to compare to each other, the information from Table 2.1 is also written in more detail in Sections 2.2.1 – 2.2.12.

2.2.1 United States

2.2.1.1 Organisation

Initial training in the US Air Force to counter SD is conducted during the pilot-trainee's undergraduate flight training program. There is a two-hour block of instruction for both the T-6 and the T-37 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, while the SD portion is a 2-hour block of instruction titled by the same name. This same lesson plan is used for Undergraduate Navigation Training (UNT). The syllabus of instruction requires that each pilot-trainee be demonstrated an illusion using the Barany Chair (if available). The instructor can demonstrate the yaw reversal illusion (known as the graveyard spin, the Coriolis illusion, and nystagmus). It is common practice for instructors to select only a couple trainees for nystagmus. Each student is given at least one demonstration. The remainder of the class observes while the demonstrations are being conducted. Initial training to counter SD is conducted during the pilot-trainee's undergraduate flight training program. There are two aircraft now for specialized undergraduate pilot training, the T-6 and the T-37.

In the US Navy, initial SD training is conducted as part of the Naval Aviation Survival Training Program (NASTP), Aviation Physiology Curricula (NP-1) by the Naval Operational Medical Institute (NOMI) Pensacola, Florida. Initial SD training is conducted in conjunction with the initial aviation physiology and water survival training for aircrew. Typically this occurs in week 5 of the 6 week Aviation Pre-flight Indoctrination (API) program. API occurs before basic flight training.

2.2.1.2 Classroom

Classroom-based lecture series (1.5 hours) covers:

- Sensory systems involved in orientation – Anatomy and physiology of visual, vestibular, and somatosensory systems.
- Illusions – Discuss the types of illusions related to the limitations of the sensory systems.
- Physical and physiological factors affecting SD – Limitations of human information processing and attention, and loss of situational awareness.
- SD hazards with NVGs are covered as a specific topic.

2.2.1.3 Ground-Based Demonstration

In the US Navy, ground-based SD training is provided by the Multi-Station Disorientation Demonstrator (MSDD) which augments classroom lectures by demonstrating that spatial disorientation is a normal response to a variety of conditions. The MSDD enables students to experience spatial disorientation errors caused by the loss of reliable points of reference, conflicting sensory cues, and elevated inertial forces. All students experience at least one of the following effects: Sub-threshold rotation, Somatogyral illusion, Coriolis effect, Nystagmus, Oculogyral illusion, Somatogravic illusion, G-excess illusion, or Autokinesis.

Because of the increased night operations tempo of the USAF and the use of NVGs, the USAF has stepped up its NVG training, provided by AFRL/HEA at Mesa, Arizona. HEA trains many pilots each year in their Distributed Mission Trainers equipped with their Night Vision Training System. Pilots learn to use NVGs and are subjected to unusual attitudes and different illumination conditions in the simulator to increase the awareness of the disorienting effects of NVGs.

2.2.1.4 In-Flight

There currently is no specific section of the training syllabus for in-flight SD instruction in the US Air Force. Efforts are now being made to incorporate the in-flight demonstrations described in the ASCC AIR STD 61/117/13, entitled “In-Flight Demonstration of the Limitations of the Orientation Senses and Spatial Disorientation in High Performance Fixed Wing Aircraft” [32]. See also Chapter 4 for more details about this air standard.

Specific SD countermeasures training is embedded within a host of maneuvers each pilot-trainee must learn to earn his/her wings. For instance, unusual attitude recoveries must be practiced and proficiency maintained on almost all the in-flight sorties. In addition, specific procedures are learned and practiced should a wingman lose sight of lead when learning to fly formation. The intent of the procedure is to immediately obtain a safe separation distance between aircraft and for the wingman to quickly re-establish an instrument crosscheck for accurate spatial orientation. Also, during instrument flight training, the need for an efficient and accurate instrument crosscheck is constantly reminded to each pilot-trainee. (This point is made clear in the flight simulator portion mentioned above for the USAF). There are also a few pre-mission briefing items that may relate to some type of SD countermeasure, but all-in-all, specific training aimed at SD countermeasures is generally treated as a component needed to accomplish some other more specific flight maneuver or procedure.

There currently is no structured program of in-flight SD training in the US Navy. During the course of normal flying training, QFIs (Qualified Flight Instructors) may discuss a range of SD-related topics, but not in a structured format.

In-flight recovery from SD is taught by QFIs during primary and advanced stages of flight training. However, the emphasis is on the aeronautical recovery of the aircraft during unusual attitudes rather than an assessment of SD and the factors that allowed the unusual attitude to develop.

2.2.1.5 Refresher Training

In the US Air Force, information covered in the syllabus "Perception and Spatial Disorientation Issues Affecting Human Performance and Situational Awareness", offers modified courses for helicopter and high-performance aircraft.

Topics cover:

- Special senses, including anatomy and physiology of the visual, vestibular, and kinesthetic systems, their limitations, and specific visual and vestibular illusions. NVDs are covered during the visual section. Also includes a section on auditory cues and spatial disorientation.
- Circumstances that contribute to disorientation and loss of SA, including NVDs. This also covers the corrective actions to rectify disorientation once recognized.
- Discussions of salient accidents and aircraft incidents which illustrate different facets of spatial disorientation.

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 aerospace physiologist. As for the five-year recurrence training: There is a block of 45 – 60 minutes of instruction on SD during the aerospace physiology refresher course.

Refresher training, also known as continuation training, 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. It is not required, although most instructors include some aspect of it. Most pilots are required to attend this annual refresher course. In addition, SD is sometimes the topic for discussion at the hour-long monthly flying safety meeting. Again, the specific subject of SD may or may not be addressed, depending on the instructor and the requirement to brief other material more relevant at the time.

In the US Navy, SD refresher training comprises an SD lecture required every 4 years as part of the platform-specific Naval Aviation Survival Training Program (NASTP) Aviation Physiology refresher training, and includes a review of visual and vestibular physiology, their sensory limitations, and specific visual and vestibular illusions.

2.2.1.6 Objectives and Evaluation

The stated objectives in the US Air Force for SD training are:

- To understand how perceptual illusions associated with the visual, inner ear, and seat-of-the-pants sensory systems lead to spatial disorientation and loss of situational awareness.
- To understand how loss of situational awareness associated with spatial disorientation impacts combat effectiveness and flying safety.
- To describe the corrective and preventative procedures for spatial disorientation.

No formal process has been established to monitor the effectiveness of SD training in the USAF.

In the US Navy, the terminal objective of SD training is to demonstrate knowledge of the physiological hazards and restrictions associated with SD in the flight environment. Enabling objectives include:

- Select the correct description for each of the four sensory systems, enabling orientation, equilibrium, and balance.
- Select the sensory systems providing the strongest and usually the most reliable orientation information.

- Identify the function of the vestibular system and its two subsystems, the semicircular canals and otolith organs.
- Determine the reason for the somatosensory systems unreliability in flight.
- Select the correct physiological explanations for specific vestibular illusions.
- Given an in-flight Spatial Disorientation scenario, identify the probable illusion experienced by the crewmember(s).
- Identify physical and physiological factors affecting Spatial Disorientation.
- Identify five methods used to prevent Spatial Disorientation.
- Identify seven procedures used to overcome Spatial Disorientation.
- Using a Spatial Disorientation Demonstrator, experience Spatial Disorientation and practice/ perform methods to maintain aircraft control while disorientated.

The effectiveness of SD training is validated by a written examination after the initial SD instruction. Naval Aerospace Medical Research Laboratory (NAMRL) continually monitors SD-related accident and incident rates.

2.2.1.7 Credentials SD Trainers

- The US Air Force instructors who become “instrument experts” must be graduates of the USAF Advanced Instrument School. This is a three-week program devoted to teaching instructor pilots the details of instrument procedures and the controlled airspace system (both national and international). The school is located at Randolph AFB, Texas. The instruction block lasts three hours and covers the costs, causes and countermeasures for SD.

In the US Navy, SD training is provided at NOMI for all Flight Surgeons, and Aerospace Physiologists. All SD training (lectures and ground-based demonstrations) is conducted at NOMI by Aerospace Physiologists.

2.2.2 United Kingdom

2.2.2.1 Organisation

Initial SD training in the Royal Air Force and Navy is conducted at the Centre for Aviation Medicine (Henlow) and follows NATO STANAG 3114 and ASCC AIR STD 61/117/1 [27] (see British Army, below, for description).

Army initial SD training is given in conjunction with the initial aeromedical physiology training, conducted at the outset of ab-initio flying training. RAF initial SD training is conducted at the completion of elementary flying training, in conjunction with other aviation medicine training. In addition, a short, classroom-based, introduction is given to some students prior to the beginning of elementary flying training. Non-pilot aircrew receive the aviation medicine training prior to commencing their basic flight training.

Royal Navy initial SD training is given in conjunction with aeromedical physiology training at the outset of ab-initio flying training.

2.2.2.2 Classroom

In all 3 UK services the classroom-based lecture series follows NATO STANAG 3114 and includes:

- Orientation overview – Definitions of orientation and disorientation, their importance to operational flight safety, and the relationship of the orientating senses.
- Special senses – Anatomy and physiology of the visual, vestibular, and kinesthetic systems, their limitations and common illusions (visual and vestibular).
- Psychology of orientation – Limitations of human information processing, attention, situational awareness, crew resource management, and perceptual errors such as errors of expectancy, and "break-off" and "giant-hand" phenomena. Illustration with a variety of recent SD accidents.
- SD hazards with NVGs are covered as a specific topic.

2.2.2.3 Ground-Based Demonstration

Ground-based SD demonstrations in the British Army are conducted using the DISO trainer at RAF Henlow. Students experience at least one visual and one vestibular illusion during their training. Non-participating students observe those illusions that they do not personally experience. The Lynx flight simulator is used to demonstrate IMC-related SD and train IMC procedures.

In the Royal Air Force, ground-based SD training is conducted using the DISO Trainer. Students experience at least one visual and one vestibular illusion during their training. Non-participating students observe those illusions that they do not personally experience. Scenarios designed to give students training in situations conducive to SD are used in the RAF Valley Hawk simulator. Similar helicopter-specific scenarios are currently under evaluation using the Griffin helicopter simulator at RAF Shawbury.

In the Royal Navy, ground-based SD training is conducted using the RAF DISO Trainer with students covering the same profiles as those used by RAF trainees. The Lynx flight simulator is used to demonstrate IMC-related SD and train IMC procedures. SD-specific scenarios are being considered for incorporation in simulator-based continuation training.

2.2.2.4 In-Flight

The British Army Air Corps has an established in-flight SD demonstration sortie that is exemplary. It is conducted during the operational training phase of ab-initio training and at all subsequent refreshers. The following sensory limitations are demonstrated:

- Sub-threshold manoeuvres.
- Decay of response of the semicircular canals to detect sustained angular rotation.
- Minor supra-threshold stimulation misinterpreted as change in attitude.
- Inadvertent descent (Type I).
- Poor perception of rotation and lateral movement in the hover.

In-flight demonstration of SD in the Royal Air Force and Royal Navy is conducted during the Tutor, Firefly and Tucano aircraft flying phases (for fixed-wing aircrew). QFIs demonstrate the following:

- The need for instruments – With the student's eyes open, fly a small barrel roll. Give control to the student to maintain straight and level with his/her eyes closed.
- How the natural senses cannot detect very low angular accelerations – With the student's eyes closed, roll very slowly (1 degree per second) to about 20 degrees. Ask the student for aircraft attitude. Repeat the demonstration, rolling to 40 degrees and then rapidly reduce bank to 20 degrees.

UA recovery training and inadvertent IMC is part of the general flying syllabus and is taught by AIs (Aircrew Instructors). The future remit of AIs may also be extended to cover some of the aspects of the in-flight SD demonstration sortie.

2.2.2.5 Refresher Training

SD refresher training in the British Army is conducted on a 5-yearly basis and includes lectures illustrated by SD accidents, discussion of aircrew SD experiences, and completion of the SD demonstration sortie.

SD refresher training in the Royal Air Force is conducted every 5 years and covers the NATO STANAG 3114 requirements. It offers also discussions on SD experiences from aircrew and is another opportunity to experience illusions using the DISO.

Royal Navy SD refresher training is required every 4 years, comprises a lecture series but does not include practical demonstration.

2.2.2.6 Objectives and Evaluation

The SD training objectives of the British Army are:

- "To understand the basic mechanisms of spatial orientation, appreciate the limitations of the orientation senses in flight, and how to best prevent and overcome SD" (classroom-based lectures); and
- "To augment the ground-based training in SD by demonstrating the limitations of orientation perception in flight … and to gain further understanding in the phases of flight in which SD is most likely" (SD demonstration sortie).

The SD training was validated by a written examination (for the lectures) and a questionnaire (after the SD demonstration sortie). In addition, the SD accident rate is monitored, and SD incidents are surveyed.

The training objectives of the Royal Air Force and Royal Navy are:

- "To describe the operation and limitations of the human orientation system and the effect that those limitations have on safe aircraft operations. A further objective is to give safe strategies to overcome sensory limitations with a view to mitigating the effects of any disorientation experience" (for lectures);
- "To allow aircrew to experience a disorientation episodes in a safe, controlled environment and hence, improve their awareness of the problem of disorientation" (for the Airfox DISO); and
- "To reinforce the lessons learned on the ground and provide further proof that the senses can be fooled…" (for in-flight SD training).

The effectiveness of SD training is validated by a written examination after the initial SD instruction. Centre for Aviation Medicine periodically monitors SD-related accident and incident rates.

2.2.2.7 Credentials SD Trainers

In the British Army, all SD training (lectures, ground-based training, and SD demonstration sorties) is conducted by Army Specialists in Aviation Medicine (SAMs) [who have completed the Diploma in Aviation Medicine]. Simulator-based training is conducted by AIs who have received additional briefings in SD from CA Avn Med (Army). Medical officers or ex-RAF aircrew deliver ground-based instruction (including the DISO) to all Royal Air Force and ab-initio Royal Navy aircrew at RAF Henlow. In-flight training is conducted by AIs.

2.2.3 Canada

2.2.3.1 Organisation

SD training is conducted centrally at the Canadian Forces School of Survival and Aeromedical Training during the initial aeromedical training given to novice aircrew.

2.2.3.2 Classroom

In Canada, the classroom-based lecture series covers:

- Sensory systems involved in orientation – Anatomy and physiology of visual, vestibular and somatosensory systems.
- Illusions – Discuss the types of illusions related to the limitations of the sensory systems.
- Psychology of SD – Limitations of human information processing and attention, and LSA.

2.2.3.3 Ground-Based Demonstration

Ground-based SD demonstration in Canada is provided by two mechanisms:

- Barany Chair – Demonstrates the limitations of the vestibular system and basic vestibular illusions.
- Vertigon (Flightmatic Inc) – Induces a Coriolis illusion after sustained rotation around the yaw-axis.

The Gyro IPT (Integrated Physiological Trainer, manufactured by ETC) is used to demonstrate Coriolis and somatogyral illusions in novice pilots only. Due to the limited rotation about axes, its benefit over the Barany Chair and Vertigon has not been conclusively established.

2.2.3.4 In-Flight

In Canada, there is no structured in-flight demonstration of SD, but some QFIs mention SD-relevant points during training sorties. There is no structured or standard in-flight UA recovery training. During training sorties, QFIs place the aircraft in an unusual attitude and then get the student to execute the appropriate recovery actions – the emphasis is on the recovery of the aircraft rather than on the factors contributing to the development of spatial disorientation which allowed the unusual attitude to occur.

2.2.3.5 Refresher Training

Re-certification training is conducted every five years thereafter, typically at the squadron level. While no re-certification course CTS (Course Training Standard) or CTP (Course Training Plan) exist, it is understood that re-certification training consists of the major Enabling Objectives (EOs) of the Initial course Performance Objectives (POs). This training is conducted over a period of a half-day and includes briefings on specific illusions pertinent to the type of aircraft flown by those being briefed. It also includes review briefings on the other aeromedical training aspects covered in the initial training course. Finally, there are no formal evaluation tools nor any formal SD recovery exercises or drills.

2.2.3.6 Objectives and Evaluation

Canadian Forces Commanders require pilots who possess the knowledge and skills necessary to perform many tasks in the presence of physiological hazards. The objective of the training is to provide Canadian Forces Pilots with the skills and knowledge to prevent, recognise, and control the physiological effects of flying including spatial disorientation. SD training is conducted as part of the Initial Pilot Aeromedical

Training Course conducted over five days. SD forms seven of the 26 EOs of the course and includes the following objectives:

- Explain the principles of vision.
- Explain the principles of night vision (unaided).
- Identify and manage the visual hazards of flight.
- Identify visual illusion.
- Identify the limitations of the use of NVGs.
- Describe the effects of spatial disorientation.
- Describe situational awareness and motion/simulator sickness.

The students' progress was monitored during the training by administering a written Enabling Check (EC) and verbal feedback based on performance during simulation. Continuous feedback was given to the trainees regarding their progress in the course and to identify any difficulty.

2.2.3.7 Credentials SD Trainers

SD training is provided at the School of Operational Aerospace Medicine for all flight surgeons, aeromedical technicians, and bioscience officers in Canada.

2.2.4 Australia

2.2.4.1 Organisation

Initial SD training in Australia is conducted through the Institute of Aviation Medicine. For pilot aircrew of all services, the training is conducted during initial fixed-wing flying training in conjunction with initial aviation medicine training. Australian SD training is performed in conjunction with the initial aviation medicine for aircrew lectures. Early in the Basic Flying Training phase student aircrew are given the initial aviation medicine for aircrew lectures (including SD) and the Barany Chair demonstration. At the completion of this phase of flying training, all aircrew attend AVMED for SD demonstrations using the Gyro-Lab (as well as a hypobaric chamber exposure) before completing a second fixed-wing flying phase.

2.2.4.2 Classroom

The lecture series covers:

- Special senses – Anatomy and physiology of visual and vestibular senses, including discussions of specific visual and vestibular illusions.
- Spatial disorientation – The role of the vision, vestibular organs, and proprioceptors in maintaining spatial orientation, the sensory limitations and the development of false orientation perception (including the circumstances where spatial disorientation is likely). Includes discussion of the corrective actions to overcome/dispel false perceptions and re-establish spatial orientation.
- Human factors and disorientation – Topics include human information processing, errors of expectancy, central illusions such as "giant hand" and "break-off" phenomena.
- SD with NVG operations are covered in detail during the NVG instructor course and the training of novice NVG aircrew.

2.2.4.3 Ground-Based Demonstration

In the Royal Australian Air Force, ground-based SD demonstrations are conducted in two devices.

- Barany Chair. The Barany Chair is used to demonstrate the limitations of the semicircular canals, subthreshold rotation, and the Coriolis Effect. This is conducted during the initial aviation medicine training during Basic Flying Training.
- Gyro-1 (developed by ETC). This demonstration is conducted during the transition from basic flying training to the subsequent fixed-wing flight phase. The students experience one of the following illusions – autokinesis, the Leans, Coriolis Effect, graveyard spin, nystagmus, and oculogyral illusion, with the non-participating students observing.

Instrument flying training, including UAR, is performed in the S70 Blackhawk simulator.

2.2.4.4 In-Flight

There is no structured programme of in-flight SD training in Australia. During the course of normal flying training, QFIs may discuss a range of SD-related topics, but not in a structured format. In-flight recovery from SD is taught by QFIs during flying training, however, the emphasis is on the aeronautical recovery of the aircraft and IFR-skills rather than an assessment of SD and the factors that allowed the unusual attitude to develop.

2.2.4.5 Refresher Training

SD topics are included in the aviation medicine refresher training for all aircrew, 3-yearly for the RAAF and Army. Topics include a review of visual and vestibular physiology, their sensory limitations, and specific visual and vestibular illusions. SD with NVGs is also covered during the refresher training, as is a discussion with aircrew regarding their SD experiences.

2.2.4.6 Objectives and Evaluation

No formal process has been established to monitor the effectiveness of SD training in the Australian Defence Forces.

2.2.4.7 Credentials SD Trainers

SD training in the Australian Defence Force is conducted jointly by medical officers, Aviation Physiology Training Officers (APTOs), and qualified flying instructors (QFIs). All “train the trainer” courses are conducted at AVMED – the Health Specialist Officer course for medical officers, the Aviation Physiology Training Officer course for APTOs, and the Qualified Flying Instructor Aviation Medicine Refresher course for QFIs. Medical officer instructors at AVMED are required to have a Diploma in Aviation Medicine, and non-medical instructors are APTOs who have undergone additional training in aerospace physiology with the USAF.

2.2.5 New Zealand

2.2.5.1 Organisation

The training is provided in association with initial aviation medicine training for aircrew. This is given early in the Basic Flying Course prior to commencing practical flight training. SD training is also given to experienced aircrew during the QFI course.

2.2.5.2 Classroom

The New Zealand air force provides a classroom-based series of three lectures that cover:

- Spatial disorientation (definition and importance in flying);

- Mechanisms of spatial orientation;
- Describe common vestibular and visual illusions (and describe importance in SD);
- Explain means by which SD can be reduced and in-flight recovery actions; and
- Includes use of training video.

2.2.5.3 Ground-Based Demonstration

Ground-based demonstration of SD in New Zealand is provided by Barany Chair, used to demonstrate the limitations in semi-circular canal physiology and vestibular illusions. This is given during the spatial disorientation component of the initial aviation medicine course.

2.2.5.4 In-Flight

There are no specific SD training flights in New Zealand and QFIs do not have a structured list of SD scenarios or illusions that they demonstrate during training sorties. Student pilots are placed in an unusual attitude with their eyes closed, asked to describe their orientation, and then asked to open their eyes and re-orientate prior to taking the aircraft controls. They are also trained in the transition from IMC to VMC.

2.2.5.5 Refresher Training

In New Zealand, SD and associated human factors are covered in the 3-yearly aircrew aviation medicine refresher course.

2.2.5.6 Objectives and Evaluation

New Zealand follows the following training objectives and measures:

- Outline the mechanisms of orientation;
- Identify the anatomy and functions of the vestibular system;
- Describe the function of the proprioceptors;
- Outline the various types of orientation;
- Identify situations in which disorientation may occur;
- Describe the anatomy and physiology of the visual system;
- List cues used in depth perception;
- Understand the physiological and perceptual limitations of vision;
- Identify situations in which visual illusions can occur; and
- List the visual problems associated with various types of flight.

Apart from SD and vision questions in the final exam, there is no formal SD evaluation process.

2.2.5.7 Credentials SD Trainers

Aircrew undergoing QFI training are given specific refresher training on SD in New Zealand.

2.2.6 Czech Republic

2.2.6.1 Organisation

The initial SD training is provided in association with the aviation physiology course for student pilots. This course is given before practical flight training.

2.2.6.2 Classroom

Classroom lectures (four hours, lecturer is MD) consist of psychology, Human Factor issues and LSA/SD problems (definition, physiology of sensors, illusions, recovery actions, etc.). The SD problem is also treated within the IFC theoretical lectures (by a pilot instructor).

2.2.6.3 Ground-Based Demonstration

Ground-based demonstration of SD with the GYRO IPT II shows the limitations of sense of attitude during visual and vestibular illusions during the initial pilot aeromedical training conform NATO STANAG 3114 [36]. This is given during pilot studies. The spatial disorientation demonstration takes about one hour. It consists of two phases. At first a passive demonstration is provided in the dark (with a group of four students, one inside the GYRO) of the limitations of the sensory systems (illusions: autokinesis, vestibular subthreshold, somatogravic, somatogyral, oculogyral, leans, Coriolis). After familiarization every student pilot controls the GYRO IPT II himself and experiences SD (illusions: false horizon (day), somatogyral – spin recovery, runway width, leans, sloped runway, oculogyral, somatogyral, black hole approach, Coriolis).

2.2.6.4 In-Flight

There are no specific SD training flights in Czech AF. In-flight demonstration (by pilot instructor) includes only unusual attitude recovery and is given every 6 – 12 months. Pilots are also trained in IMC flying – 25% of flight hours.

2.2.6.5 Refresher Training

SD training is given to experienced pilots during the continuation aeromedical training course minimally every five years according to NATO STANAG 3114. The SD training consists of theoretical lectures (one hour) and a flight with some illusion profiles in the simulator GYRO IPT II (also one hour). Leans and somatogyral illusion are obligatory.

2.2.6.6 Objectives and Evaluation

The Czech AF adheres to the following training objectives:

- Outline of the mechanisms of spatial orientation;
- Shortly explain physiology and limitation of visual, vestibular system and other sensory systems;
- Outline the various types of disorientation;
- Identify situations in which disorientation may occur; and
- Explain common types of illusions.

2.2.6.7 Credentials SD Trainers

All SD training is conducted by MD (with Diploma in Aviation Medicine) in the Institute of Aviation Medicine. They are qualified for GYRO IPT SD training by AMTI ETC USA. All training courses for flight instructor (ex-military aircrew) for GYRO trainer are done by MD.

2.2.7 Italy

2.2.7.1 Organisation

Ground-based SD training is conducted centrally at the ITAF Aerospace Medicine Dept. (Pratica di Mare AFB). The basic training is provided in association with initial aviation medicine training for aircrew. This is given early in the Flying Course prior to commencing practical jet flight training (in the US on T-37 or in Italy on MB-339). In agreement with the STANAG 3114, SD training is also given every 5 years to experienced aircrew during the refresher aerospace physiology course. For pilots and navigators employed in aero-tactical squadrons and helicopters, or as flight instructors, specific (basic and advanced) courses on SD are held.

2.2.7.2 Classroom

Classroom-based series of lectures are provided, that cover:

- Spatial orientation and disorientation (definition and impact on flight safety);
- Mechanisms of spatial orientation;
- Common vestibular and visual illusions and their importance in SD onset;
- Psychological aspects related to SD (including the “Giant Hand” and the “Break Off” phenomena);
- Particular operational environments where the SD onset can be facilitated (NVG use, effects of rapid onset accelerations, sleep deprivation, etc.);
- Explain means by which SD can be reduced and analysis of possible in-flight recovery actions; and
- The program for specific courses on SD also includes the use of training videos.

2.2.7.3 Ground-Based Demonstration

Ground-based demonstration of SD is provided by a rotatory chair (with possibility of off-axis rotations), used to demonstrate the limitations in semi-circular canal physiology (sensory threshold and adaptation, nystagmus) and some vestibular illusions (Coriolis and Purkinje phenomena, pitch-up sensations during an x-axis acceleration). This is given during the spatial disorientation component of the initial aviation medicine course. For more advanced training (i.e. refresher and specific courses on SD) a flight simulator device (Airfox DISO) is also utilized to run the illusions within an aviation environment.

2.2.7.4 In-Flight

With the exception of helicopter pilots at the beginning of their flight career on helicopters, there is no specific in-flight SD training in the ITAF. Pilot instructors do not have a structured list of SD scenarios or illusions that they demonstrate during training sorties, although recovery from unusual attitudes is a standard situation during the flight training course of student pilots. During the SD course for helicopter student pilots, which is held at the ITAF Aerospace Medicine Dept. (Pratica di Mare AFB), i.e. within an aeromedical environment, a group of 4 trainees performs 5 different flight profiles that evoke vestibular illusions. One subject (eyes closed) is exposed to the illusion, while the others listen to his/her description of what is going on. Each profile includes a pre- and post-illusion very short briefing, which is held by the SD instructor (Medical Officer), who is part of the helicopter crew.

2.2.7.5 Refresher Training

Standard aero-physiological training in the ITAF recurs every five years (i.e. in accordance with the STANAG 3114). Within this training, there is a block of 2 hrs of theoretical instruction on SD, together

with 3 more hrs dedicated to practical exercises. A specific advanced course on SD is also provided to those aircrews considered at risk for SD (see above point 2.2.7.1).

2.2.7.6 Objectives and Evaluation

The stated objectives in the ITAF for SD training is to give adequate theoretical and practical knowledge on SD in flight, possibly with specific details on the type of flight missions which are usually conducted by the trainees. More advanced courses aim at refreshing knowledge on the topic, and add further information and practical exercises dedicated to the specific trainees' flight activity.

At the end of each course, a questionnaire with a few easy questions on SD is administered to the classroom (a discussion follows the correction of questionnaires); moreover, a second questionnaire dedicated to criticism and possible suggestions for the course improvement is also submitted.

2.2.8 The Netherlands

2.2.8.1 Organisation

Ground-based SD awareness training is centralized in Soesterberg at the RNLAF Centre for Man and Aviation (CML), and at TNO Human Factors. The topic SD is covered during the initial Aerospace Physiology course at the CML, which takes place just prior to practical flight training,. Two months later, early in the Flying Course, more extensive practical demonstrations are given at the facilities of TNO. Refresher training is given in association with recurrent Physiology training.

2.2.8.2 Classroom

The 2hr classroom lecture at the CML covers:

- Physiology of human sensory systems;
- Mechanisms of spatial orientation and disorientation;
- Common visual and vestibular illusions and their importance to flight safety;
- Physiological conditions that facilitate SD (sleep deprivation, alcohol); and
- Definition and classification of SD.

The lecture is illustrated by video fragments, and a syllabus. Immediately following this lecture, each student gets 30 minutes of practical demonstration as a first familiarization with SD.

2.2.8.3 Ground-Based Demonstration

Ground-based demonstrations at the CML employ a flight simulator device (DISO). For initial familiarization of student pilots, primarily passive illusions are shown, i.e. without an active flight task. For refresher purposes, the device is capable of producing active (man-in-the-loop) illusions. Demonstrations at TNO currently take one day, and employ equipment of the vestibular laboratory (3D rotating chair, tilting room), which is suitable for showing elementary vestibular and visual illusions underlying in-flight spatial disorientation. The course also includes a one hour demonstration of the limitations of night vision devices to maintain a correct spatial orientation (NVG, thermal imagery). The motion-base simulator DESDEMONA is used for SD demonstration to student pilots, and for SD avoidance and recovery training for continuation training.

2.2.8.4 In-Flight

The RNLAF does not structurally conduct in-flight SD demos, but trains unusual attitude recovery.

2.2.8.5 Refresher Training

Refresher courses on SD are provided at the CML in association with aeromedical training. Jet and helicopter pilots receive refresher training immediately after completion of their flight training. The SD refresher consists of actively flown illusions in the flight simulator devices, during which the related theory is discussed. A second refresher session is given three years later. From then, refreshers are given every five year. In addition, SD is dealt with during recurrent NVG training.

2.2.8.6 Objectives and Evaluation

The purpose of the SD awareness training is to give pilots a thorough understanding of their sensory systems, and their response to flight-related motion stimuli. In the initial aerospace physiology course during Ground school, the pilots' knowledge is evaluated through a written exam. Furthermore, the pilots can express their appreciation of the TNO course by means of an anonymous questionnaire at the end of the course.

2.2.9 France

2.2.9.1 Organisation

SD training in France is conducted at the Department of Aviation Medicine (Mont de Marsan). Aeromedical officers give the lectures.

2.2.9.2 Classroom

French air force provides a classroom-based series of two lectures. The first one covers sensory systems involved in orientation and common vestibular and visual illusions. The second one describes visual illusions observed in aeronautics.

2.2.9.3 Ground-Based Demonstration

Ground-based SD training is provided by a centrifuge (linear acceleration 1.04 G, pitch and roll tilt ± 40 deg.). Pilots experience autokinesis, somatogyral, somatogravic (pitch up, pitch down and inversion) and Coriolis illusions.

2.2.9.4 In-Flight

There is no structured programme of in-flight SD training in France.

2.2.9.5 Refresher Training

There is no structured refresher training in France. However, medical officers could decide to give some SD course to the pilots of their base depending on the flying mishaps.

2.2.9.6 Objectives and Evaluation

The SD training objectives are to allow pilots to experience a conflict between what they feel the aircraft is doing and what the flight instruments show that it is doing. The conclusion is that the use of flight instruments is the procedure to overcome SD. No process has been established to monitor the effectiveness of SD training in France.

2.2.10 Germany

2.2.10.1 Organisation

The German Air Force Institute of Aviation Medicine (GAFIAM) is responsible in the Division Aviation Physiology for the basic and continuation aeromedical training of the entire flight personnel (Air Force, Army, Navy, and Medical Corps) in accordance with STANAG 3114. The SD training is integrated in the aeromedical training for aircrew. Theses lectures and the SD-demonstrations in the ground-based training device are given prior to the first practical flight training. SD training is also given to experienced aircrew during the continuation training courses.

2.2.10.2 Classroom

The classroom lectures include:

- Special senses – Anatomy and physiology of visual and vestibular senses, including discussions of specific visual and vestibular illusions.
- Spatial disorientation – Type I and type II SD, spatial orientation.
- Spatial disorientation – The role of vision, vestibular organs, and proprioceptors in maintaining spatial orientation, the sensory limitations and the development of false orientation perception (including the circumstances where spatial disorientation is likely).
- Discussion of the corrective actions to overcome false perceptions and re-establish spatial orientation: believe and trust the instruments.
- Human factors and disorientation – Topics include human information processing, errors of expectancy, central illusions such as “giant hand” and “break-off” phenomena.
- SD with NVG operations is covered in detail during the night vision lectures and night vision demonstrations.

2.2.10.3 Ground-Based Demonstration

The Barany chair is still used in the classroom lectures in basic physiological courses to aircrew for basic understanding Coriolis effects and individual movement percepts above and below the individual threshold.

Since 2005 the GAF ground-based SD training is provided by the DOT Disorientation Trainer (AMST Airfox) which augments classroom lectures by demonstrating that spatial disorientation is a normal response to a variety of conditions. DOT enables students to experience spatial disorientation errors caused by the loss of reliable points of reference, conflicting sensory cues, and elevated inertial forces. All students experience at least two of the following effects: Sub-threshold rotation, Somatogyral illusion, Coriolis Effect, Nystagmus, Oculogyral illusion, Somatogravic illusion, G-excess illusion, or Autokinesis. The lectures are designed for experienced pilots, experienced non-pilot aircrews, student pilots and medical (enlisted) aircrews.

The SD-training varies between “flying the DOT by the trainee” with the task, to detect typical forms of SD and “demonstration flights” by the instructor pilot outside the simulator, who demonstrates illusions and effects to the student “as a passenger”.

2.2.10.4 In-Flight

The German Air Force has currently no specific syllabus for in-flight SD instruction. During flight it is annually required to have a graded unusual attitude recovery during check ride. This is usually done by an

Instructor Pilot, placing the pilot with eyes closed in an unusual attitude, giving back the aircraft and having done the recovery by the pilot with eyes open. During pre-flight briefing it is required to emphasize SD-items, especially when bad weather conditions are expected during flight.

However, during Basic Flight Training every student pilot has to do a special syllabus item on T-37 aircraft, demonstrating some SD (sub threshold manoeuvres, supra threshold manoeuvres, inability of the semicircular canals to detect sustained angular rotation).

2.2.10.5 Refresher Training

Continuation training is provided every four years at the GAF Institute of Aviation Medicine, Division "Aviation Physiology", during the Aerospace Physiology Training Course, in accordance with STANAG 3114. The SD issues are lectured first in a one hour classroom presentation and second in an additional one hour training in the DOT (AMST Airfox) with a group of up to 6 trainees. Lectures and practical SD-training are presented by aerospace physiology officers (pilot instructors).

2.2.10.6 Objectives and Evaluation

The training objectives in the German Air Force for SD training are to:

- Understand the function of the vestibular system and its two subsystems (semicircular canals and otolith organs);
- Understand the function of the proprioceptive system;
- Understand how perceptual illusions of the sensory system can lead to Spatial Disorientation;
- Understand the anatomy and physiology of the visual system and its limitations; and
- Understand the corrective and preventive procedures to avoid spatial disorientation.

No formal process has been established to evaluate the effectiveness of SD training in the German Air Force, except for a written examination in the flight surgeon course.

2.2.11 Sweden

2.2.11.1 Organisation

Education/training consists mainly of lectures during basic flight training in combination with actual flight training. No formalized ground training is available today.

2.2.11.2 Classroom

Lectures covering flight physiology are administered by flight surgeons and flight physiology officers and are focused on vestibular, visual and darkness related disorientation. Spatial disorientation is also integrated in the situational awareness concept.

2.2.11.3 Ground-Based Demonstration

There is no ground-based SD demonstration today. Unusual attitude recovery training is performed in the simulator. The Swedish Dynamic Flight Simulator demonstrates the G-excess illusion and Coriolis stimulation, but this is not the main target of training. Helicopter pilots do not train in the DFS.

2.2.11.4 In-Flight

In-flight recovery from SD is integrated in the flight training process. No formalized scheme.

2.2.11.5 Refresher Training

There is no formal process regulating training intervals or components regarding SD.

2.2.11.6 Objectives and Evaluation

Flight physiology training mainly follows a crew-to-crew concept and main objective is safe pilot behaviour in *real* flight.

2.2.12 Greece

2.2.12.1 Organisation

The Hellenic Centre for Aviation Medicine (HCAM-Athens) is responsible for the basic and continuation aeromedical training of entire flight personnel in accordance with STANAG 3114. The initial SD training is provided in association with the aviation physiology course for aircrew. This course is given before practical jet flight training (T-6 and T-2). In addition, a short, classroom-based, introduction is given to students' pilots prior to the beginning of elementary flying training at the Hellenic Air Force Academy. Aeromedical officers give the lectures. Finally, instructor-pilots also treat the SD problem within the IFC Flying theoretical lectures. In agreement with the STANAG 3114, SD training is also given every 3 – 5 years to experienced aircrew during the refresher aerospace physiology course. All SD training is conducted by MD (with Diploma in Aviation Medicine) at HCAM-Athens. They are qualified for the DISO trainer by a special training at AMST, AUSTRIA.

2.2.12.2 Classroom

The classroom-based lecture series follows NATO STANAG 3114 and includes:

- Orientation overview – Definitions of orientation and disorientation, their importance to operational flight safety, and the relationship between all of the orientating senses.
- Special senses – Anatomy and physiology of the visual, vestibular, and kinesthetic systems, their limitations and common illusions (visual and vestibular).
- Psychology of orientation – Limitations of human information processing and attention, and loss of situational awareness.
- SD hazards with NVGs are covered as a specific topic during the night vision lectures and night vision demonstrations.
- The lecture also includes the use of training videos.

2.2.12.3 Ground-Based Demonstration

Ground-based SD demonstrations in the Hellenic Air Force are conducted using the DISO trainer (AMST Airfox) at HCAM Athens. Students experience at least four of the following effects (observed by non-participating students): Sub-threshold rotation, Somatogyral illusion, the Leans, Coriolis Effect, graveyard spin, Nystagmus, Oculogyral illusion, Somatogravic illusion, G-excess illusion, or Autokinesis (NATO STANAG 3114). For initial familiarization of student pilots, primarily passive illusions are shown, and for refresher purposes, the device is capable of producing active illusions (see Table 2.2). The spatial disorientation demonstration takes at least one hour. The course also includes a demonstration of the limitations of night vision devices.

Table 2.2: SD Training Sorties (Standard Profiles for SD Training)

Candidates	*AUTOKINESIS*	Jet Pilots	*LEANS*	Transport Aircraft Pilots	*LEANS*	Helicopter Pilots	*LEANS*
	NYSTAGMUS		*DARK TAKE OFF*		*DARK TAKE OFF*		*DARK TAKE OFF*
	SOMATOGYRAL ILLUSION		*SIZE-DISTANCE / HEIGHT-DEPTH ILLUSIONS*		*SIZE-DISTANCE/ HEIGHT-DEPTH ILLUSIONS*		*SIZE-DISTANCE/ HEIGHT-DEPTH ILLUSIONS*
	SOMATOGYRAL ILLUSION		*BLACK HOLE APPROACH*		*BLACK HOLE APPROACH*		*BLACK HOLE APPROACH*
	CORIOLIS PASSIVE		*FALSE HORIZON CLOUDS ILLUSION*		*FALSE HORIZON GROUND LIGHTS ILLUSION*		*FLICKER VERTIGO*
			GRAVEYARD SPIN		*GRAVEYARD SPIN*		*FALSE HORIZON GROUND LIGHTS ILLUSION*

2.2.12.4 In-Flight

There is no structured programme of in-flight SD training in Greece, although recovery from unusual attitudes is a standard situation during the flight-training course of student pilots. They are also trained in the transition from IMC to VMC. Finally, during pre-flight briefing it is required to emphasize SD-items (bad weather, over sea flying).

2.2.12.5 Refresher Training

The SD refresher training course is given to experienced pilots during the continuation aeromedical training course (NATO STANAG 3114) minimally every 3 – 5 years. The SD training consists of one-hour theoretical lectures (Topics include a review of visual and vestibular physiology, their sensory limitations, and specific visual and vestibular illusions), and a flight with at least four illusion profiles using the DISO trainer (AMST Airfox) at HCAM Athens (also one hour). SD with NVGs is also covered during the refresher aeromedical training.

2.2.12.6 Objectives and Evaluation

The training objectives in the Hellenic Air Force for SD training are to:

- Understand the anatomy, physiology and the function of the visual system, of the vestibular system, of the proprioceptive system and the limitations of human physiology in-flight.
- Understand how perceptual illusions of the sensory system can lead to spatial Disorientation.
- Identify situations in which disorientation may occur.
- Describe the effects of spatial disorientation.
- Describe the various types of disorientation.

- Identify the limitations of the use of NVGs.
- Describe situational awareness and motion/simulator sickness.

The SD training is validated by a written examination (for the lectures) and a questionnaire (after the SD demonstration sortie). Finally, the pilots can express their criticism and possible suggestions for the course improvement by means of an anonymous questionnaire at the end of the course. No process has been established to monitor the effectiveness of SD training in Greece.

2.3 CONCLUSIONS

The summaries of the SD training courses as provided in the previous sections shows that the approach is quite different per country. There is a general agreement about the contents of the academic instruction, but the demonstrations and training courses clearly show different approaches. This is in some cases understandable because of the differences in environmental circumstances or operational theatre. The aim of this report is therefore to provide sufficient information about all the aspects of understanding and demonstrating spatial disorientation and training spatial disorientation countermeasures to allow the staff to make an adequate choice for SD training that benefits flight safety in his/her country.