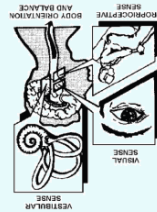


# Flightfax®

Online newsletter of Army aircraft mishap prevention information



Army Aviation has a problem with spatial disorientation while operating in Degraded Visual Environments (DVE). Last year (FY13), we experienced two (of eight total) Class A accidents due to loss of orientation in DVE; five of 18 Class As in FY12; two of 14 in FY11; and eight of 21 in FY10. My point is that the historical trend for losses due to orientation miscues within DVE over the last several years matches exactly the trend Army Aviation has experienced since USACRC/SC established their consolidated database in 1972. Historically, approximately 20 percent of our Class A/B mishaps are attributed directly to spatial disorientation / loss of situational awareness in DVE. In other words, we as an institution have made no progress, in either enhanced training methods or with a technical solution, in reducing the accident rates for this loss factor.

Two definitions are important in understanding the significance of the historical loss rate percentages introduced above. The first is the term “*spatial disorientation*” which is defined as “*when the aviator fails to sense correctly the position, motion or attitude of his aircraft or of himself within the fixed coordinate system provided by the surface of the earth, and the gravitational vertical,*” and the second is the term “*degraded visual environment*” which is defined as “*reduced visibility of potentially varying degree, wherein situational awareness and aircraft control cannot be maintained as comprehensively as there are in normal visual meteorological conditions and can potentially be lost.*”

I contend that the full implication of spatial disorientation is poorly understood by Army rotary wing aviators. I freely admit that I was guilty of this misunderstanding also for the first 21 years of my career until I had the opportunity to research this topic in more detail with the assistance of the technical experts in the United States Army Aviation Research Laboratory (USAARL). The common perceptions of spatial disorientation are the well known visual and somatogyral/somatogravic illusions taught in flight school to prepare students to operate in Instrument Meteorological Conditions. Loss of spatial disorientation in a rotary wing aircraft, however, is very different from what we commonly think. USAARL has studied spatial disorientation extensively and noted in their 1995 report (volume 95-25), “Spatial Disorientation: A Survey of U.S. Army Helicopter Accidents 1987 – 1992,” on the nature of spatial disorientation (my highlighting for effect):

***The well known causes certainly exist but do not appear to be predominant.*** For example, brownout, whiteout, or inadvertent entry to IMC account for a total of only 25 percent of the SD accidents. By contrast, aircrew distraction was thought to play a part in 44 percent of SD accidents, ***while misjudgment of clearance to the ground or a terrestrial obstacle was thought to play a part in 65 percent.*** The typical picture is less one of a classical illusion or an environmental problem ***than one of hard-pressed aircrew, flying a systems intensive aircraft under NVD, failing to detect a dangerous flight path...***

*Other textbook conditions, such as flicker vertigo or illusions due to downwash, proved almost nonexistent in our accident database. Similarly, there were no obvious cases of vestibular illusions, although we cannot by any means rule out low grade vestibular disturbances. By comparison, the role of poor visual cues was highlighted by the relationship between SD and night flight and by the high percentage of accidents in which the inadequacies of NVDs were considered to have played a part.*

Continued on next page

It is worth emphasizing the key phrase that the typical rotary wing spatial disorientation scenario is the “hard-pressed aircrew....failing to detect a dangerous flight path” while faced with internal and external distractions and crew coordination challenges. In this context, the USACRC/SC accident statistics, in particular those occurring during the past 12 years of conflict, clearly show the depth of our problem. More than 20 years ago, we recognized all of this but we are still struggling with these issues today. We know that poor visual cues negatively affect the pilot’s sense of position and motion, and contribute to a disproportionate number of rotary wing accidents, which segues into the next topic of DVE.

Spatial disorientation and DVE are linked. Where spatial disorientation is what happens to the pilot, degraded visual environment is the condition of reduced visibility in which the loss of orientation occurs. Think of it as a “what happens” and a “where it happens” inter-relationship. With that said, DVE is an intentionally broad definition that, in essence, covers any restriction to visibility: smoke, rain, night, dust, haze, brownout, whiteout, etc. The restriction to visibility could be induced by the weather, the lack of illumination at night, or even a helicopter’s own rotor wash with the recirculation of dust or snow during brownout and whiteout. Identifying the “where it happens” aspect of a mishap is critically important and the trending information from the past 12 years of Class A and B mishaps shows that operating in DVE accounts for 24 percent of our accidents. Not surprising that this is roughly in line with the 20 percent historical loss rate for spatial disorientation. Since the initiation of combat operations for OEF/OIF, there have been a total of 367 Class A/B accidents with 88 mishaps involving DVE. Of the 88 mishaps, 67 percent occurred in combat; 52 percent happened during the landing phase of flight, and 57 percent involved brownout conditions. Recall the nature of spatial disorientation mishaps defined by USAARL as the hard-pressed aircrew, with internal and external distractions, failing to recognize a dangerous flight path and one can clearly see the relationship between DVE and disorientation.

In this issue of *Flightfax*, we are going to deep dive into this topic with an overview of spatial disorientation, a *Flightfax* Forum with thoughts on operating in DVE, and concluding with a Blast from the Past covering the role of vision in spatial disorientation accidents.

So the real question is how we move forward to break the continued cycle of 20 percent annual losses attributed to SD/DVE. In my opinion, it is a three step process. The first is education, all Army aviators must be informed that losses due to spatial disorientation / DVE in the mission profiles that we normally fly is completely different than our typical idea of classic illusions. The second is training, we should update our training POIs to target how RW pilots normally experience spatial disorientation (dark, dusty, in the landing profile, while task saturated) followed by both training in our simulators and live in the aircraft. Lastly, the aviation enterprise needs to field a technical solution to increase aviator’s situational awareness while operating in DVE. A significant research effort is on-going to improve aircraft handling qualities through the use of digital flight controls, sensor systems that will be able to penetrate obscurants, and on improved symbology to present position and orientation information effectively to the pilots. Until the technical solutions are ready, commanders need to rely on education and good risk decisions to reduce spatial disorientation accidents.

Until next month, fly safe and manage your risk levels!

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# Spatial Disorientation

## Overview

Spatial disorientation (SD) occurs when a pilot does not correctly sense the position, motion and attitude of an aircraft relative the surface of the Earth. It is often simply described as the inability to determine 'which way is up,' although the effects of disorientation can be considerably more subtle than that description.

Pilots obtain information about their orientation from:

- The visual system (eyes), which can obtain information from a range of cues outside the aircraft and relevant flight instruments inside the aircraft.
- The vestibular system, which consists of the balance organs located in the inner ears. The semicircular canals provide information about angular or rotational accelerations in the vertical (yaw), horizontal (pitch) and longitudinal (roll) axes, and the otolith organs provide information about linear accelerations.
- The somatosensory system, which includes a range of receptors in the muscles, tendons, joints and skin that sense gravity and other pressures on the body. Such perceptions are often known as the 'seat of the pants' aspect of flying.

The visual system generally provides about 80 percent of a person's raw orientation information, with the remainder provided by the vestibular and somatosensory systems, both of which are prone to misinterpretation and illusions during flight (Newman 2007). Although the visual system can overcome these limitations, the risk of SD is significantly increased if the relevant visual cues are absent, ambiguous or not attended to.

## ***Nature of spatial disorientation accidents***

Almost all pilots will experience SD events at some time, but the events are usually recognized and do not result in adverse consequences. Nevertheless, SD has always been involved in a significant proportion of aviation accidents, particularly those with more serious consequences. Statistics from the United States show that SD was involved in:

- 11 percent of fatal general aviation accidents during 1976–1992 (Collins and Dollar 1996)
- 2 percent of general aviation accidents during 1983–1992, with 92 percent resulting in fatalities (Mortimer 1995)
- 1.2 percent of civil helicopter accidents during 1983–1996, with 61 percent resulting in fatalities (Mortimer 1997)
- 11 percent of United States Air Force accidents during 1990–2006, with 69 percent resulting in fatalities (Lyons and others 2006)
- 11 percent of helicopter accidents and 31 percent of fatal helicopter accidents in the United States Army during 2002–2011 (Gaydos and others 2012).

Many authors have indicated that accident statistics often underestimate the proportion of accidents that are associated with SD due to the difficulty in establishing the contributing factors in some accidents and differences in the use of definitions (Gibbs and others 2012, Mortimer 1997, Newman 2007).

When SD does result in an accident, it is usually in the form of a controlled flight into terrain or in-flight loss of control, resulting in a collision with terrain or in-flight break-up. With most SD accidents, the pilot does not recognize the problem, or at least does not recognize it in time to effectively recover the situation. This unrecognized SD, often known as Type I, can occur for an extended period of time lasting up to tens of seconds or even longer (Previc and Ecoline 2004).

Recognized SD, or Type II, is a more common event and occurs when the pilot is aware that their perception is incorrect, aware there is inconsistency in the information from the different sensory systems, or aware that the sensory information does not agree with the aircraft's flight instruments. Usually the situation is able to be recovered before an accident.

When Type II SD accidents do occur, they generally involve erratic flight paths resulting from the pilot having difficulty maintaining control of the aircraft's flight path. A range of factors can influence the extent to which a pilot may experience SD or be able to recover from SD. Common factors include limited or ambiguous visual cues outside the cockpit, not directing sufficient attention to the flight instruments due to workload or distraction, and not being proficient in instrument flying skills. McGrath and others (2003) stated:

The typical SD mishap occurs when visual attention is directed away from the aircraft's orientation instruments and/or the horizon (due to, for example, temporary distraction, increased workload, cockpit emergencies, transitions between visual and meteorological conditions, reduced visibility, or boredom). Most SD mishaps are not due to radical maneuvers. When a pilot looks away from the horizon (loss of focal and peripheral visual cues), or looks away from his artificial horizon in instrument weather (loss of focal visual cues), the central nervous system computes spatial orientation with the remaining information at its disposal, vestibular and somatosensory. The vestibular and somatosensory information are concordant, but frequently incorrect. In such circumstances, it is physiologically normal to experience spatial disorientation.

### ***Misperceptions associated with a gradually increasing bank angle***

There are many misperceptions and illusions that can occur during flight, and these are discussed by many reference sources (such as Benson 1999, Gillingham and Previc 1993, Newman 2007). This section briefly reviews some misperceptions that can be associated with a gradually increasing bank angle.

#### ***Movement below the detection threshold***

If a roll movement occurs gradually, it may be below the level that a pilot can detect. The threshold for the detection of short-duration roll movements (5 seconds or less) is usually reported as an angular or rotational velocity of about 2° per second. For longer durations the threshold is usually reported as an angular acceleration of about 0.5° per second squared (Cheung 2004). In operational settings these types of sensory thresholds are often higher, particularly when a pilot's attention is directed elsewhere (Benson 1999a, Gillingham and Previc 1993).

#### ***The 'leans'***

Sometimes a pilot either intentionally or unintentionally initiates a roll at a rate below the detection threshold, and then notices the problem and initiates a roll in the opposite direction at a rate above the threshold in order to get the aircraft back level. The semicircular canals detect the acceleration of the corrective roll but not that of the original roll. As a result, a pilot can perceive that the aircraft is actually banking in the direction of the corrective roll even though it is level.

This is one of the most common forms of SD, and usually results only in a pilot leaning their body in the direction of the initial roll. However, it can also result in a pilot rolling the aircraft back in the direction of the original roll if they are not monitoring their instruments (Benson 1999).

#### ***Somatogyral illusion***

During the entry into a turn, the semicircular canals will detect the initial angular acceleration. If the rotation is continued at a constant rate the canals will soon no longer be stimulated (or 'wash out'). This can occur after 10 - 20 seconds (Cheung 2004). If the pilot then attempts to roll out of the turn, they can falsely perceive an undesired, ongoing turn in the opposite direction. This

illusion is usually discussed in terms of aircraft spinning in the yaw axis, but it also is relevant to movement in the roll axis. As described by Gillingham and Previc (1993):

...when trying to stop the turn by rolling back to a wings-level attitude, the pilot feels not only a turn in the direction opposite to that of the original turn, but also a bank in the direction opposite to that of the original bank. Unwilling to accept this sensation of making the wrong control input, the hapless pilot rolls back into the direction of the original banked turn. Now the pilot's sensation is compatible with a desired mode of flight, but the flight instruments indicate a loss of altitude (because the banked turn is wasting lift) and a continuing turn. So the pilot pulls back on the stick and perhaps adds power to arrest the unwanted descent and regain the lost altitude. This action would be successful if the aircraft were flying wings-level, but with the aircraft in a steeply banked attitude it tightens the turn, serving only to make matters worse. Unless the pilot eventually recognizes what is occurring and rolls out of the unperceived banked turn, the aircraft will continue to descend in an ever-tightening spiral toward the ground, hence the name graveyard spiral.

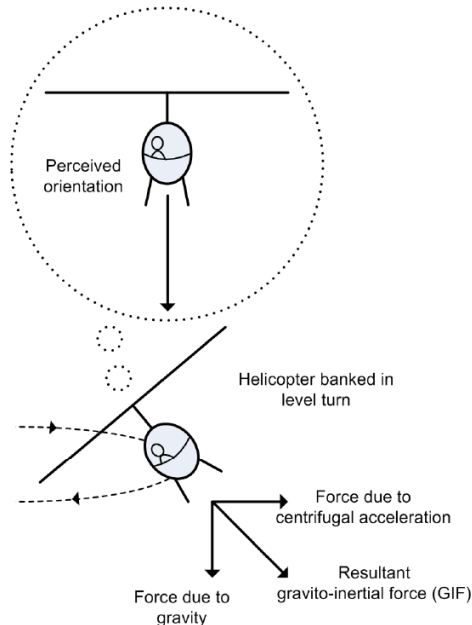
In summary, for the somatogyral illusion to occur, there has to be sustained rotation above the detection threshold.

### **Somatogravic illusion**

During some aspects of a flight, a pilot is exposed to linear accelerations in various directions in addition to the normal gravitational force ( $g$ ). The resultant total force vector is known as the gravito-inertial force (GIF). When a pilot misinterprets the GIF vector to indicate that they are tilted at a different attitude than they actually are, the pilot is experiencing the somatogravic illusion. Although the somatogravic illusion is usually discussed in terms of false pitch illusions that can occur when an aircraft accelerates during a take-off, it can also occur during turns.

During a constant airspeed turn, a pilot feels a centrifugal force as well as the gravitational force. If an aircraft yaws or turns without banking, the pilot will feel a sideways force because the resultant GIF vector points towards the outside of the turn. During a coordinated or balanced turn, the pilot manipulates the aircraft's controls to minimize any such sideways forces. Consequently, the resultant GIF vector points towards the floor of the aircraft (or from the pilot's head to feet), which is a similar perception to when the aircraft is in straight and level flight (Figure 19).

Figure 19: Gravito-inertial force during turn and potential misperception



As previously discussed, in a gradual or prolonged turn the semicircular canals do not contribute to the pilot's perception of bank. In the absence of visual cues, the pilot may then interpret the direction of the resultant GIF vector during a coordinated turn as being the same as that during straight-and-level flight.

In addition to level turns, misperceptions of the GIF vector can occur during a descending turn and result in a spiral descent. As described by Gillingham and Previc (1993):

A pilot who is flying "by the seat of the pants" applies the necessary control inputs to create a resultant G-force [GIF] vector having the same magnitude and direction as that which the desired flight path would create. Unfortunately, any particular G vector is not unique to one particular condition of aircraft attitude and motion, and the likelihood that the G vector created by a pilot flying without reference to instruments is that of the flight condition desired is remote indeed. Specifically, once an aircraft has departed a desired wings-level attitude [or other desired bank angle] because of an unperceived roll, and the pilot does not correct the resulting bank, the only way he can create a G vector which matches that of the straight and level condition is with a descending spiral... a skillful pilot can easily manipulate the [flight controls] to cancel all vestibular and other non-visual sensory indications that the aircraft is turning and diving.

In terms of the ability to detect changes in the angle of the GIF vector, Benson 1999 stated: Typically, an individual can set or determine bodily attitude with respect to the gravitational vertical with an accuracy of  $\pm 2^\circ$ , but if the rate of movement is very slow ( $0.1^\circ/\text{s}$ ) body tilt of  $10^\circ$  or more can take place before deviation from verticality is detected.

In terms of the magnitude of the GIF vector, a level turn at a  $60^\circ$  bank angle would result in a GIF magnitude of 2 g, which would be easily detectable to a pilot. However, a  $30^\circ$  bank angle would result in a GIF magnitude of only about 1.15 g. However, when the aircraft is also accelerating downward the resultant force is decreased, which may lead a pilot to believe the aircraft is in a bank of less magnitude than it actually is. An increase in the magnitude of the GIF vector would also be harder to detect if it was gradual.

As previously noted, detection thresholds can be higher in operational settings. In particular, helicopter flights involve continual small variations in movement.

In summary, an undetected increasing bank angle can result in a somatogravic illusion, which can result in a descending, spiral turn. A pilot can easily and automatically manipulate the flight controls to cancel any non-visual sensory indications that the aircraft is turning or descending, which will maintain a GIF vector oriented close to the pilot's head-to-feet axis.

NOTE: The information in this article was extracted from the Australian Transport Safety Bureau (ATSB) Transport Safety Report, Aviation Occurrence Investigation, AO-2011-102, Final – 14 November 2013 - involving a helicopter flying VFR flight into dark night.

They say milk is good for your teeth. You know what else is good for your teeth?

Minding your own business...



# Defragging the Hard Drive: A Change in Aviation Training Philosophy

LTC Josh Sauls

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Deputy Director

**One of the most grating problems that we deal with in today's business environment is a computer that is so bogged down with extraneous information that it is no longer able to perform even the most mundane tasks in a timely manner. We can feel our blood pressure rise as we watch that hourglass spin and spin when we are simply trying to open an email. Only a year earlier, this very same computer probably worked with lighting-like speed but slowly over time, we have bogged it down with information so that it is now an actual hazard to our health because of its blood pressure elevating properties.**

Given how exasperating this is, it is amazing that we, the aviation branch, do the very same thing to our Aviators' organic hard drives – their brains. We at DES routinely observe instructor pilots demanding that their aviators commit to memory every pressure, temperature, and voltage possible on their aircraft. We have observed pilot in command (PC) oral evaluations that lasted two hours and never got beyond the performance planning card and the electrical system. Given that these PC evaluations were for AH-64 PCs, I was surprised that the instructor pilots were so concerned that their students could regurgitate the voltage required to operate a pressure regulator shut-off valve (PRSOV) but did not ask them any questions regarding tactical employment.

Let's face it, today's aircraft are so technologically advanced that they can and will provide vast amounts of information to the pilot that formerly had to be committed to memory. I can still remember the days of memorizing every conceivable pressure and temperature of the AH-1 because that venerable old airframe was instrumented with nothing but steam gages with slippage marks on the glass. The lack of technology required that an aviator memorize that type of data. However, today's aircraft are equipped with digital indications that warn an aviator of impending exceedences with everything from count-down timers to color codes to human voices. We have systems that record temperatures and pressures out to the third decimal point and times out to the millisecond. We even have systems that will display emergency procedures to the aircrew automatically.

With that being the case, why are we not unburdening our aviators of the requirement to fill up their hard drives with this type of information – information that the aircraft is quite capable of managing on its own? Why are we not spending more time requiring our aviators to know and understand aviation doctrine and tactics? Apache pilots should spend the vast majority of their study time ensuring that they are experts at employing weapons systems. Blackhawk pilots should spend the majority of time becoming subject matter experts at conducting air assaults. We as standardization leaders should be creating tactically proficient war fighters as opposed to competitors for the show Jeopardy.

We started to embrace technology when we first fielded the AH-64D. DES sent a memo to the field that relieved aviators of the responsibility of memorizing a significant amount of data because the aircraft did an excellent job of managing that information. However, over time, the community slid back to the old habits of playing "I'm a drop of oil" again.

Continued on next page

It is time that we embrace the advantages that our advanced technology offers. We have to break the bonds of inertia and unburden our aviators of the requirement to spend so much time with rote memorization. Instructor pilots must shift their focus and require their pilots to become true subject matter experts in their mission and the associated doctrine, tactics, techniques and procedures. Does an aviator really need to be able to recite each and every monocular cue from memory or be able to draw the eyeball? We believe that the branch would be much better served if our aviators had a good general knowledge of this type of information and spent more study time on how to tactically employ their respective aircraft.

Obviously, there are things that we will continue to have to commit to memory. Underlined steps of emergency procedures are a good example. Pilots will always have to have an intuitive understanding of how to manage aircraft emergencies. This level of knowledge will require some rote memorization no matter how much technology resides on an aircraft. However, if the aviator can't use a particular piece of information from the cockpit, did he ever really need to commit it to memory in the first place?

There is no doubt that this is a topic that will require some focused discussions within the standardization community. DES will be taking a very hard look at how we can manage effective change in this area. We are interested in hearing from the field on this subject and are challenging the branch to take an honest look at our training philosophies and make a real effort to figure out how we can use our technology to more efficiently unburden the most important processor on the aircraft....the aviator's brain.

**--LTC Josh Sauls, DES Deputy Director, may be contacted at (334) 255-3589, DSN 558.**

### ***Actual Accident Finding: Learn from the experience of others***

**FINDING:** While leading a nine-aircraft night formation flight encountering decreasing weather conditions, flight lead, in an AH-64A, violated the control measures which were established by the unit standing operating procedures (SOP) for en route weather minimums.

As the weather forced the flight to descend below the established, briefed, 500-foot AGL minimum flight altitude, to altitudes as low as 120 feet AGL, flight lead did not properly modify the flight planning and procedures. That is, he elected to continue with the planned mission in unsafe weather while attempting to maintain visual contact with the ground rather than divert or delay the flight for the required minimum mission weather.

He and his flight descended and continued in the unsafe weather without advising the other crews or advising the air mission commander (AMC) for approval, and chalk 7 struck high-tension wires. The wires were struck as the PI of chalk 7 was attempting an immediate landing to ensure safe separation from chalk 6. Chalk 7 sustained visible windscreen damage during that wire strike.

The actions by flight lead were a result of overconfidence and inadequate supervision by the AMC. Flight lead was confident he could continue even with the decreasing weather in that he had use of the forward looking infrared (FLIR).

Additionally, the AMC, in Chalk 4, provided no guidance to flight lead or initiated any on-the-spot corrections to flight lead even after the AMC also flew into the decreasing weather that was below the SOP - established minimums for operation.



# **Mishap Review: Shadow currency training**

**While conducting unmanned aircraft operator currency training, a RQ-7B Shadow unmanned aircraft struck a utility pole while the operator was attempting to land it. The collision with the utility pole resulted in the destruction of the unmanned aircraft.**



## **History of flight**

The operators of an RQ-7B Shadow unmanned aircraft unsuccessfully attempted to land their unmanned aircraft (UA) after completing four hours of currency training. The aircraft commander (AC), a 15W, had a total of 590 RQ-7B flight hours with 520 hours in theater. The aircraft operator (AO), also a 15W, had a total of 503 RQ-7B hours with 273 hours in theater. The operators attempted twice to land their UA in the designated landing area utilizing the automatic landing system, but were at a wrong altitude for the system to acquire the aircraft. The aircraft commander adjusted the aircraft to the correct transition altitude and attempted to land it two additional times, again with no success. Following the check list and standing operating procedures, the AC transferred the control of the aircraft to a back-up control station to make another landing attempt. After the transfer, the AO erroneously adjusted the altimeter settings on his control screen twice, which lowered the UA's altitude dangerously low without the operator's knowledge. Just prior to attempting to land, the aircraft, the aircraft struck a utility pole adjacent to an elementary school. After the collision, it fell to the ground and came to rest on a road near the front of a school. A civilian vehicle traveling on the road collided with the wreckage. The utility pole and vehicle collision resulted in the total destruction of the UA and minor damage to the civilian vehicle. There were no injuries.

## **Commentary**

The investigation determined the aircraft operator (AO) of the RQ-7B failed to follow a caution defined in the operator's manual in that the AO twice changed the altimeter setting while operating below 3,000'. The operator's manual cautions against changing the altimeter settings while flying under 3,000 feet AGL, as it may cause the UA to descend to a low altitude without the crew being aware. As a result, the RQ-7B dropped in altitude to such a degree that it struck a utility pole resulting in catastrophic damage. Additionally, The AO's aircraft commander failed to provide correction when the AO asked for the altimeter setting and allowed the change while the UA was below 3,000' AGL.

# Class A – C Mishap Tables

Manned Aircraft Class A – C Mishap Table											as of 27 May 14
Month	FY 13				Fatalities	FY 14					
	Class A Mishaps	Class B Mishaps	Class C Mishaps	Fatalities		Class A Mishaps	Class B Mishaps	Class C Mishaps	Fatalities		
1 <sup>st</sup> Qtr	October	1	0	7	0		0	0	1	0	
	November	0	1	5	0		3	0	5	0	
	December	2	1	0	0		1	0	3	0	
2 <sup>nd</sup> Qtr	January	0	0	6	0		3	1	3	4	
	February	0	0	2	0		1	0	3	0	
	March	2	1	5	6		1	3	0	0	
3 <sup>rd</sup> Qtr	April	1	1	6	2		1	0	4	0	
	May	0	0	6	0		1	1		1	
	June	1	1	4	0						
4 <sup>th</sup> Qtr	July	0	0	7	0						
	August	1	1	9	0						
	September	0	1	1	0						
Total for Year		8	7	58	8	Year to Date	11	5	19	5	

UAS Class A – C Mishap Table											as of 27 May 14
	FY 13					FY 14					
	Class A Mishaps	Class B Mishaps	Class C Mishaps	Total		Class A Mishaps	Class B Mishaps	Class C Mishaps	Total		
MQ-1	5	1	0	6	W/GE	2	1	3	6		
MQ-5	2	0	3	5	Hunter	1			1		
RQ-7	0	4	10	14	Shadow		6	3	9		
RQ-11					Raven			1	1		
RQ-20	0	0	6	6	Puma			1	1		
YMQ-18											
SUAV					SUAV						
Aerostat	2	3	1	6	Aerostat	1		2	3		
Total for Year	9	8	20	37	Year to Date	4	7	10	21		

You may have noticed a theme in this month's *Flightfax* - spatial disorientation (SD). A couple of articles are provided for you to refresh your mind on what it is, why it happens, and what can be done about it as well as the definition of degraded visual environment (DVE).

So what does spatial disorientation have to do with DVE? Quite a bit actually. Until only a few years ago I had never been exposed to the term "Degraded Visual Environment." I was familiar with dust landings, white-outs, IIMC, black hole approaches, etc., but had never characterized them under one hat. DVE includes many conditions: IMC, low illumination, low contrast, brownout, whiteout, blowing sand, dust, smoke, fog, heavy rain, salt spray, etc. Just about anything that partially or completely reduces aircrew visibility and could cause a loss of situational awareness for the crew. So whether you punched into a low cloud deck trying to scud run or you're engulfed in a dust cloud at the bottom of a VMC approach, the potential effects of DVE and spatial disorientation have been thrust upon you. Luckily, we have been trained for such occurrences – right? Everyone has to demonstrate proficiency in doing a go-around, instrument take-off and recovery from an unusual attitude. These are staples in a pilot's proficiency training. They have not changed significantly in years. There are plenty of notes in the ATMs regarding NVG/snow/dust considerations for various maneuvers. If you lose visual contact execute a go-around – correct?

In the last five and one-half years there have been 23 Class A mishaps (out of a total of 96) that can be attributable to DVE. Seven of the 23 were fatal mishaps resulting in 24 fatalities. Total cost of over \$260 million. The predominant aircraft were the UH-60 and CH-47 tallying 19 of the mishaps. Dust landings or take-offs accounted for the majority with 15 mishaps and one fatality. What of the others? Of the eight not included with the dust, there was one IIMC and seven associated with operating in low contrast conditions and/or low illumination. These eight accounted for the remaining 23 fatalities. It can be expected, on a yearly average, of having at least one full blown spatial D mishap with fatalities.

The dust landings are more prevalent but not as deadly. Typically they occur at lower speeds within a few feet of the ground when an unregistered drift, unseen obstacle, or unintended hard landing is the result. Until technologies mature that will see through the dust or snow and assist the pilot in landing the aircraft, it is still experience, training and techniques that control the outcome of the approach.

It's the other categories that present different challenges, such as the spatial disorientation that can develop when confronted with operating in low contrast/low illumination conditions. Ask any group of lift pilots about the most challenging flight conditions they face and invariably these flight conditions rise to the top. Read the following excerpts from accidents that occurred over 25 years apart –

*During a night vision goggle training mission flown at 100' above the trees and 40 knots airspeed, Chalk #2 in a flight of three aircraft was observed to make an abrupt right turn and crash into the trees. All four crewmembers sustained fatal injuries during the crash sequence. Aircraft was totally destroyed and consumed by post-crash fire.*

*While flying as Chalk 3 in a flight of four aircraft, using night vision goggles, in a staggered trail left formation, at approximately 650 feet above ground level and 120 knots indicated airspeed, the pilot (PI) experienced spatial disorientation and lost control of the aircraft. As a result, the aircraft struck the ground in a nose low, left banking attitude. The aircraft was destroyed and all seven Soldiers onboard the aircraft were fatally injured.*

Both aircraft were operating visually in good weather. What isn't readily identifiable from the

description is that each of the aircraft were operating without a visible horizon – one deep in a forested mountain valley and the other over featureless desert terrain.

All Army aviators are instrument qualified and maintain currency in instrument tasks. They associate these tasks with operating in IMC conditions – either planned or unplanned. They have developed their instrument scan pattern to overcome the challenges of operating in the clouds. So how does this relate to operating in VMC conditions? I refer back to a line from the first article: *The visual system generally provides about 80 percent of a person's raw orientation information...the risk of spatial disorientation is significantly increased if the relevant visual cues are absent, ambiguous, or not attended to.*

Essentially, if your aircraft is venturing into low contrast/low illumination with no visible horizon or lacking the needed visual cues, then your need for instrument reference increases dramatically. Whereas you normally refer to your flight instruments occasionally while operating VMC in good conditions, it changes significantly at night under challenging conditions. The instruments become your primary means of maintaining orientation. The same for snow covered terrain or over water flight. This seems to be an area, in my view, that training within our aviation community falls short.

How many times has the phrase “it sure is dark out here” or “I can’t see anything” been communicated within your crew? That’s a subtle code telling the crew the conditions are very challenging and they need to step up their game. Rather than subtle codes, wouldn’t a better solution be to announce the degraded visual condition and coordinate crew actions to overcome them? Different pilots will tell you how they respond to these type of situations or how they increase coordination between crewmembers as conditions become more challenging. That’s developed through their experience operating in those conditions.

How about the less experienced that have not been exposed to this arena? You put them in Chalk 3 thinking they’ll be tucked within the safety of the rest of the flight. The double-edged sword is that they may spend most of their visual energy trying to maintain formation instead of maintaining aircraft orientation. The potential failure is not recognizing that, although they are flying VFR, they are actually flying the equivalent of IMC and need the instrument scan to assist.

Operating in degraded visual conditions is a challenge. Coordinating actions within your crew and your flight to reduce the effects can go a long way to minimize the potential disorienting effects that can occur. Do you have to fly directly into the abyss? Or can your flight route be modified to include more ground references. Does the 180 turn around have to be done in steep turns or can they be flattened out in a more gradual manner? How about modifying a pattern rather than orbiting your flight? The potential effects of spatial disorientation should be considered well before you’re in the aircraft. Flight routes, weather, illumination data, as well as the risk assessment worksheet can all give indicators of where mitigation measures should be applied. You may check the block on low illumination but have you combined it with the effects of cloud cover, featureless terrain, no ground lights and dust at the objective? These are examples of cues to flying that are not seen from the aircraft.

Technology solutions are coming but they’re not here yet. Training is still key to overcoming DVE. When was the last time you flew a VMC mission in the simulators with the visibility and illumination turned down low? It’s a great place to practice those crew coordinating actions. Hangar flying with other pilots will help you refine your techniques and broaden your own experience base, but other things can be included. Discussions on decision points, such as when to make a go-around or changing routes or even when to mission abort will strengthen your ability to make the correct decision when you’re faced with challenging circumstances.

# Blast From The Past

Articles from the archives of past Flightfax issues

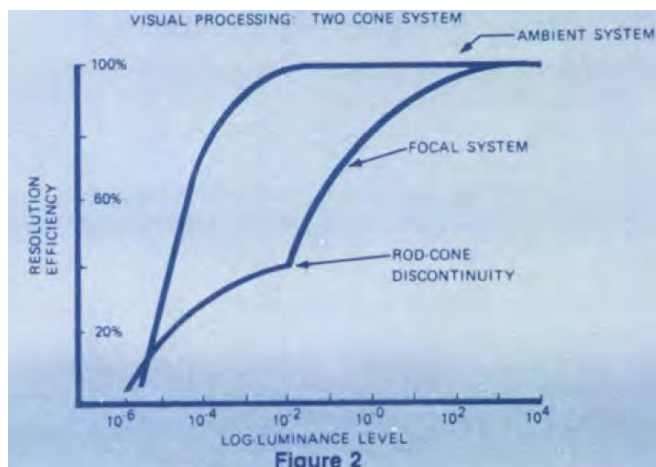
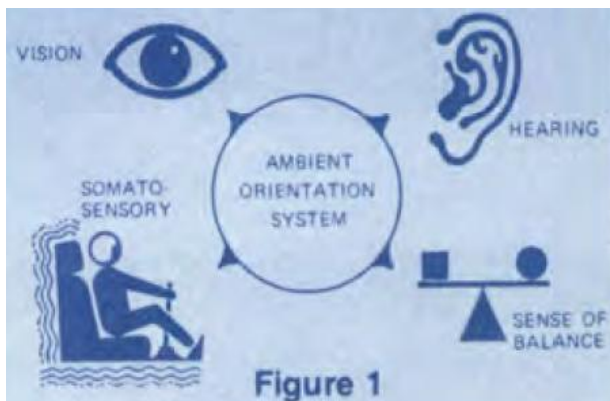
## The role of vision in spatial disorientation 12 Oct 83 Flightfax

This article, by Colonel Grant B. McNaughton, MG, Directorate of Aerospace Safety, is reprinted from **Flying Safety**.

We normally think of spatial disorientation (SD) or pilot's vertigo as due to tumbling of our gyro-the balance organ or vestibular apparatus in our inner ear. While it is certainly true that vestibular inputs can cause vertigo, the vestibular apparatus is not the only source of conflicting information leading to SD. Other sources of orientation information (hence conflicting inputs) include vision, the somato-sensory (feel of the aircraft and seat of the pants) system, and, to some extent, hearing. Of all these sources, the most consistent and possibly most important cause of SD is conflict between two functional components within the visual system itself.

Though in some respects an oversimplification, the concept of a two mode visual system is important to understanding the role of vision in SD. The two modes are:

- A **focal** mode, which "focuses," used for tasks requiring acuity or resolution; e.g., reading the 20/20 line or the letdown plate, identifying the bogey, or aiming the gun. The focal mode is exclusively visual and requires good lighting and good optical resolution. It also requires conscious attention.
- An **ambient** mode, which orients us to the "ambient" environment, tells where we are, and whether we or the environment is moving. The ambient mode is hard-wired to the same terminals in the brain into which feed our other sources of orientation information-vestibular, somato-sensory and hearing (figure 1). Rather than being an isolated ambient visual system, we actually have an ambient orientation system. In this system, vision and the other senses each contribute a share of the inputs. The ambient mode functions quite well at low light levels and does not require acuity correction. For example, though you can't read in the dark, you can orient, provided there is some light (figure 2). The ambient mode functions at a reflex rather than a conscious level and, provided the stimulus is visible, orientation responses appear to occur on an "all or none" basis. The ambient mode acts in concert with the other senses to sub-serve spatial orientation, balance, posture and gaze stability.



An important aspect of these two modes of processing is that they can be dissociated, as demonstrated by the fact that you can read while walking. This dissociation has some impact on night driving, for example. You steer by your ambient mode, which is relatively unaffected at night.

Continued on next page

As long as you can steer, you have confidence in your ability to drive, so you drive at the same speed as during daytime, or commonly a little faster. The problem is that your focal vision (hence hazard recognition) has been selectively degraded, and you may not see obstructions such as joggers, animals, or potholes in time. (Also, your reactions are slower at night.)

There are other fundamental differences between the two modes. The focal mode is confined to the optical center of the eye but the ambient includes the entire retina-over 3,000 times as much area. The ambient mode functions on the "mass rule" and reacts in proportion to the amount of it that is stimulated. Big objects or big motions are more commanding. This, coupled with the fact that the ambient mode is not particularly discerning (i.e., it can be fooled), provides the basis for the overwhelming sense of self-motion, known as the "vection" illusion-generated by full visual simulators. It also accounts for the disorienting "Star Wars" effect of bubble-type canopies at night.

Another difference: Whereas the focal mode actively focuses on objects for recognition and detail, the ambient passively takes in the "quality" of the surroundings-for example, the quality of "surfaceness" of a surface, or the "horizoness" of a horizon.

Of interest is the discovery that visual areas of the brain sub-serving the ambient mode appear to contain receptors specifically responsive to lines, and are quite ready to accept uncritically any line with the quality of "horizoness" as a horizon line. Thus, the commanding nature of sloping cloud decks or terrain, of a lighted shoreline or highway through an uninhabited region at night, or other false or misplaced horizons can subtly misorient the pilot. In keeping with the mass rule, the larger or longer the horizon, the more commanding.

Think of the most disorienting situations: formation, flying in and out of clouds, then, suddenly, totally IMC; flying high above the desert on a moonless night, no discernible horizon, and stars and ground lights blending; taking off into weather; night weather penetration with your external lights on; approaching through rain, snow, or weather with landing lights on. And you can think of others. In all these situations, you're visual; you're not under the bag. This does not imply you can't get disoriented under the bag; you can, from your unbridled vestibular inputs, but not nearly so easily as when your ambient visual system is bombarded with confusing and reflecting stimuli.

What's common to these situations is:

- Lack of a true horizon or reference to the surface.
- Mass stimulation of the ambient visual system (by watching your flight lead, canopy reflections, clouds, stars, rain, blowing snow, lights, etc.) causing the vection illusion.
- Situation worsened by anything which tumbles your gyros, such as accelerations (linear or angular), or abrupt head motions.

Whereas excessive erroneous inputs to the ambient mode cause one type of SD (the powerful vection illusion), lack of ambient inputs causes another: the target displacement illusion. This can occur in shooting an approach over "black hole" terrain, devoid of lights or any visual clues to the ambient mode. As you maneuver toward the distant approach lights, with no ambient inputs as a "reference point," it may appear that the target lights, not you, have moved. This is something akin to the autokinetic effect in which a stationary light will appear to move when gazed at; it can be somewhat confusing. Point sources of light provide no orientation information-either in relative attitude or in distance. Yet there is a common tendency to "go visual" too soon despite the lack of

valid external orientation cues upon which to establish visual dominance. As a result, you become a set-up for the powerful vestibular illusions and can get into some unplanned attitudes.

If the runway lacks VASIs, the lack of ambient cues allows for another tendency: that is to fly a "banana" shaped approach, convexity downward. (The reason for this is that the eye, lacking other references, will attempt to maintain the same angle subtended by the visible runway-the near and far ends. In order to hold that same angle, you wind up flying the arc of a big circle, the chord of which is the visible portion of the runway, landing short or bending things shy of the runway.)

To cope effectively with spatial disorientation, you must establish visual dominance on valid, orientation cues. In other words, increase the ratio of "matching" cues to " mismatching" or conflicting cues. Under IMC, the only valid orientation cues are your instruments - primarily the attitude indicator. If single ship, reduce the disorienting mismatching visual inputs by turning down/off unnecessary light, inside and out, to reduce canopy glare and reflections; by lowering the seat; or by going heads-down. Then simultaneously expand the effectiveness of your valid orientation cues by leaning forward and concentrating on them-again primarily the attitude indicator. Make the attitude indicator indicate straight and level for at least 30 - 60 seconds (to allow the vestibular inputs time to subside).

Unfortunately, the most disorienting situation is formation flight in reduced visibility-IMC or at night. Though you may not be able to go heads-down (or sneak a peek) at the attitude indicator, tell lead you're disoriented and request flight parameters-primarily attitude. If possible, have him fly straight and level 30 - 60 seconds to settle your own gyros. If that doesn't help, try getting to VMC for reference to a horizon or the surface. Lead should also consider transferring lead to you-to let you get your ambient mode out of "Star Wars" and devote the full attention of your focal mode to the necessary gauges. (This should all be briefed ahead of time.)

Spatial disorientation is a common problem. It is to be expected under situations in which your visual system is either bombarded with disorienting cues or denied valid orienting cues true horizon or surface-thus setting you up for the equally disorienting vestibular illusions. The best course is prevention by maintaining visual dominance (focal mode) on valid orientation cues (gauges). If SD occurs, increase the ratio of matching to mismatching orientation cues by getting your head out of the Star Wars reflections and focusing on the appropriate gauges. In formation flying, have a plan and brief it. SD is a killer. Don't take it lightly.

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**NIGHT OR NIGHT VISION GOGGLE (NVG) CONSIDERATIONS:** Instrument meteorological conditions (IMC) is not a prerequisite for an unusual attitude. Low level ambient light may induce visual illusions and spatial disorientation. During night vision goggle (NVG) operations, video noise may contribute to loss of visual cues.

**SNOW/SAND/DUST CONSIDERATIONS:** Obscurants other than weather can induce loss of visual contact. At low altitudes where these conditions would be encountered, it is extremely important that these procedures be initiated immediately to prevent ground contact.

# Selected Aircraft Mishap Briefs

Information based on Preliminary reports of aircraft mishaps reported in April 2014.

## Attack helicopters



-D Series. Aircraft experienced an NR overspeed (125%) during maneuvering flight training. Aircraft was landed w/o further incident. (Class C)

## Utility helicopters

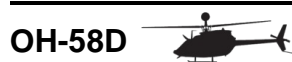


-A Series. Flight of 2 UH-60A were ground-taxiing to parking when the lead aircraft contacted a light pole with the main rotor system. Flying debris damaged the trail UH-60, as well as other parked fixed-wing aircraft. (Class A)

-M Series (HH). Post-flight inspection revealed damage to the FLIR; subsequent inspection confirmed right main landing gear strut damage as well. Both components require replacement. (Class C)

-A Series. Crew was performing an aerodynamic braking technique during a roll-on landing when the main rotor struck the tail rotor drive shaft. (Class C)

## Observation helicopters



-Aircraft experienced an over-torque condition (123% Mast Torque/2 sec; 132% Engine Torque) during RL progression training, Task 1074: Respond to Engine Failure at Cruise Flight (terminating with power). (Class C)

## Unmanned Aircraft Systems



-System was ground-taxiing for take-off when the tail section contacted the runway. System was shut down w/o further incident and turned over for inspection. Reportedly the craft entered a dip in the runway, resulting in glare and loss of visual acuity by the operator. (Class C)

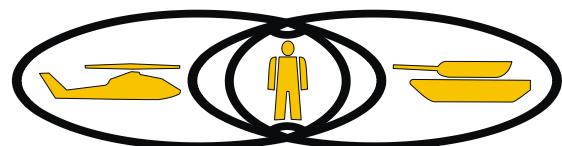
-The system propeller was damaged during engine run-up following maintenance. Reportedly the 'rudder rigging fixture, which was positioned by the aircraft, blew up into the propeller, damaging the fuselage and tail section as well. (Class C)



-Crew experienced a 'Flap Servo Failure' during UAS flight training and the system reportedly exceeded its roll tolerance during recovery. System descended to ground contact inverted and was recovered with damage. (Class B)

-Crew lost link with the UA in preparation for landing during ATP currency training. The UA descended to ground contact on a public road within Class D airspace. The wreckage was struck by an approaching vehicle. (Class B)

If you have comments, input, or contributions to Flightfax, feel free to contact the Aviation Directorate, U.S. Army Combat Readiness/Safety Center at com (334) 255-3530; DSN 558



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