Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER 506683
UNCLASSIFIED	

TITLE

LOSS OF AVIATION SITUATION AWARNESS IN THE CANADIAN FORCES

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to:

AGARD-CP-575

AGARD-CP-575

AGARD

ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

7 RUE ANCELLE, 92200 NEUILLY-SUR-SEINE, FRANCE

AGARD CONFERENCE PROCEEDINGS 575

Situation Awareness: Limitations and Enhancement in the Aviation Environment

(la Conscience de la situation: les limitations et l'amélioration en environnement aéronautique)

Papers presented at the Aerospace Medical Panel Symposium held in Brussels, Belgium from 24-27 April 1995.

NORTH ATLANTIC TREATY ORGANIZATION

Published January 1996

Distribution and Availability on Back Cover

LOSS OF AVIATION SITUATION AWARENESS IN THE CANADIAN FORCES

Bob Cheung Ph.D., Ken Money Ph.D., Paul Sarkar B.Sc.

Defence and Civil Institute of Environmental Medicine
P.O. Box 2000, North York, Ontario
Canada
M3M 3B9

SUMMARY

The ability of a pilot to maintain situation awareness has been recognised as crucial to mission success for some time. Situation awareness has been used to refer narrowly to a combination of tactical awareness and spatial orientation. However, situation awareness is the accurate perception and comprehension of a number of factors and conditions that could affect the aircraft and the air crew within a period of time. The present study concentrates on accidents and incidents in which there was a loss of situation awareness excluding spatial disorientation.

Each accident and incident were systematically reviewed to assess the role of situation awareness. Loss of situation awareness has been implicated in many close calls and accidents. A total of 64 mishaps between 1982-1993 were found to be related to loss of situation awareness in the Canadian Forces (CF) and it appeared throughout all mission and aircraft types.

A focused and structured training program in managing cockpit resources and in maintaining attention would assist air crew in identifying conditions where situation awareness could potentially be lost and where appropriate strategies could be used to avoid the loss or to deal with the loss. Such training could be implemented through real-time man-in-the-loop flight simulator training of pilots in various flight scenarios. Similar training could also improve the performance and efficiency of air traffic controllers.

LIST OF ABBREVIATIONS

ACM	air combat manoeuvre
AGL	above ground level
ATC	air traffic control
CF	Canadian forces
G	gravity
IFR	instrument flight rules
kias	knots indicated air-speed
LH	left hand
LSA	loss of situation awareness
MDA	minimum descent altitude
RH	right hand
RPM	revolutions per minute
SA	situation awareness
SD	spatial disorientation
SO	spatial orientation
TSA	tactical situation awareness
VFR	visual flight rules

INTRODUCTION

Situation awareness (SA) is considered to be a crucial prerequisite for the safe operation of complex dynamic systems especially in aviation. Currently it is a fashionable concept among students of cockpit automation and pilot performance. The definition of situation awareness varies considerably. There is as yet no satisfactory definition of SA or boundary to constrain the concept. Historically, SA has referred to tactical situation awareness, i.e. how pilots gain awareness of the enemy before they gain awareness of themselves and how pilots devise methods to complete the mission. In relation to human cognition, SA was defined as the perception of the relevant elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future (1). The elements of this definition were explicitly defined for air-to-air tactical missions. Fracker (2) defines SA as the knowledge that results when attention is allocated to a zone of interest at a given level of abstraction. In human/machine systems, SA is defined as the conscious awareness of actions within two mutually

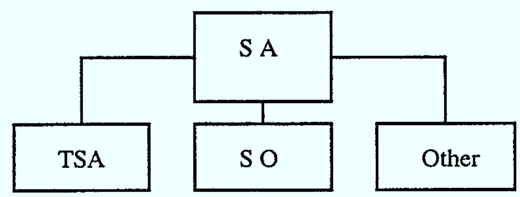
Paper presented at the AGARD AMP Symposium on "Situation Awareness: Limitations and Enhancement in the Aviation Environment", held in Brussels, Belgium from 24-27 April 1995, and published in CP-575.

embedded envelopes with the inner envelope consisting of unaided sensory space of the operator and the outer envelope consisting of information available to the operator via remote sensing (3). Despite the importance and popularity of SA, little progress has been made with respect to better understanding and successfully manipulating the phenomenon from an operational point of view.

There have been numerous task analysis studies investigating the frequency and severity of spatial disorientation (SD) implicated accidents and incidents (4, 5, 6, 7, 8). However, data on the prevalence of loss of situation awareness (LSA) are very scanty. There were very few studies which directly dealt with the incidents and accidents due to the loss of situation awareness and some of the scientific literature tends to deal with situation awareness and spatial disorientation synonymously (9, 10). Part of the reason for such a discrepancy is that some investigators have included LSA in the list of illusions one could encounter when spatially disorientated (11). Others attempted to overcome the classification problems by grouping accidents in a combined class called SD/LSA (12). There are very few operational definitions of SA (6, 13) and a commonly accepted operational definition of SA is lacking.

Operationally, the term situation awareness in the aviation environment is used more appropriately to refer to the awareness of the large group of factors that are important in keeping the aircraft safe from hazardous situations or potentially dangerous flight paths. These factors include geographical location, attitude, weather, tactical environment, weapons capabilities, individual capacities, effective communication, administrative constraints, adherence to proper flight rules, and also spatial orientation (SO). This hierarchical structure of spatial orientation as a part of SA has been proposed by Gillingham (6) and more recently by Navathe and Singh (14). In an attempt to derive an operational definition of spatial disorientation, Navathe and Singh limited loss of SA as a psychological limitation/overload, a condition wherein the aircraft enters a dangerous flight path as a result of central error due to illusion, error of judgment, lack of information or preoccupation (14). SA is intended to be the broader term encompassing more than spatial disorientation (SD) references and including the cognitive process as its principal dimension. In other words, SD is one kind of loss of SA, but loss of SA could also be due to factors other than SD. (See Fig. 1).

Figure 1: Hierarchical Structure of Situation Awareness



The objective of this study is to describe incidents and accidents related to loss of SA due to factors other than spatial disorientation according to the aforementioned operational definition. A separate study on spatial disorientation implicated accidents in the Canadian Forces have recently been presented elsewhere (4). An attempt will be made to classify LSA according to the various possible cause factors. Information was gathered concerning the genesis of loss of situation awareness so that training and research efforts could be appropriately applied.

METHODS

Narratives regarding accidents and incidents between 1982 and 1993 were obtained from ACAIRS (Aircraft Accident Incident Reporting System) of the CF Directorate of Flight Safety. Each accident and incident was systematically reviewed to assess the role of loss of situation awareness. Within the Canadian Forces, formal inquiries were held only for Category A accidents. In addition to investigating the reported cause factors, specific information was collected for each accident and where possible for each incident. This specific information included: pilot experience, aircraft type, mission profile, time of day, weather and terrain of the flight path. This information was tabulated and summarised for analysis.

The CF Handbook of Flight Safety defines an accident as an event in which an aircraft is missing or in which there is A, B or C category damage, or a person receives fatal or serious injury. A Category A accident is when an aircraft is destroyed, declared missing, or damaged beyond economical repair. A Category B accident is when the aircraft must be shipped to a contractor or depot-level facility for repair. A

Category C accident is when the aircraft must be flown to a contractor or depot-level facilities for repairs; repairs are carried out by a mobile repair party; or a major component has to be replaced. An incident is defined as an event in which there is D category damage, when damage to any component of the aircraft can be repaired within field-level resources or a person receives minor injury. A Category E incident is when there is no aircraft damage, but accident potential exists. (15). These definitions were adopted for this study.

RESULTS

Between 1982 and 1993, a total of 64 mishaps were found to be related to loss of situation awareness excluding spatial disorientation, 11 in helicopters and 53 in fixed wing aircraft. There were 3 Category A, 2 Category B and 1 Category C accidents. The rest were classified as incidents including 5 in Category D and 53 in Category E. The time of day when and the terrain of the flight path where the accidents or incidents occurred appeared not to play a role in the mishaps.

Aircraft type

Accidents and incidents related to loss of situation awareness span across all aircraft types as illustrated in Table 1.

Table 1: Situation Awareness Accidents and Incidents by Aircraft Type

Aircraft Type	SA Accidents and Incidents
CF 18 (Hornet)	18
CF 5 (Freedom Fighter)	12
CT 114 (Tutor)	12
CT 133 (Silver Star)	6
CH 124 (Sea King)	3
CH 135 (Twin Huey)	3
CP 140 (Aurora)	3
CH 136 (Kiowa)	2
CC 115 (Buffalo)	1
CH 113 (Labrador)	1
CH 139 (Jet Ranger)	1
CH 147 (Chinook)	1
CP 121 (Tracker)	1

Mission profiles

About 30% of the mishaps occurred within the air space centred around the runway that extends from the ground to 1,000 feet (300 m.) above ground level (AGL). There were 14 SA-related mishaps during landings, 5 during takeoffs, 8 during formation flying, 18 during air combat manoeuvres, 17 during routine flight training, and 2 during aerobatics manoeuvres.

Weather

The occurrence of LSA was not limited to extreme weather condition. A number of near misses and a fatal collision with objects occurred on very good VFR days. There were three incidents involving the degradation of weather beyond forecasted levels. A solo student pilot who did not have valid instrument ratings was airborne at the time of an amended forecast on a clearhood mission that could have necessitated diversion. Airborne pilots who were aware of the worsening weather situation did not pass the information to allow for a timely forecast amendment. Another case involved a pilot who chose to continue and descend below MDA (Minimum Descent Altitude) to gain visual reference with the airport despite the forecast weather was below MDA for the planned approach. The pilot landed the aircraft only after 3 attempts. In another case, no warning was given about severe wind shear and turbulence, and visibility was extremely limited due to heavy rain and darkness at night; the pilot encountered moderate mixed icing and severe wind shear through the descent and final phase of the approach.

Flying experience

In general, the flying experience of the pilots played a minor role in most cases. Pilots of all ages and of varying amounts of flying experience are susceptible to loss of situation awareness. In those incidents where experience played a role, the inexperienced younger pilots were not familiar with all the possibilities and limitations of the specific aircraft.

DISCUSSION

Circumstances and Causal Factors

For any accident investigation, it is difficult to attribute one single cause factor for the mishap, especially in modern fighter aircraft with advanced technology and difficult mission requirements. When there is a loss of life, it is often especially difficult to be sure of the cause. Accidents are usually the result of a chain of events that culminate in the mishap. There is seldom one overpowering cause, but rather a number of contributory factors or errors. The cause factors assigned should by no means be treated as the only cause, but as contributory factors under the circumstances. All of the accidents and incidents that we reviewed involved one or more of the following as tabulated in Table 2:

Table 2: Contributory Factors and Related Problems

Contributory Factor	Problem Experienced
Geographical Location	(i) Unfamiliar with environment away from home base. (ii) Lack of awareness of altitude.
Weather	Unforeseen weather condition.
Individual Capacity	(i) Limitation of personal capacity. (ii) Inattention. (iii) Distraction. (iv) Channelised attention.
Adherence to Proper Flight Rules	(i) Failure to maintain adequate clearance around aircraft. (ii) Failure to maintain instrument scan. (iii) Failure to observe instructions from tower.
Administrative Constraints	With available flying hours steadily declined, the inexperienced younger pilots would not be as familiar with all the possibilities and limitations of the specific aircraft as desired.
Effective Communication	(i) Use of non-standard procedures or instruction. (ii) Lack of effective communication among pilots and aircrew. (iii) Lack of effective communication between pilots and air traffic controllers.

Consequences of loss of SA

Loss of situation awareness resulted in mid-air collision or collision with a ground-based object, near misses, high G overstress, ground/water impact, undercarriage overspeed, departure from controlled flight and unawareness of low fuel state.

Collision

Collision or contact with ground-based objects commonly occurred when air crews failed to maintain adequate clearance around the aircraft, i.e. rotor blades or undercarriage striking tree tops. In one case, an unoccupied seat pack was improperly secured and departed the aircraft through the canopy glass when the pilot executed a right bank. The seat pack broke the glass.

Near miss

A number of near misses occurred during multi-bogey ACM (Air Combat Manoeuvre) training during landing after the formation break-up. Other near misses occurred as a result of unsafe overshoot procedures during landing. The lack of awareness of the layout of an away base where landing was to be made resulted in landing on taxi way. Quite a number of near misses occurred in very good VFR conditions during the approach to landing or the landing phase itself.

Overstress

Most of the G overstress cases occurred when pilots unknowingly failed to maintain attitude, allowing the nose to drop too far and causing overstress of the aircraft during subsequent aggressive pull-up. Other nose low situations occurred during various aircraft manoeuvres including hesitation roll, lag back-cross manoeuvre and while checking position during formation flying. Some overstress situations occurred during unscheduled aerobatics sequences; sometimes, the pilot was distracted as he came out of one manoeuvre and entered the next.

LSA in Air Traffic Controllers

There were a number of cases where the lack of situation awareness applied to both air traffic controller and air crew. Both air traffic control (ATC) personnel and aircrew allowed themselves to engage in incomplete and non-standard communication which contributed to several near misses. A number of mishaps were due to ineffective communication between the ATC and the pilot. In one case the controller allowed himself to become occupied with communication problems with another aircraft, and passed incomplete information to an aircraft performing a simulated forced landing. In another case the ATC controller became engrossed with a squadrons of helicopters requesting take off information instead of handling a four plane formation returning to base for a VFR pitch and landing. As a result a near miss occurred.

Several human factors issues also entered into the decision making performance of a relatively inexperienced ATC controller. This controller was only VFR qualified and yet required a good knowledge of IFR procedures to carry out his duties safely and effectively. During local night mission training, the controller apparently did not foresee the potential danger in departing a light civilian aircraft on one runway while a F5 was in the circuit for landing on a nearby runway. The F5 pilot was preoccupied with his fuel state, and did not recognise nor acknowledge the instruction to overshoot. The instructions that were issued by the duty controller were non-standard and vague. The supervisor assigned to monitor the duty controller thought that the controller had the situation under control and did not feel supervisory input was necessary. It resulted in a near miss incident where the aircraft came within 200-300 ft. (60-90 m.) of one another.

Case Studies on Accidents Related to LSA

<u>**Case 1 Cat A**</u>

While responding to an aircraft malfunction (drop in hydraulic pressure), the pilot, who was the sole occupant of the aircraft, failed to monitor the aircraft's descent rate and altitude. Apparently, the pilot chose to release the aircraft controls while the aircraft was in a turn at relatively low altitude in order to reset the hydraulic pressure. No ejection was attempted and no radio calls or emergency squawks were observed. The pilot sustained fatal injuries on initial impact. As a result of this accident, the validity of including a circuit breaker reset action item in the "loss of hydraulic pressure" non-critical emergency was examined. It was discovered that the circuit breaker only serves to electrically protect the hydraulic gauge and will not aid in resolving zero hydraulic pressure situations; therefore, the reset was removed from the checklist response. The primary rule in dealing with minor emergencies is to maintain aircraft control first and attend to the aircraft malfunction or emergency secondarily. It appears that in this accident the pilot became so engrossed in a non-critical emergency procedure that he failed to maintain his overall situation awareness.

<u>**Case 2 Cat A**</u>

The mission was planned as a routine navigation training exercise at 500 ft. (150 m.) AGL. Approximately 20 minutes after take-off, a Belgian F16 on an intersecting low level route spotted the T33 on his right side at the same altitude. The F16 pulled up and commenced a high left turn to execute a simulated attack. The T33 sighted the F16 and started a 180 degree defensive turn to the left in accordance with existing procedures. After completion of the turn the T33 was observed to level the wings, hit tree tops of a small hill and caught fire. The aircraft then impacted into a small grassy field 1200 ft. (360 m.) later and was destroyed. There were no attempts to eject; the two crew members sustained fatal injuries. On the basis of available information, it is suspected that the pilots concentrated on monitoring the F16 and failed to monitor and clear their own flight path adequately. In this particular case, the mission undertaken was not overseen closely enough to ensure that the participating pilots had commensurate experience and training.

<u>**Case 3 Cat A**</u>

While a Chinook helicopter was in a turning manoeuvre, the rear rotor struck and cut a telephone pole that was doubling as a light standard while it was taxing to the fuel facilities. This resulted in a chronic rotor imbalance followed by rotor blades striking the fuselage causing an explosive fire. The aircraft flipped over and came to rest among the fuel tanks. Survivors managed to exit the ball of flames suffering various degrees of burns. In this case, the aircraft was in a turning manoeuvre near a known obstacle within the minimum turning radii of that aircraft. The unit failed to observe the 75 ft. (22.5 m.) obstruction clearance limits required when taxiing.

<u>**Case 4 Cat B**</u>

A student pilot was executing a low level 180 degree turning autorotation from 250 ft. (75 m.)

above ground level. Halfway through the turn he allowed the rotor RPM to increase. The instructor assisted in controlling the RPM by increasing collective pitch and with the student still at the controls, returned his attention inside the cockpit to monitor the rotor RPM. At this point the student increased bank and attitude. The instructor took control when excessive bank and close proximity to the ground became evident. He levelled the aircraft and landed hard with speed short of the autorotation area. The helicopter sustained Category B damage. In this case the instructor was concerned with keeping the rotor RPM within limits and while concentrating on the RPM gauge lost situation awareness and allowed the aircraft to arrive at a position from which a safe recovery was not possible. The student, while performing a low-level 180 degree autorotation from 250 ft. (75 m.), allowed the aircraft to overbank and develops a nose low attitude during the turn resulting in a rapid rate of descent.

Case 5 Cat B

Two F18 aircraft collided while conducting a re-positioning exercise on an authorised William Tell workup mission. One aircraft lost the RH vertical stabilizer while the tactical lead aircraft sustained damage to the LH portion of the fuselage between the cockpit area and the nose radome. It was found that the pilot focussed his attention on the radar display for too long, thereby neglecting to clear the aircraft flight path during the lead change. The pilot of the tactical lead, did not exercise sufficient control of his formation, nor did he monitor the position of the wing man or the chase aircraft during the intercept. This resulted in a low level of situation awareness and created a hazardous situation which subsequently resulted in a mid-air collision. The lead pilot, expecting that the wing man was on his right side, mistook the chase aircraft located in this position as the wing man and acknowledged the lead change by calling "visual". A "building block" approach in preparing for this type of mission was not implemented which led to a situation where the pilots were unsure of how to accomplish the lead change procedure which was known to be a critical portion of the profile.

Case 6 Cat C

During a 4 plane ground attack mission the lead aircraft was in a left banked turn over a small, glassy-surfaced lake; on rolling out on heading he felt two bumps under the aircraft. Subsequently the RH engine compressor stalled. After the stall was cleared there was a long flame from the tail pipe and rising engine temperature. The engine was shut down. He also discovered that the pitch damper was not functioning resulting in a heavy control situation at 200 kias. In this case the pilot was distracted and failed to monitor his nose position and allowed the aircraft to descend and contact the trees while rolling out of a hard turn at low level.

REMEDIAL ACTIONS

Situation awareness provides the capacity to function in an anticipatory rather than a reactive mode. Traditionally, pilot training has concentrated mainly on developing physical flying skills, and knowledge of aircraft systems and procedures. Pilots tend to learn airmanship and develop situation awareness on the job. Usually hard lessons (accidents) are learned sporadically and are not part of a structured program. The increasing flow of information available from inside and outside the cockpit must be coordinated and utilised by the flight crew to achieve and maintain SA. This could be accomplished by cockpit management training that includes a thorough review of the event chains that lead to accidents, including a discussion of how to identify and interrupt error chains.

Instruction in the following would be valuable: awareness of local high potential conflict areas, lookout technique, situation awareness through effective listening out techniques, anticipation and needs for prompt reactions, the "see and be seen" principle which requires more cockpit time devoted to lookout. Simulator training in complete cockpit resource management during execution of a mission would provide the pilot with strong flight context experience and would be better than simulating isolated failures. A structured program could show the pilots how to recognise those situations where SA is usually lost and provides techniques to deal with these situations. Simulator training allows us to safely recreate in-flight situations rarely encountered in everyday flying. This adds to our experience file without risking injury, death and destruction of the aircraft. Subsequently, we may draw upon this file to react correctly. Properly designed simulator training scenarios will allow flight crews ample opportunity to become proficient in the use of these principles. This applies in varying degrees to all pilots, regardless of their type of aircraft or style of operation.
Introduction of a type-specific cockpit resource

management program in each of the CF flying operations will be complementary to existing programs. Current training efforts could be greatly enhanced by incorporating training that focuses specifically on the development of pilot SA. Such instruction could be internalised meaningfully when it is coupled with experience that can be provided in simulators and actual aircraft. Research should be carried out to determine the possibility of establishing an aircrew awareness management program for single seat fighter aircraft.

Human performance failures are primarily attention failures, and the mechanism of directing attention is not well understood. SA is a complex process of perception and pattern matching limited by working memory and attention capacity. Mechanisms such as attention sharing and automated processing may serve to alleviate these limitations to some degree.

CONCLUSION

SA is critical to pilot performance and survival in all types of flying operations. It fluctuates throughout any mission in any aircraft type. Maintenance of SA is not only for instrument flight. Loss of situation awareness has been implicated in many close calls and accidents. A unified operational definition of situation awareness is necessary, and perhaps tactical situation awareness and spatial disorientation should be considered as separate entities. Furthermore, a third category of SA could encompass the rest of pilot-induced cause factors.

For the near term, the only practical approach is to improve situation awareness training for pilots and air crews. Research has revealed that innovative training programs can reduce aircrew errors associated with situation awareness and judgment. The attention levels in air crews can be raised and habit patterns developed to handle threats in the flight environment. We need to identify the role and significance of attention problems in loss of situation awareness. The impact of selected contributory factors on attention problems, and those factors impacting on the pilot's ability to maintain situation awareness needs to be described. To minimise loss of situation awareness we should investigate mission and flight planning techniques. The mission plan should include response actions for each of the human performance events assigned a high probability of occurrence. Real-time, man-in-the-loop simulation training of pilots in various flight scenarios would improve the maintenance of awareness of situation information in flight. Similar training could also improve the performance of air traffic controllers.

REFERENCES

1. Endsley M.R., "Design and evaluation for situation awareness enhancement", *in* "Proceedings of the Human Factors Society-32nd Annual meeting 1988", Santa Monica CA: The Human Factors Society, 1988, pp 97-101.

2. Fracker M.L., "A theory of situation assessment; implications for measuring situation awareness", *in* "Proceedings of the Human Factors Society 32nd annual meeting, 1988", Santa Monica, CA: The Human Factors Society, 1988, pp 102-106.

3. Beringer D.B., Hancock P.A., "Exploring situation awareness: a review and the effects of stress on rectilinear normalization", *in* "Proceedings of the Fifth International Symposium on Aviation Psychology", Apr 17-20, 1989, pp 646-651.

4. Cheung B., Money K., Wright H., Bateman W., "Spatial disorientation implicated accidents in Canadian Forces 1982-1992", Aviat Space Environm Med, 1995 (in press).

5. Bellenkes A., Bason R., Yacavone D.O., "Spatial disorientation in naval aviation mishaps: a review of Class A incidents from 1980 through 1989", Aviat Space Environ Med, *63*, 1992, pp 128-31.

6. Gillingham K.K., "The spatial disorientation problem in the United States Air Force", J of Vestibular Res, 2, 1992, pp 297-306.

7. Lyons T.J., Ercoline W.R., Freeman J.E., Gillingham K.K., "Classification problems of U.S. Air Force spatial disorientation accidents, 1989-1991", Aviat Space Environ Med, *65*, 1994, pp 147-152.

8. Pike W.S., "Pilot disorientation as the most frequent cause of fatal, weather-related accidents in UK Civil and general aviation", J of Navigation, *45*, 2, 1992, pp 229-240.

9. Holland D., Freeman J., "Loss of situational awareness and spatial disorientation in the USAF 1980-89", abstract presented at the Aerospace

Medical Association annual meeting, Miami, Florida, May 1992.

10. McNaughton G.B. "Vision in spatial disorientation (SDO) and loss of situational awareness", Proceedings of the Third Symposium on Aviation Psychology, April 22-25, 1983.

11. Kuipers A., Kappers A., van Holten C.R., van Bergen J.H.W., Oosterveld W.J., "Spatial disorientation incidents in the RNLAF F16 and F5 aircraft and suggestion for prevention", *in* "Situational awareness in aerospace operations", Neuilly-sur-Seine, France, NATO/AGARD CP 478, 1990.

12. Lyons T.J., Ercoline W.R., Freeman J.E., Gillingham K.K., "Classification of US Air Force spatial disorientation accidents: 1989-91", Aviat Space Environ Med, *65*, 1994, pp 147-52.

13. Waag W.L., Houck M.R., "Tools for assessing situational awareness in an operational fighter environment", Aviat Space Environ Med, *65* , (5, suppl.), 1994, p A13-9.

14. Navathe P.D., Singh B., "An operational definition for spatial disorientation", Aviat Space Environ Med, *65*, 1994, pp 1153-5.

15. Department of National Defence Canada, "Flight Safety for the Canadian Forces", Canada, AGA-135-001/AA-001, 1988.