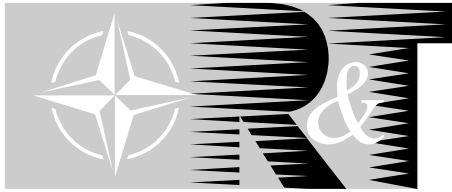


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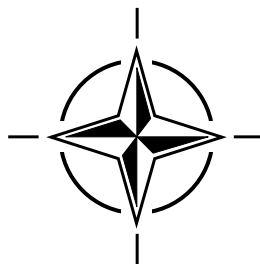
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RTO MEETING PROCEEDINGS 86

Spatial Disorientation in Military Vehicles: Causes, Consequences and Cures

(Désorientation spatiale dans les véhicules militaires:
causes, conséquences et remèdes)

*Papers presented at the RTO Human Factors and Medicine Panel (HFM) Symposium
held in La Coruña, Spain, 15-17 April 2002.*



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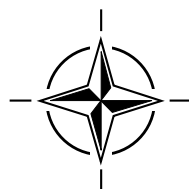
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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

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- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.

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Spatial Disorientation in Military Vehicles: Causes, Consequences and Cures

(RTO MP-086 / HFM-085)

Executive Summary

Spatial disorientation (SD) is a condition characterised by the failure of the operator to sense correctly the position attitude or motion of the vehicle, or of him/herself, within a fixed co-ordinate system provided by the surface of the earth and the gravitational vertical. SD has afflicted pilots since the early days of powered flight, yet despite an understanding of the causes of SD, improvements in the display of information on spatial orientation and greater emphasis on SD training, accidents primarily attributable to SD continue to occur. In contrast to the overall accident rate, which has fallen progressively over the past 30 years, the SD accident rate has remained more or less constant for the last 15 years. This would appear to be due, at least in part, to the introduction of new technologies, such as Night Vision Goggles, that have allowed operations in environments which previously were not possible. In view of the apparent lack of progress in combating SD and the continuing loss of life and aircraft, the Human Factors and Medicine Panel (HFM) considered it to be timely for the topic of SD to be revisited in the light of emerging techniques and technologies which might have application not only to SD in flight but also to other military environments. The resulting Symposium, entitled 'Spatial Disorientation in Military Vehicles: Causes, Consequences and Cures', was held in La Coruña, Spain, on 15-17 April, 2002, at which 1 keynote, 32 oral and 14 poster presentations were made.

Despite the wide-ranging scope of the call for papers relating to SD in land, sea and air operations, the greater proportion of the papers dealt with SD in flight. Results of questionnaire surveys in four countries confirmed the ubiquity of SD incidents in military aviation and showed the importance of visual illusions, distraction and lack of crew co-ordination, in addition to the well recognised vestibular illusions, as causal factors. This information is of value both in training and in the understanding of accidents in which SD may be implicated. Eight papers reviewed the SD training of aircrew. The use of some form of ground-based rotatory device to demonstrate various illusions is common practice, but there would appear to be benefit in the use of a full-mission, motion-based simulator to demonstrate realistically SD scenarios.

SD during and following combat manoeuvres in an agile aircraft is postulated but, as yet, not documented. Centrifuge simulations in which aviators were exposed to changes in bodily orientation during $+G_z$ load, or to transient $+G_z/G_y$ or $+G_z/G_x$ stimuli, revealed large individual differences in the sensations and in the intensity of disorientation evoked. Further work is required to identify population norms and for comparison to be made with observations in flight, where an increased $+G_z$ acceleration is associated with lower angular rates and lower Coriolis accelerations than in a centrifuge.

The most important advance of recent years with the potential to combat SD has been the use of tactile stimuli to give information on spatial orientation. The value of the Tactile Situation Awareness System (TSAS) (developed by the US Navy) has been shown to reduce errors in maintaining hover, in both actual and simulated helicopter flight, when TSAS was active and that the system reduced subjective workload. It was also shown to be effective in cueing TF climb/dive commands, tactical lateral steering and flight director guidance, and location of threats. Other simulator experiments have demonstrated the benefit of a tactile display in countering the decrement in performance in the hover that occurred when the pilot's workload was increased by a secondary task. These experiments substantiated the claim that tactile cues are 'intuitive' and are processed at a low level within the central nervous system and do not make claim on higher level resources. TSAS coupled to a GPS receiver has been shown to aid Special Tactics forces by indicating cross-track and glide slope errors during parachute descent, and, when on the ground, deviation from a pre-determined course and proximity to a designated

way-point. Tactile navigation cues have also been successfully employed by divers and pilots of high speed insertion craft to indicate deviation from track or of a craft's heading from that required to reach a target way-point.

Prevention of SD by the use of a system to monitor a pilot's functional state in order to detect any performance decrement was described. The proposed system would provide 'cognitive assistance' to the pilot and, if necessary, take over partial or full control of the aircraft if the pilot was incapacitated or flight safety compromised. The system is inchoate insofar as it has yet to be implemented in hardware. A number of laboratory experiments on visual displays and on perception of orientation of the visual vertical were presented. These were without immediate practical application but they have some relevance to the design of new head-mounted and cockpit displays.

The two descriptions of disorientation in land vehicles dealt with rarely encountered conditions, one a phobic postural vertigo of motor car drivers, the other an effect of the vibration and cyclical accelerations experienced by racing drivers. Difficulties of orientation and escape from the inverted hull of a rigid inflatable craft (RIC) identified the need for escape training comparable to that performed by helicopter crews.

Désorientation spatiale dans les véhicules militaires: causes, conséquences et remèdes

(RTO MP-086 / HFM-085)

Synthèse

La désorientation spatiale (DS) se caractérise, pour l'opérateur, par une incapacité à appréhender sa position, son attitude et sa trajectoire ou celles d'un véhicule, à l'intérieur d'un système de coordonnées fixes, déterminé par la surface de la terre et la verticale gravitationnelle. Depuis les premiers vols propulsés, les pilotes ont été affectés par la DS. Ses causes sont connues, des progrès ont été faits dans la distribution des informations et une plus grande importance a été accordée à l'entraînement DS et pourtant elle demeure encore la cause de nombreux accidents. Alors que le taux global d'accidents a progressivement diminué depuis 30 ans, celui lié à la DS est resté plus ou moins constant au cours des 15 dernières années. Une des raisons de ce niveau élevé pourrait être l'introduction de nouvelles technologies, telles que les lunettes de vision nocturne, qui permettent d'effectuer des missions dans des environnements inaccessibles auparavant. En raison de cette stagnation apparente dans la lutte contre la DS qui continue à entraîner des pertes d'avions et de vies humaines, la commission sur les facteurs humains et la médecine (HFM) a jugé opportun de réexaminer le sujet de la DS, à la lumière des nouvelles techniques et technologies qui pourraient être appliquées non seulement à la DS en vol, mais aussi à d'autres environnements militaires. Il a donc été décidé d'organiser à La Corogne, en Espagne, du 15 au 17 avril 2002 un Symposium intitulé « La désorientation spatiale dans les véhicules militaires : Causes, conséquences et remèdes » avec 32 présentations orales et 14 séances d'affiches.

Malgré le large domaine offert lors de l'appel aux textes de conférence, (opérations terrestres, maritimes et aériennes), l'essentiel des communications a porté sur la DS en vol. Les résultats de questionnaires distribués dans quatre pays ont confirmé la permanence des incidents DS dans l'aviation militaire et ont démontré que les causes principales étaient les illusions visuelles, le manque d'attention et d'éventuelle coordination entre membres d'équipage, en plus des illusions vestibulaires bien connues. Ces informations sont importantes tant pour l'entraînement que pour la compréhension d'accidents impliquant la DS. Huit communications portaient sur l'entraînement DS des équipages. L'utilisation au sol de dispositifs en rotation pour démontrer les différents types d'illusions est maintenant généralisée, mais la mise en œuvre, pour une démonstration réaliste de scénarios DS, d'un simulateur avec système de mouvement pour la simulation intégrale des missions semble intéressante.

Pour les avions de combat très manœuvrants, l'impact de la DS pendant et après les phases de combat est parfaitement admise mais encore mal documentée. Des simulations en centrifugeuse avec des pilotes soumis à des changements d'orientation corporelle à $+G_z$, et à des stimuli transitoires à $+G_z/G_y$ ou à $+G_z/G_x$, ont révélé de grandes différences entre les individus en matière de sensation et d'intensité de désorientation. Des travaux supplémentaires sont maintenant nécessaires pour identifier les normes de chaque type d'individus. Il sera possible de les comparer avec les observations effectuées en vol, où l'augmentation des accélérations $+G_z$ est associée à des vitesses angulaires moins élevées, ainsi qu'à des accélérations Coriolis moins fortes qu'en centrifugeuse.

L'avancée la plus importante enregistrée au cours des dernières années dans la lutte contre la DS a été l'emploi de stimuli tactiles pour donner des informations sur la désorientation spatiale. L'intérêt du Système Tactile de Conscience de la Situation (TSAS) (développé par l'US NAVY) a été démontré. Lorsque ce système est actif, on observe une réduction d'erreurs de maintien de vol stationnaire, tant en vol réel que simulé. En plus, le système a permis de réduire la charge de travail subjectif. Son efficacité a également été démontrée pour la signalisation des commandes piqué/cabré, le pilotage latéral tactique, le guidage du système central de vol, et la localisation de la menace. D'autres

expériences en simulateur ont démontré les avantages du visuel tactile, qui permet de compenser, en vol stationnaire, la baisse de performances entraînée par l'augmentation, par des tâches secondaires, de la charge de travail du pilote. Ces expériences ont confirmé que la signalisation tactile est « intuitive », qu'elle est traitée à un niveau inférieur du système nerveux et qu'elle ne sollicite pas des ressources de niveau supérieur. L'intérêt pour les Forces Tactiques Spéciales d'un TSAS associé à un récepteur GPS a aussi été souligné. Il permet d'indiquer d'éventuelles erreurs de position transversale et d'alignement de descente lors du parachutage, et une fois au sol des écarts par rapport à la route prévue à proximité d'un point de cheminement désigné. Les systèmes tactiles de navigation ont également été utilisés avec succès par des plongeurs et des pilotes de vedettes rapides pour indiquer des écarts d'itinéraire ou de cap pour se rendre à un point donné.

La prévention de la DS grâce à un système permettant de contrôler l'aptitude opérationnelle du pilote afin de détecter toute dégradation des performances a été décrite. Le système proposé pourrait fournir de « l'assistance cognitive » au pilote et, le cas échéant, prendre le contrôle partiel ou total de l'avion au cas où le pilote serait frappé d'incapacité soudaine ou lorsque la sécurité du vol serait compromise. Le système est incomplet dans la mesure où la réalisation matérielle reste à faire. Un certain nombre d'expériences de laboratoire sur des dispositifs de visualisation, ainsi que sur l'orientation de la verticale visuelle ont été présentées. Si celles-ci n'ont pas d'application pratique immédiate, elles paraissent adaptées pour la conception des nouveaux visuels de casque et les écrans du poste de pilotage.

Les deux descriptions de la désorientation dans les véhicules terrestres ont porté sur des conditions rarement rencontrées, à savoir le vertige postural phobique chez les conducteurs de voiture, et les effets des vibrations et des accélérations cycliques subies par les pilotes de course. Les difficultés rencontrées en cas de retournement de radeaux de sauvetage rigides (RIC) pour s'orienter sous les coques rigides et pouvoir évacuer, ont mis en exergue un besoin d'entraînement à l'évacuation comparable à l'entraînement des équipages d'hélicoptère.

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Acceleration stresses (physiology) Aerospace medicine Agile aircraft Air navigation Attitude (inclination) Attitude indicators Cognition Cognitive assistance Flight crews Flight simulators Human factors engineering Hypergravity Marine navigation Motion Motor vehicles Orientation	Perception Physiological effects Physiology Pilot training Rigid inflatable craft Sensory physiology Situational awareness Space perception Spatial disorientation Spatial information Spatial orientation Stimulus (psychophysiology) Tactile displays Vestibular sense Visual displays Visual perception				
14. Abstract					
<p>Spatial disorientation (SD), a condition in which the operator fails to sense correctly the position, motion or attitude of the vehicle or of him/herself, continues to be a cause of aircraft accidents, with accident rates that, unlike the overall rate, have not fallen over the past 15 years. The Symposium was convened to review current knowledge of the causes of SD and preventative measures, applicable to air, land and maritime environments. Thirty two oral and 14 poster presentations covered the following topics: Causal mechanisms; Operational and psychophysiological consequences of SD; Incidence of SD in air, land and maritime environments; SD training programmes and training devices; Cognitive and sensory aids for the maintenance of spatial orientation, with an emphasis on the use of tactile cues.</p>					

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