

## Seasickness, How It Affects Sailors and Relationships with Land and Air Motion Effects

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### **ABSTRACT**

*Seasickness or Mal de Mer is a very unpleasant experience, and most sailors, if all, had to cope with it. In its extreme form it leaves the victim unwilling to perform any task, even to assist in his or her own rescue. Motion sickness or cinetose is dependent on the magnitude of ship motion, but how it affects human operator is not unequivocal.*

*We will review the different factors, environmental, physiological and psychological, involved in cinetose genesis and how they influence human performance.*

*Application to land, air and space vehicles will be discussed.*

### **1.0 INTRODUCTION**

Seasickness or Mal de Mer is a form of motion sickness or cinetose, like airsickness, car sickness, amusement-park-ride sickness, motion-picture sickness, Mal de Débarquement, camel sickness, flight or ship-simulator sickness, virtual reality sickness, space sickness. Almost any normal subjects will suffer from cinetose as long as the motion stimuli applied to the individual or its environment (real or virtual) are reaching a certain intensity and last enough. Delay of symptoms apparition vary, from a few minutes to many hours depending on subject susceptibility. Although the underlying neurophysiologic mechanism is still obscure, current theory are still focusing on the “sensory conflict”. Cinetoses occurs when there is a mismatch between orientation information generated by various sensors (vestibular, auditory, visual...). But among the sensors involved, the vestibular system is required (subjects without functioning vestibular end-organs are immune to cinetose) [1].

### **2.0 CINETOSE SUSCEPTIBILITY**

There is a lot of inter-individual cinetose susceptibility differences as well as intra-individual differences. Age is an important factor: children are more susceptible than adults, with a peak susceptibility between 3 and 12, then susceptibility decrease to climb again after 60. Females are reported to be less resistant than males at any given age, with pregnancy and menses aggravating the occurrence of symptoms.

Besides gender and age other factors may influence and explain why individual cinetose susceptibility may fluctuate. Sleep deprivation, fatigue will increase the susceptibility. Adaptation is a major factor to develop cinetose tolerance. It requires about 3 days to develop at sea or in space.

*Paper presented at the RTO AVT Symposium on “Habitability of Combat and Transport Vehicles: Noise, Vibration and Motion”, held in Prague, Czech Republic, 4-7 October 2004, and published in RTO-MP-AVT-110.*

# Report Documentation Page

*Form Approved*  
*OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>01 OCT 2004</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>			
4. TITLE AND SUBTITLE <b>Seasickness, How It Affects Sailors and Relationships with Land and Air Motion Effects</b>		5a. CONTRACT NUMBER			
		5b. GRANT NUMBER			
		5c. PROGRAM ELEMENT NUMBER			
6. AUTHOR(S)		5d. PROJECT NUMBER			
		5e. TASK NUMBER			
		5f. WORK UNIT NUMBER			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Etat Major de la Marine Antenne Programmes BP 55 83800 Toulon Armées France</b>		8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)			
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)			
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>See also ADM201923, Habitability of Combat and Transport Vehicles: Noise, Vibration and Motion (L'habitabilite des vehicules de combat et de transport: le bruit, les vibrations et le mouvement). , The original document contains color images.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>UU</b>	18. NUMBER OF PAGES <b>6</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

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Positioning will influence severity of symptoms: lying down is reported to help cope with cinetose.

Fed subjects are also less immune from cinetose. Seven subjects submitted to Coriolis stimulation in a fasted situation displayed motion sickness after  $182 \pm 31.1$  head movements whereas if fed with yogurt it required only  $95 \pm 20.9$  head movements. [2] But these results are not unequivocal, in a recent study, cinetose symptoms induced by a rotating optokinetic drum were best prevented by ingestion of a liquid protein-dominant meal which was more effective than a carbohydrate beverage. In the same study, the no-meal condition lead to more severe cinetose symptoms compared to the fed condition [3].

Behavioral contagion seems to be also a very potent factor involved in cinetose, that was long suspected but never really addressed. Houchens and Jones examined data from four studies of cinetose [4]. Effect size for contagion was estimated at 14% in these studies. Behavioral contagion could explain why significant differences are observed for attrition rate due to air sickness in basic flight training or why cinetose occur more frequently in some simulators than others.

Type of motion will also influence severity of symptoms. Cinetose occurs with low motion frequency, usually below 2 Hz (usual motion frequency in different vehicles are reported in Table I below). Yaw stimulation produces stronger symptoms of cinetose than pitch. At sea vertical movements seem to be more potent than horizontal ones, with a critical frequency range between 0.1 and 0.5 Hz. We may relate this data to an experiment that was done with horizontal and vertical prisms. Subjects had to wear these reversing prism and move along. With the reversed vision in the horizontal direction, nine of ten subjects exhibited cinetose symptoms whereas with reversed vision in the vertical direction, none of the subjects suffered from cinetose. The authors explained that sensory mismatch by the role of vision for spatial orientation which is less important for vertical information than horizontal information. Vertical information depends on visual cues as well as gravity on proprioceptive and otolithic sensors. [5].

Visual stimuli can be a major contributing factor to cinetose. Illusion of self-motion (vection) can be induced by moving visual scenes. But vection effect and cinetose depend from different visual inputs. Vection is relying on peripheral vision (full-field stimulation), whereas cinetose depends on foveal vision. Vection and cinetose can vary independently, depending of the type of visual stimuli [6].

Therefore severity of cinetose will depend on individual's susceptibility, as well as behavioural contagion, characteristics of head movement and environments.

Table I

vehicles	Usual frequency range
car	0.8-1.3 Hz and 9-12 Hz
bus	0.8-2 Hz and 8 –12 Hz
trucks	1.5-4 Hz and 8 –12 Hz
trains	1-8 Hz
helicopters	3-6 Hz and 15-21 Hz
Commercial aircraft	0.2-7 Hz
Ships :	
Roll	0.1-0.3 Hz
Pitch	0.06-0.2 Hz

### 3.0 SYMPTOMS OF CINETOSE

Two states can be described in cinetose syndrome. In the initial phase, subjects are experiencing light headache, dizziness with stomach awareness, apathy, lethargy, pallor, cold perspiration, reduced core temperature, yawning, salivary changes, reduced heart rate and blood pressure, increased respiratory rate. Then the symptoms lead to nausea, vomiting, prostration, vertigo... The clinical variations observed are due to the individual sympathetic and parasympathetic activity with in most cases an increase sympathetic activity and a decrease parasympathetic activity. Adaptation to cinetose is accompanied by the recovery of autonomic nervous system balance.

Detrimental effects on cognitive processes, like short-term memory, are reported with exposure to whole-body vibration [7]. Even if these studies were conducted with frequency above the frequency range involved in cinetose, effects on decision-making process are more likely to occur, illustrated by apathy, lack of will to survive.

### 4.0 OPERATIONAL SIGNIFICANCE OF CINETOSES

The operational significance can lead to disastrous effects. Performance will be affected by cinetose, but survival can be at stake when motion sickness occurs during critical events.

- At sea many studies conducted on military ships as well as yacht races report a logarithmic decrease of Mal de Mer symptoms as days at sea increase. Sickness was greatest among female and younger crewmembers. [8]

Landolt and coll. reported how Mal de Mer can affect the well being but also the life of occupants of Totally-Enclosed Motor-Propelled Survival Craft (TEMPSC) [9]. In 1984, one 31 year-old man died following a rescue from its TEMPSC. Mal de Mer was a major contributor to his death. After successfully abandoning a damaged ship or offshore drilling unit, evacuees in an intact TEMPSC are submitted to specific stressors that may increase cinetose occurrence. These stressors include:

- Anxiety: due to the circumstances of the wreck.
- Large vertical motion: due to sea conditions and size of the craft.
- Overcrowded, poorly ventilated, small enclosure with little visual reference. It increases behavioural contagion, sensory mismatch, heat stress, nauseogenic odors.

Since TEMPSC occupants must survive sometimes for days before being rescue, Mal de Mer that is frequently experienced in these crafts (at least 75%), may endanger their survival. They could choke on inhaled vomit, or suffer from dehydration aggravated by uncontrolled vomiting, or while prostrated, unwilling to survive, they could just stop fighting for life.

- A survey was conducted on Bomber crews (B-1B and B52) during operational flights [10]. Pilots had the lowest airsickness incidence (5 %), whereas non-pilots crewmembers reported a frequency of airsickness of 76 %.
- Simulator sickness affects crewmembers on a very heterogeneous way, depending upon simulator type, cinetose may occurs with either fixed-base and motion-base flight simulator and rotary winged or fixed wing aircraft simulators. In France, on a motion helicopter simulator, up to 70% of pilots were subjected to cinetose symptoms [11]. Most of these symptoms, including dizziness (73%), postural disequilibrium (39%), vertigo (30%), nausea (30%) or sleepiness (12%), lasted less than 4 hours, and

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could affect in-flight performances. The frequency range that will more likely evoke simulator sickness is most probably around 0.06 Hz [12].

- Incidence of cinetose in space is closed to 70% for first flight crewmembers, with nearly half of the cases graded mild, 35% moderate and 11% severe. Symptoms develop within the first 6 hours of spaceflight, with a peak in 24-48 hours and usually resolve over 3-4 days.

### 5.0 COUNTERMEASURES FOR CINETOSE

Different types of countermeasures are available.

- Many pharmacological compounds are or were used, including promethazine, dimenhydrinate, scopolamine, terfenadine, flunarizine. Most of these drugs have side effects that can lead to decrement of performances.
- A behavioral approach can also be used including biofeedback relaxation therapy, ground-based training and in-flight desensitization therapy.
- Acupressure and acustimulation bands may also be used, but the latest studies do not show any significant protection from cinetose symptoms compared to placebo. [13-14]

### 6.0 CONCLUSIONS

Cinetose may affect any operator or “passenger “ of any type of military vehicle, but also operators or subjects submitted to virtual motion like in flight, bridge or armored vehicles simulators or drones-UAV operators. Physical or cognitive performances of these operators while conducting their task can significantly decrease, and put their mission at risk. The human payload, i.e. military personnel (paratroopers, marines, foot soldiers), deployed by aircraft, land or sea vehicles may be incapacitated during their transport and unfit to complete their operational tasks when disembarking from such vehicles. Therefore preventive measures to minimize cinetose must be implemented from design of vehicles, to operational procedures and personnel training.

- [1] Cheung BSK, Howard IP, Money KE. Visually-induced sickness in normal and bilaterally labyrinthine-defective subjects. *Aviat Space Environ Med.* 1991 ;32 :527-31.
- [2] Stewart JJ, Wood MJ, Wood CD. Electrogastrograms during motion sickness in fasted and fed subjects. *Aviat Space Environ Med.* 1989 ;60 :214-7.
- [3] Levine ME et Coll. Protein-predominant meals inhibit the development of gastric tachyarrhythmia, nausea and the symptoms of motion sickness. *Aliment Pharmacol Ther.* 2004;19(5):583-90.
- [4] Houchens PW, Jones MB. Behavioral contagion in an experimental motion environment. *Aviat Space Environ Med.* 2003 ;74 :649-53.
- [5] Takahashi M et coll. Locomotion and motion sickness during horizontally and vertically reversed vision. *Aviat Space Environ Med.* 1991 ;62 :136-40.
- [6] Webb NA, Griffin MJ. Eye movement, vection, and motion sickness with foveal and peripheral vision. *Aviat Space Environ Med.* 2003 ;74 :622-5.

- [7] Sherwood N, Griffin MJ. Effects of whole-body vibration on short-term memory. *Aviat Space Environ Med.* 1990 ;61 :1092-7.
- [8] Turner M, Griffin MJ. Motion sickness incidence during a round-the-world yacht race. *Aviat Space Environ Med.* 1995 ;66 :689-56.
- [9] Landolt LP, Light IM, Greenen MG, Monaco C. Seasickness in totally-enclosed motor propelled survival craft: five offshore oil rig disasters. *Aviat Space Environ Med.* 1992 ;63 :138-44.
- [10] Strongin TS, Charlton SG. Motion sickness in operational bomber crews. *Aviat Space Environ Med.* 1991 ;62 :57-9.
- [11] Burlaton JP et Coll. Enquête sur le mal des simulateurs. *Médecine Aéronautique et Spatiale.* 1998. 148 :248-52.
- [12] Duh HB et Coll. « Conflicting » motion cues to the visual and vestibular self motion systems around 0.06 Hz evoke simulator sickness. *Hum Factors.* 2004;46:142-53.
- [13] Bruce DG et Coll. Acupressure and motion sickness. *Aviat Space Environ Med.* 1990 ;61 :361-5.
- [14] Miller KE, Muth ER. Efficacy of acupressure and acustimulation bands for the prevention of motion sickness. *Aviat Space Environ Med.* 2004 ;75 :227-34.

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### Detailed Analysis or Short Description of the AVT-110 contributions and Question/Reply

The Questions/Answers listed in the next paragraphs (table) are limited to the written discussion forms received by the Technical Evaluator. The answers were normally given by the first mentioned author-speaker.

#### KN2 B. Sicard.' Seasickness. How it affects Sailors and Relationships with Land and Air Motion effects' (EM Marine-FR)

This second KN reviews the different factors, environmental, physiological and psychological, involved in cinétose genesis and how they influence human performance. The cinétose mostly occurs at low frequency (a few Hz – 1 / 4 – 8 / 12 in trucks, 3 / 6 – 15 / 21 in helicopters, 0.2 / 7 in commercial aircrafts, 0.06 / 0.3 on ships). The author drew our attention on the fact that the cinétose also affects subjects trained on virtual simulators as well as UAV operators, concluding that preventive measures to minimize the cinétose (motion sickness) have to be implemented from the design of the vehicles on and to operational procedures and personnel training.

##### Discussor's name: C. Petiau

Q. Avez-vous mis au point des critères limites de mouvement en dessous desquels il n'y a plus de cinétose?

R. Non car il y a de très fortes variations interindividuelles avec une implication forte des facteurs psychologiques. La finalité n'est d'autre part pas la prévention des cinétoses mais le maintien des performances.

##### Discussor's name: M.A. Ksiazek

Q. Comment estimez vous actuellement la bande de fréquence du mal de mer? Faudra-t-il, selon vous, modifier les normes internationales y relatives?

R. Cela intéresse les armateurs civils pour lesquels la prévention des cinétoses est critique pour les passagers payants. La marine de combat s'intéresse plutôt au maintien des performances qui est fonction des tâches des opérateurs.