Symposium Paper

AEROMEDICAL PROBLEMS OF HIGH SPEED LOW ALTITUDE FLYING

Visual Problems in High Speed Low Level Flying

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Introduction

ALTHOUGH the modern jet aircraft are designed and equipped to reach higher altitude at faster speed, missions like reconnaissance, ground attack and escape from enemy radar detection, have brought in a newer concept called DPSA, with capabilities of long range flights at transonic speeds at tree top heights. Certain peculiar visual problems are often encountered under such flight conditions and with higher complexities of flying tasks, increase in visual loads often necessitates automation of various controls to relieve the pilot to some extent. Most of the DPSA have automatic computer controlled systems, which enable them to be flown almost blind, following the terrain closely at specified heights in all weather conditions. To fulfil this stringent requirement, the most advanced NAWASS (Navigation, Weapon Aiming Sub-System) available at the moment, has been fitted in certain aircraft. All the instrument data and navigational instructions are shown on the associated Head up display (HUD) and a quick glance will confirm the exact location on a projected map display. Whether such systems are foolproof and whether such displays can be pro perly interpreted under stress, considering human re actions, are basic and vital questions. However, it certain that in manned flight, most of the critic tasks will continue to be performed under visual con trols in spite of the automation achieved.

Visual Problems

Visual problems of low level high speed flig can be discussed under four broad groups :

(a) Visual capacities,

(b) Ageing,

(c) Aircraft design and

(d) Environmental factors.

Limitations of Visual Capacities

(*i*) *Reaction time :* Problems of visual percep tion increases with increasing speed of aircraft. Th pilot cannot perceive, identify and act the instant a object enters his field of view[3]. Each of these tak time as shown in Table I. In terms of distanc travelled during perception time of 5.5 sec, it will b

TABLE I

Time intervals and distance travelled between first sighting an object and change of flight paths (After Byrenes[1])

Operations	Time in seconds		Progressive distance travelled in fe		
	For operation	Progressive total	At 600 mph	At 1800 mph	At 3600 mph
1. Perception and extrafoveal to foveal perception (minimum recognition)	1.045	1.045	424	2,754	5,544
2. Decision and motor response	2.40	3.445	3,032	9,095	18,090
3. Aircraft response	2.0	5.445	4,792	14,375	28,750

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TABLE II

Pick up range for a fighter aircraft (Fuselage Diameter 34") and the intervals at (1800 mph) for various visual acuities

Visual acuity	Pick up range (miles)	Time Interval (seconds)
6/12	2.2	4.4
6/9	2.9	5.9
6/6	4.4	8.9
6/5	5.3	10.7
6/4	6.6	13.3

5 miles at 3600 mph and to avoid collision, he should site it at least 6 miles away[9]. If he has to identify an enemy aircraft, it takes another 1-2 seconds. Similarly, shifting the sight from outside to inside the cockpit and back will take 2.5 seconds which means 3 miles of blind flying. The fact that time of accommodation increases with age must also be considered in terms of distance travelled in old pilots. Relationship of static visual acuity to pick up range shows that 6/9 vision is consistent with 5.9 sec. of perception time (Table II).

(ii) Blur zone: Visibility of objects flashing past under high speed low level flying depends upon what has been termed 'Dynamic Visual Acuity.' Its upper threshold is 100°/sec. beyond which it becomes impossible to see an object of specific size and contrast. This is illustrated in Fig 1 (a) and Fig 1 (b). Inside the blur zone, the pilot cannot see any details, whereas outside it he can discern details. At higher velocities, the blur zone increases in direct proportion to speed and inversely with altitude. Inflight experiments have shown that it takes 0.2 sec for the eye to follow a moving target. Thus for recognition of an object, the distance covered during the reaction time has to be added to the blur zone. The shaded area in Fig. 2 shows the extent of static visibility.

(iii) Vibration: Visual decrement in the frequency range less than 2Hz are minimal, since there is little relative movement of the eye with respect to the instrument under operational conditions[6]. Vibrations of higher frequency may result in blurring of displays and the pilot may be forced to ignore all but the very critical instruments. In 2—12 Hz at an amplitude of 0.5G, there is significant visual decrement. The next peak is in the range 25—40Hz. These higher frequency responses are of limited practical significance. Kapoor[4] found that decrement was more when both the subject and objects were vibrating. Another comparative study showed that decrement was more with vertical display for Gz vibration. The inertia reel locking mechanism of the restraint system is motivated at higher frequencies of vibration (i.e. above 12Hz) which affords protection against very high amplitude oscillations.

(iv) Depth Perception: In making judgements of depth perception, computer-like summation takes place of various clues, mostly without conscious

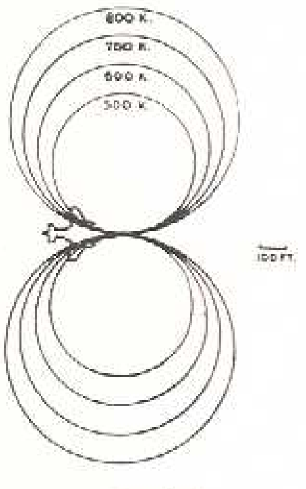

Fig. 1(a)
Effect of speed on blur zone at 0 feet (Threshold 100°/sec.) (From Mercier et al[5]).

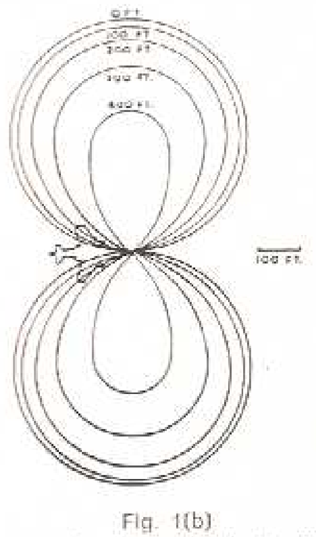

Fig. 1(b)
Effect of height on blur zone (Velocity 600 K; threshold 100°/sec.) (From Mercier et al[5]).

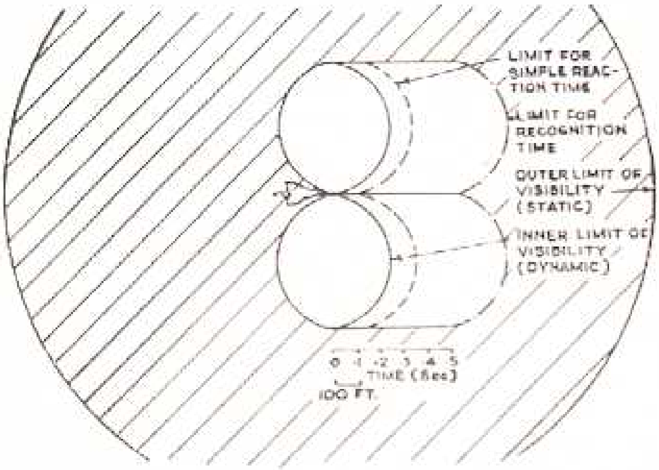

Fig. 2
Effect of height on blur zone (600 K ; 100'/sec. ; for Object 0.97 ft. diameter) (From Mercier et al[5]).

thought. This ability is enhanced by experience. With increasing duration of flight under such conditions, there seems to be progressive deterioration in judgement of height above ground. This difficulty in estimating altitude is especially evident if the pilot had to descend rapidly from high altitude to carry out the low level phase of his flight. It is advisable, when circumstances permit, to descend slowly prior to a reconnaissance sortie. In our experience, decompensation of heterophoria under stress situations is quite common, leading to poor BSV in aircrew[7]. The precipitating factors are anxiety, fatigue, metabolic disorders and head injury[6]. Titmus fly test for near vision in presbyopic subjects has also shown deterioration of stereo-acuity with age.

(v) Acceleration : Both types of linear or angular acceleration at high speed can be associated with illusions of movements or altered attitude of the aircraft. When, in addition, head movement takes place during the acceleration, it gives rise to coriolis effect in the semicircular canals and produces motion sickness.

(vi) Night vision : Night vision assumes greater importance in low level combat flights at night because of ground source of disturbing lights like exploding shells, flares, search lights etc. which destroys dark adaptation. Factors influencing night vision are congenital night blindness, retinitis pigmentosa, Oguchi's disease, Chorioretinitis, glaucoma, oxygen lack, CO accumulation and vit 'A' deficiency. Smoking of 3-4 cigarettes just before a night sortie can reduce visual threshold equal to approximatel 7000 ft altitude. Fatigue and alcohol also affect adversely.

(vii) Illusions and Visual Phenomenon : Purkin phenomenon which causes change in the relativ apparent brightness of colours and auto kinetic illu sions causing apparent movement of stationary light get further aggravated during high speed flying. Th will affect target detection and formation flying.

(viii) Scanning : Binocularly the visual fie extends 200° laterally and 130° vertically. But mo of the vision in this area is of 6/60 except in the cen ral area where the foveal vision is of 6/6. Thus, for and motion are seen in the periphery while details a seen in the centre. Scanning requires foveal fixatic for at least one second for proper visualizatio Thus with increasing speed this task becomes mo difficult in detection of target in the air or on th ground.

Ageing

Opacities in the media, retinal diseases ar refractive errors reduce vision. Such changes a often seen in elderly pilots in whom failing accon modation and convergence add to difficulties in quic change of focus from distance to near and vice-vers This produces severe eye strain and may even resu in breakdown of BSV with dangerous consequence

Visual Problems related to Cockpit Design

Cockpit Lighting : As instrument displa systems become more vital in high speed low altitu aircraft, adequate cockpit lighting becomes essentia Duel lighting system (i.e. white lighting with dimmer control and red flood lighting) are ideal f cockpit visual environment. This helps in da adaptation as well as in reading the maps and dial

Visual Problems related to Environmental Factors

(i) Temperature : Low level flights cause considerable rise in cockpit temperature due to kin tic heating and the raised ambient temperature, speci lly under hot humid conditions. The heat stress oft leads to profuse perspiration and ocular fatigue part of general fatigue. Besides, it can also le to foggy glasses and visors obstructing vision.

(ii) Atmospheric Visibility : Detection of a other aircraft or ground targets becomes difficult low level high speed flights due to the reduc

atmospheric transmission and poor back ground contrast against which they are seen. Weather conditions, time of flight, terrain and camouflage techniques considerably modify the detection problems encountered. The scatter of light through mist, surface water, sand and snow create dazzle, which if present for more than a few minutes, can seriously impair visual functions on such missions. At high speed, the optical characteristics of the windscreen can be altered by rain, rain forming ripples, smears, layers of insects impacted and shock waves. This leads to image displacement and reduced visibility resulting in landing errors. Objects appear lower than they actually are, so that the pilot may overcorrect and come on a lower glide path than he should. Prevention lies in wind shield wipers, pneumatic rain removers and chemical rain repellant. Outside visibility is affected adversely by poor illumination, haze, fog, rain and un-familiar surroundings.

Conclusion

Low level high speed flying induces a large number of visual stresses on the pilot. To match the visual functions required for such occasions proper opthalmic evaluation of a pilot has become essential to determine baseline visual parameters and repeated examination to detect earlier deterioration. Modernisation of evaluation techniques has to be introduced in such a situation.

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