Original Article

Assessment of visual field restriction (due to modification) in Helicopters by a trigonometric model in field conditions

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ABSTRACT

Most of the helicopters used in armed forces, due to its varied requirements and roles require some modification. One such modification was carried out in one of the HU in Western sector where helicopters were modified with ATGM Gyro sight and GPS for ATGM (Anti Tank Guided Missile) role.

These two modification were posing a great deal of visual field restriction. To assess the magnitude of the extent of restriction a TRIGONOMETRIC model was envisaged. With the help of this model the extent of blind zone can be forecasted for different sitting heights.

Trigonometric model in this study can accurately assess the restriction in all round peripheral (ambient) vision. In the present study it is seen that inferior quadrant of ambient vision is also restricted and reflected as a blind zone in front of the aircraft. The blind zone normally created by instrument panel increases due to installation of GPS. In vertical meridian, due to GPS, an aviator up to the sitting height of 84.5 cms, will not be able to see the horizon and with sitting height of 85 cms the blind zone will be 343.8 mtrs in front of the aircraft. If GPS is not installed the blind zone with these sitting heights will be 22.85 mtrs and 21.45 mtrs respectively. While flying the length of blind zone will correspondingly increase.

Due to ATGM Gyro sight any aviator having sitting height more than 88 cms will not be able to see any object/aircraft flying over the horizon along the arc of 107° to 135° to pilot and 70° to 118° to the co-pilot. Aviator having sitting height more than 90 cms with blind zone beyond 70 mtrs along arc subtended and this distance will decrease as per increasing sitting height.

The visual field restriction posed by these two modifications is quite significant and in order to have a good outiside visual envelop aviator will be tempted to move his head frequently which may lead to disorientation.

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KEY WORDS: Helicopter flying; Blind zone.

Since the development of rotary wing aircraft, its flying has been full of problems. Helicopter development has always lagged behind that of fixed wing aircraft. After second world war, there was resurgence in the interest in rotary wing aircraft because of its high manoeuvrability and low flying capability. Due to which its use in military has been of paramount importance. To meet various military requirements there is always some requirement of modifications on existing structure, which poses extra restriction on various human factors limitations. One such modification was carried out in a Chetak Helicopter for ATGM (Anti Tank Guided Missile) role, mounting of which along with GPS (Global

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Positioning System) posed a significant restriction in visual envelop of aircrew.

Aims: Aim of this study was to evaluate visual field restrictions posed by these two modifications and preparation of a MATHEMATICAL MODEL to forecast the extent of visual field restrictions in aircrew population.

Material and method

Present study was carried out at an Air Force base in western sector in 1995 where Chetak helicopters in one of the HU were modified for ATGM role in desert terrain. To carry out this specialised task, Chetak helicopters were fitted with ATGM (Anti Tank Guided Missile) Gyro gunsight (Slide 2) which was installed in place of centre perspex on the roof of aircraft cabin, the width of which is 60 cms.

For navigation in desert terrain GPS (Global Position System) is mounted on top of instrument panel. The dimensions of the GPS are width - 15 cms, thickness 7.5 cms, length 3.5 cms. It is mounted with its long axis anteroposteriorly on the top of instrumental panel.

Assessment of blind zone created by modification

To study the restriction caused by installation of GPS and ATGM Gyro gun sight in Chetak Helicopter preparation of a Mathematical model (Trigonometric model) was envisaged by which the quantum of restriction would be assessed in an aircrew population and an approximate forecast could be made possible for a particular pilot sitting height.

Basic considerations

For preparation of mathematical model and calculations in this study following basic considerations were taken:

i) Aircraft at level

ii) Eye Level Height (ELH) is taken 15 cms less than sitting height. Eye Level Point (ELP) is taken 20 cms anterior to seat back rest and shifts up and down parallel to seat back rest for various sitting heights along the centre of the seat rest.

iii) All the calculations and preparation of the model is as per sitting height of 85 cms (ELH of 70 cms)

iv) For description 90 degrees, 0, 360 degrees and 180 degrees corresponds to 12 O' clock, 9 O' clock and 3 O' clock of aviation terminology.

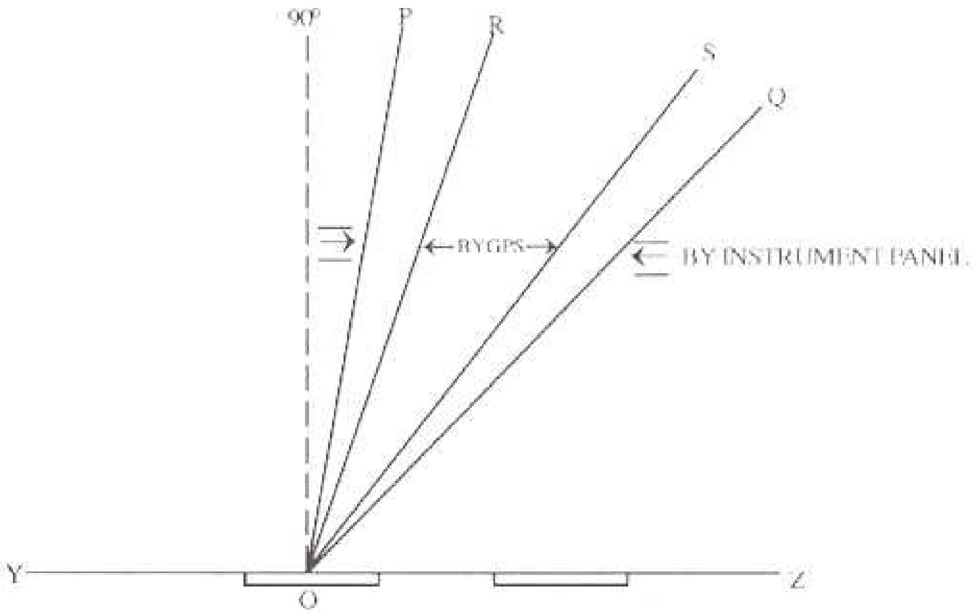
v) Aircrew seats at centre position of the railing.

Essential physical measurements of aircraft

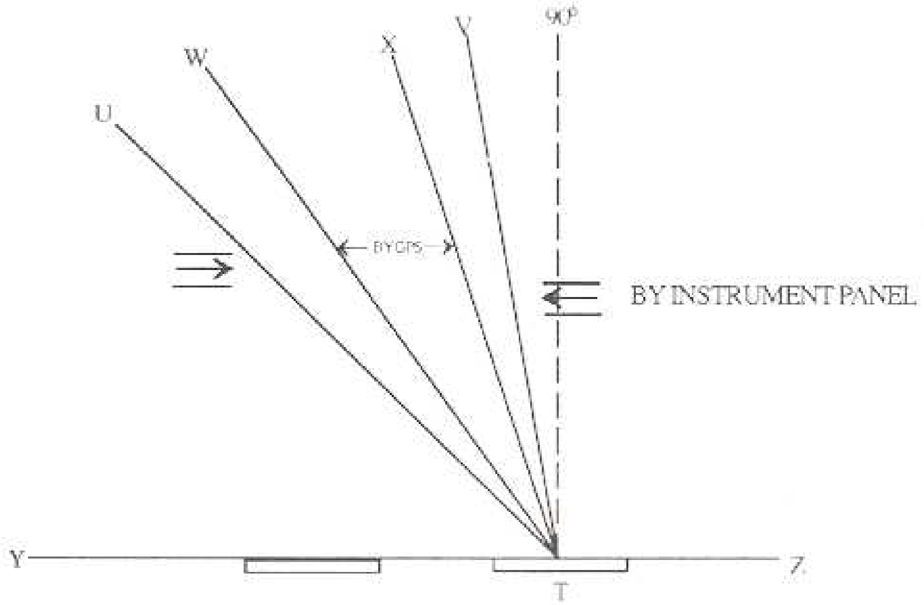
i)	Height of aircraft cabin from the ground (AB) fig 3 & 4	85 cms
ii)	Height of seat pan from aircraft cabin (BC)	25 cms
iii)	Horizontal distance of instrument panel and GPS from ELP (EF & JH) fig 3&4	95.5 cms
iv)	Vertical height of instrument panel (GF)	87 cms
v)	Vertical height of GPS (GH) fig. 4	94.5 cms
vi)	Horizontal distance of ant. end of ATGM Gyrosight (IH") fig. 6	80 cms
vii)	Vertical height of ant. end of ATGM Gyrosight (IG) fig. 6	98 cms

Procedure

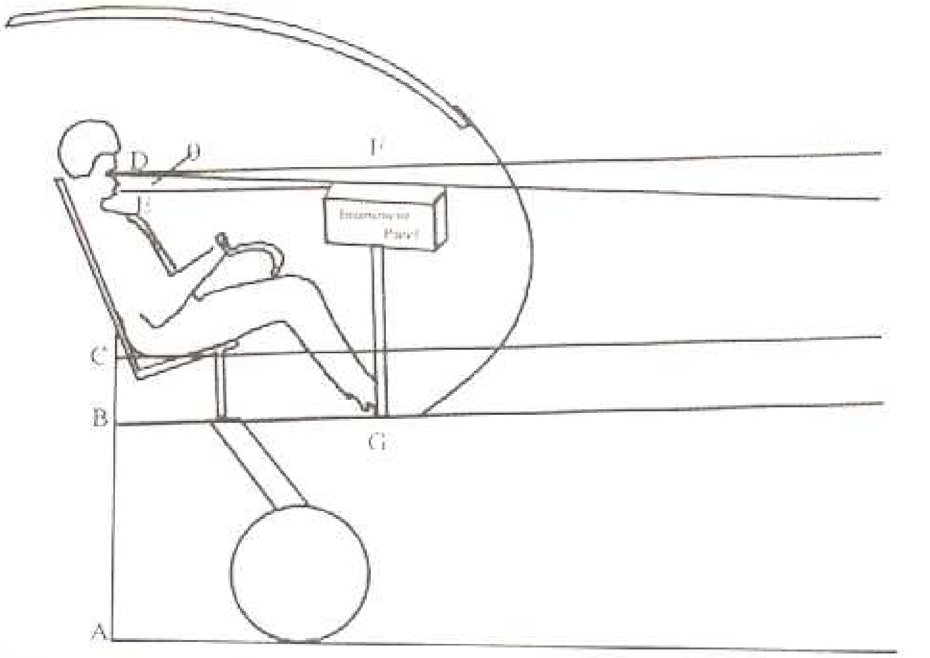
First of all aircraft cabin was made level with the help of inclinometer. The eye level point (ELP)



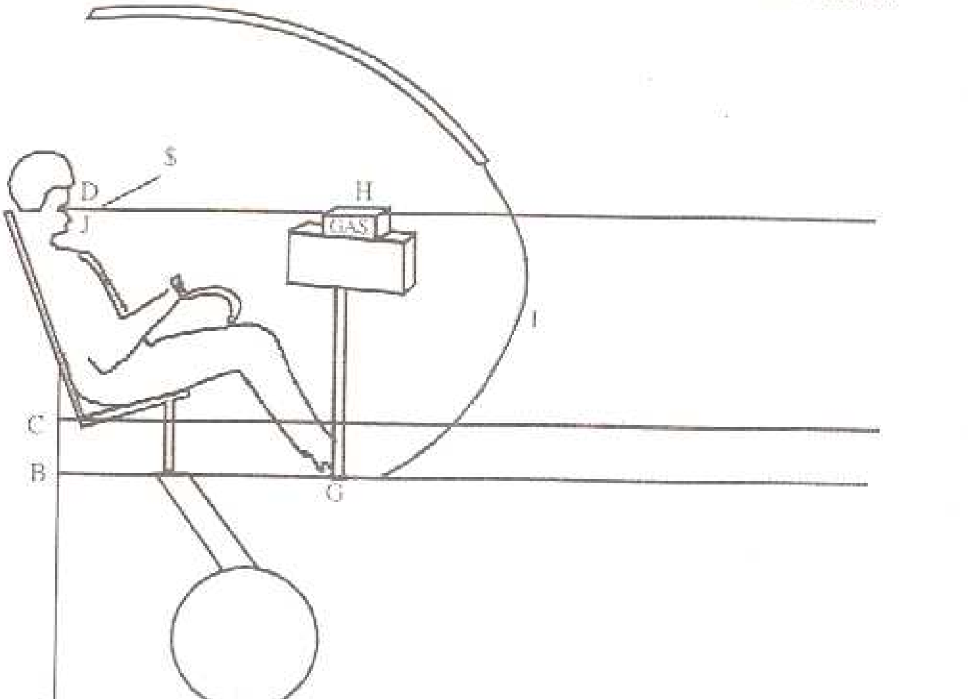
OBSTRUCTION IN OUTSIDE VISUAL ENVELOP HORIZONTAL MERIDIAN (CO-PILOT)



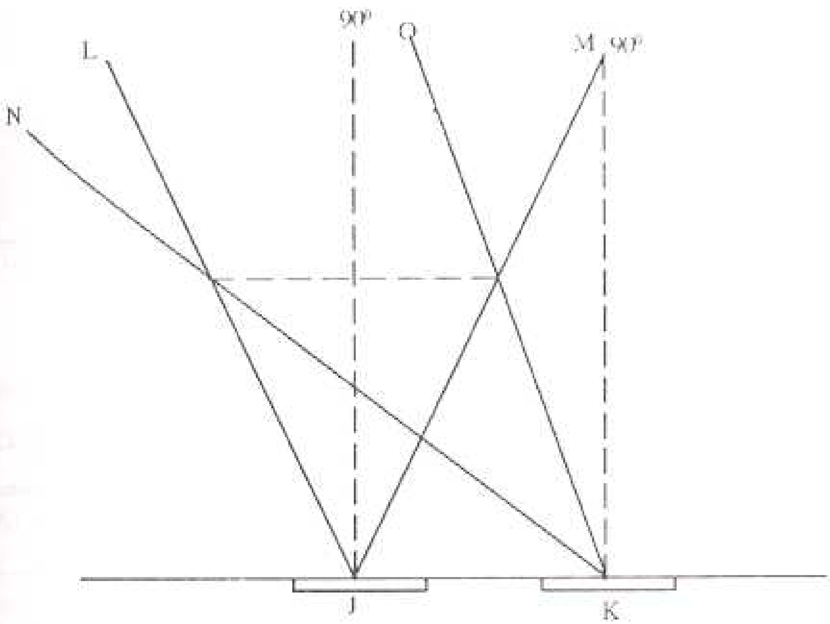
OBSTRUCTION IN OUTSIDE VISUAL ENVELOP HORIZONTAL MERIDIAN (PILOT)



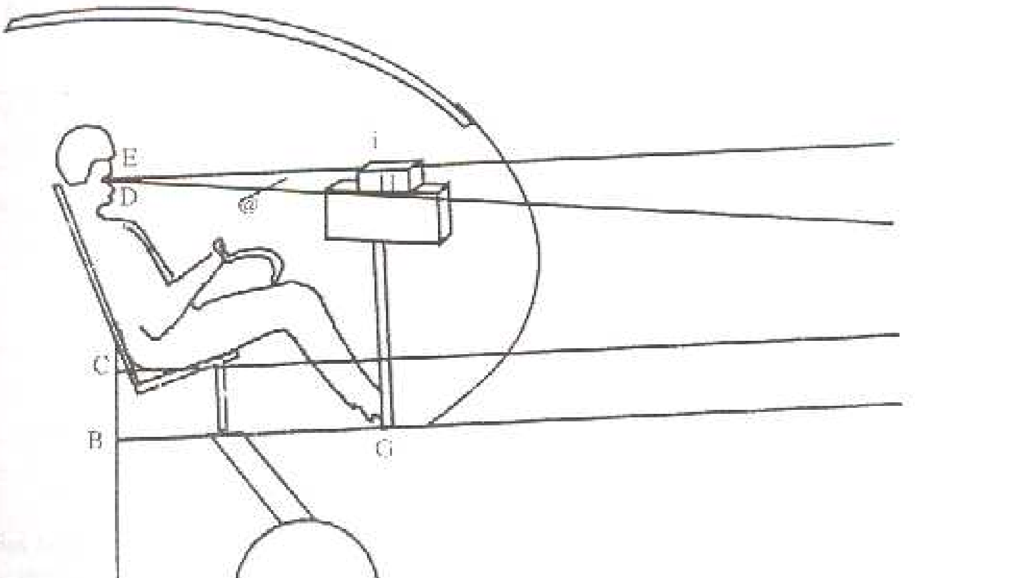
OBSTRUCTION IN OUTSIDE VISUAL ENVELOP DUE TO INSTRUMENT PANEL



OBSTRUCTION IN OUTSIDE VISUAL ENVELOP DUE TO GPS (VERTICAL MERIDIAN)



OBSTRUCTION IN OUTSIDE VISUAL ENVELOP BY ATGM HORIZONTAL MERIDIAN



OBSTRUCTION IN OUTSIDE VISUAL ENVELOP DUE TO ATGM SIGHT (VERTICAL MERIDIAN) for both pilot & co-pilot were determined with the help of two non stretchable cotton threads fixed horizontally and vertically on the airframe crossing each other at ELP. All the measurements of all distances and angles were measured from this point.

From ELP another non stretchable thread was attached to the inner most, outer most and top most edges of GPS, Instrument panel and ATGM Gyro sight and the angle thus subtended at ELP was measured with the help of inclinometer and protractor. All these angles and distances were measured for pilot's and co-pilot's ELP separately.

Observation and results

(a) Restriction in visual field due to instrument panel:

i) In horizontal meridian: (Fig 1 & 2)

The arc of blind zone created by instrument panel is given in Table - 1

Table 1: Restriction in visual field in horizontal meridian

	By instrument panel in degrees
Pilot (Fig. 2)	100° —— 128° (LVTV)
Co-Pilot (Fig. 1)	42° —— 84° (LPOQ)

L denotes Angle

ii) In vertical meridian: (Fig 6)

The restriction due to Instrument Panel in vertical meridian can be calculated by:

$$\text{Tan}\theta = \frac{\text{Perpendicular}}{\text{Base}} = \frac{EF}{De} = \frac{95.5}{8.0} = 11.9$$

Angle θ = 11.93 Tan^{-1} = 85.21°

The arc of blind zone will be projected (90° – 85.21°) 4.78° downwards to the horizontal plane.

iii) Length of blind zone created by instrument panel:

$$\text{Tan } \theta = \frac{X\ (AA'')}{\text{Total height of ELP from the ground (AD)}}$$

$$= \frac{X}{180}$$

X = 180 >< Tan O
= 180 >< 11.93 = 2147.4 cms (21.47 mtrs)

The length of blind zone in front of aircraft will be 21.47 mtrs for the pilot from 100° – 128° and for Co pilot from 42° – 84°.

b) Restriction due to GPS:

i) In horizontal meridian: (fig 1 & 2), shown in table - 2

Table 2: Restriction due to GPS in horizontal meridian

	Restriction due to GPS in Horizontal Meridian
Pilot	106° – 120° (LXTW)
Co-Pilot	35° – 75° (LROS)

L denotes Angle

ii) In vertical meridian:

$$\text{Tan } \$ = \frac{JH}{DJ} = \frac{95.5}{0.5} = 191$$

Angle \$ = 191 Tan – = 89.70

Therefore the projection of blind zone will be 0.3° (90° – 89.7°) downwards from the horizontal

iii) Length of blind zone by GPS:

Suppose length of blind zone created by GPS is X'' (AA'')

$$\text{Tan } \$ = \frac{X'' \text{ (AA'')}}{\text{AD (Total height of ELP from the ground)}} = \frac{X''}{180}$$

$$= \frac{X}{180}$$

$$X' = 180 \times \text{Tan } \$$$
$$= 180 \times 191 \quad 34380 \text{ cms} = 343.80 \text{ mtrs}$$

Therefore the aviator of 85 cms sitting height will have a blind zone of 343.80 mtrs in front of aircraft, pilot from 106° to 120° and co-pilot from 35° to 75°.

Based on its mathematical model the extent of blind zone by instrument panel and GPS in vertical meridian can be calculated for various sitting heights by following formula.

$$\text{Length of blind zone} = \frac{\text{Total height of EDP from ground} \times \text{Horizontal distance between EDP to the top of obstructing instrument}}{\text{ELH from cabin floor} - \text{Vertical height of obstructing instrument}}$$

Table 3 : Length of blind zone by instrument panel and GPS

Sitting Ht. in cms	ELH (BD) from floor of cabin BD = (A−15+25)	Difference between BD & GF	Total ht. ELH from ground (DA)	Difference between BD & GH	Blind zone created in mtrs	
					Instrument panel	GPS
80	90	03	175	− 4.5	55.70	infinitive
85	95	08	180	0.5	21.47	343.80
90	100	13	185	5.5	13.59	32.92
95	105	18	190	10.5	10.00	17.21
100	110	23	195	15.5	08.09	12.77
105	115	28	200	20.5	06.82	9.31
110	120	33	205	25.5	05.93	7.67
115	125	38	210	30.5	05.27	6.57

The length of blind zone created by instrument panel and GPS has been shown in Table No. 3.

c) Restriction in outside visual envelop due to ATGM gyrosight:

i) In horizontal meridian. As shown in Table no. 4

Table 4: Angle subtended by outer edges of ATGM gyro sight to ELP

	Angle subtended
Pilot	107° 133° (LOKN)
Co-Pilot	70° − 188° (LMJL)

ii) In vertical meridian:

$$\text{Tan}@ = \frac{(H)}{(HD)} = \frac{3}{80} = 0.0375$$

Angle @ = 0.0375 Tan $@^{-1}$ = 2.14°

Therefore an aviator with sitting height of 85 cms will not be able to see an object subtending an angle of > 2.14° above horizontal.

Based on these observations, length of blind zone created by ATGM gyro sight can be predicted for various sitting heights as given in Table - 5.

Discussion

Vision is the most important sensory cue to maintain orientation in flight. It contributes 80% of sensory inputs to maintain orientation. If this important cue is degraded or restricted by any modification or change it may lead to Disorientation [1,2]. It is the ambient vision which is more important for orientation. In this study it is the ambient vision which is restricted maximum.

Trigonometric model created in this study can accurately assess the restriction in peripheral (ambient) vision. In present study it is seen that inferior quadrant of ambient vision is also restricted and reflected as a blind zone in front of the aircraft. The blind zone normally created by instrument panel increases due to installation of GPS. In vertical meridian due to GPS, an aviator up to the sitting height of 84.5 cms will not be able to see the horizon and with sitting height of 85 cms the blind zone will be 343.8 mtrs in front of the aircraft. If GPS is not installed the blind zone with these sitting heights will be 22.85 mtrs and 21.45 mtrs respectively. While flying, the length of blind zone will correspondingly increase.

Due to ATGM Gyro sight any aviator having sitting height more than 88 cms will not be able to see any object / aircraft flying over the horizon along the arc of 107° to 135° to pilot and 70° to 118° to the co-pilot. Aviator having siting height more than 90 cms with blind zone beyond 70 mtrs along arc subtended and this distance will decrease as per increasing sitting height.

Table 5 : Angulation and length of blind zone created by ATGM

Sitting Ht in cms (A)	ELH from floor of cabin (B) = A-15+25	Total ht of ELP from grnd © (AD)	Difference between B & Ht of ATGM (GI)	Angle subtended in degrees	Length of blind zone in mtrs
80	90	175	08	5.71	Beyond infinitive
85	95	180	03	2.14	----
90	100	185	-2	1.43 V	> 70.00
95	105	190	-7	5.01 V	> 21.75
100	110	195	-12	8.54 V	> 13.00
105	115	200	-70	11.99 V	> 9.40

Denotes above horizontal; V Denotes below horizontal; > Denotes beyond

The visual field restriction posed by these two modifications is quite significant and in order to have a good outside visual envelop aviator will be tempted to move his head frequently which may lead to disorientation [1,2,3,4].

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