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 outside 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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Ind J Aerospace Med 44(1), 2000
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 Positioning 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 gunsight 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 (GP) 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)
Assessment of visual field restriction: Bautola et al

Obstruction in outside visual envelop horizontal meridian (co-pilot)

Obstruction in outside visual envelop horizontal meridian (pilot)

Ind J Aerospace Med 44(1), 2000
- Assessment of visual field restriction: Butola et al

OBSTRUCTION IN OUTSIDE VISUAL ENVELOP DUE TO INSTRUMENT PANEL

OBSTRUCTION IN OUTSIDE VISUAL ENVELOP DUE TO GPS (VERTICAL MERIDIAN)
OBSERVATION IN OUTSIDE VISUAL ENVELOPE BY ATGM HORIZONTAL MERIDIAN

OBSERVATION IN OUTSIDE VISUAL ENVELOPE 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>
<thead>
<tr>
<th>Table 1: Restriction in visual field in horizontal meridian</th>
</tr>
</thead>
<tbody>
<tr>
<td>By instrument panel in degrees</td>
</tr>
<tr>
<td>Pilot (Fig. 2) 100° — 128° (LVTV)</td>
</tr>
<tr>
<td>Co-Pilot (Fig. 1) 42° — 84° (LPOQ)</td>
</tr>
</tbody>
</table>

L denotes Angle

ii) In vertical meridian: (Fig 6)

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

\[
\text{Perpendicular over Base} = \frac{EF}{8.0} = 11.9 \quad \text{°}
\]

\[
\text{Angle} \theta = 11.93 \text{ Tan}^{-1} = 85.21°
\]

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

ii) Length of blind zone created by instrument panel:

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

\[
X = \frac{X}{180} = 180 < \tan \theta = 11.93 = 2147.4 \text{ cms (21.47 mtrs)}
\]

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>
<thead>
<tr>
<th>Table 2: Restriction due to GPS in horizontal meridian</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restriction due to GPS in Horizontal Meridian</td>
</tr>
<tr>
<td>Pilot 106° - 120° (LXTW)</td>
</tr>
<tr>
<td>Co-Pilot 35° - 75° (LROS)</td>
</tr>
</tbody>
</table>

L denotes Angle

ii) In vertical meridian:

\[
\tan \theta = \frac{\text{JH}}{\text{DJ}} = \frac{95.5}{0.5} = 191
\]

\[
\text{Angle} \theta = 191 \text{ Tan} = -89.70
\]

Therefore the projection of blind zone will be 0.3° (90° - 89.70°) downwards from the horizontal

iii) Length of blind zone by GPS:

Suppose length of blind zone created by GPS is X" (AA"")
**Assessment of visual field restriction: Butola et al**

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

\[
\frac{X}{180} \\
\]

\[
X' = 180 > < \text{Tan} \, S \\
\rightarrow = 180 > < 191 \quad 34380 \text{ cms} = 343.80 \text{ mtrs} \\
\]

Total height of EDP from ground \( \propto \) Horizontal distance between EDP to the top of obstructing instrument

Length of blind zone = ELH from cabin floor \( - \) Vertical height of obstructing instrument

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

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

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 gyro sight:

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

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

<table>
<thead>
<tr>
<th>Angle subtended</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
</tr>
<tr>
<td>Co-Pilot</td>
</tr>
</tbody>
</table>

ii) In vertical meridian:
\[ \tan @ = \frac{(HI)}{(HD)} = \frac{3}{80} = 0.0375 \]

\[ \text{Angle} @ = 0.0375 \times \tan^{-1} = 2.14^\circ \]

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.

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.

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

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

Denotes above horizontal; V Denotes below horizontal; > Denotes beyond
Assessment of visual field restriction: Butola et al

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].

References


