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PILOT SEATING ARRANGEMENTS IN THE CC 138 (TWIN OTTER) AIRCRAFT

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ABSTRACT

The pilot seating arrangement in the CC 138 (Twin Otter) aircraft was examined to consider (a) reach to controls, (b) internal/external visual fields, and (c) crew comfort. The control layout and operation were found to be acceptable. Visibility of the radio compass was found to be inadequate and a modification to solve this problem is recommended. The external visual field of short pilots was found to be restricted due to the location of the design eye position. It was also found that crew comfort was hampered due to a metal protrusion in the seat pan. A modification to the seat assembly and cushions is recommended to resolve these difficulties.

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Pilot Seating Arrangements in the CC 138 (Twin Otter) Aircraft

INTRODUCTION

Because of an Unsatisfactory Condition Report (UCR), DCIEM was requested by CFHQ(3) to examine the pilot seating arrangements in the Twin Otter (CC 138).

Pilots flying the CC 138 aircraft report that they suffer discomfort due to the seat design. The seat is considered to contribute to fatigue during a long flight and, in the UCR, it is considered to be a flight safety hazard.

Short pilots report difficulty in attaining an eye level high enough for adequate external visibility during search and rescue operations. Surprisingly, the UCR does not consider this short-coming to be a flight safety hazard: Nevertheless the situation should be corrected to increase the Twin Otter's effectiveness in the search and rescue role.

One problem not noted in the UCR, but which is related to the seated eye position, is the difficulty that many pilots experience in reading the radio compass located in the lower centre of the main instrument panel. The verticality of the main instrument panel, coupled with the short horizontal distance between it and the pilot's eye position result in a large vertical angle of view to this display (Fig. 2). Parallax is thus a serious problem encountered in using this instrument. In addition, the instrument is recessed in the panel so that the top scale markings are obscured.

METHOD

During a field trip to 424 SQN at CFB TRENTON, problems in seating were discussed with the pilots and workspace measurements were taken. An anthropometer developed by the USN (2) was modified and used to investigate the aircraft's spatial and visual characteristics with respect to the anthropometric dimensions of Canadian Forces aircrew (Fig 1).

Several constraining factors were considered before solutions were proposed, e.g., the effect (in each axis) of range of seat movement. Each factor was examined separately, keeping in mind the possible interactive or dependent effects upon other factors.

RESULTS

The pilots' and co-pilots' workspaces are identical insofar as the following factors are concerned.

1. Pilot's seat

The seats are adjustable both horizontally and vertically with a total of 10 cm travel in each direction. Horizontal adjustment will not be discussed here, as consultation with the pilots, together with the small dimensions of the cockpit, indicated that virtually all pilots fly this aircraft with the seat fully aft.

The vertical adjustment range of 10 cm allows nearly all pilots to attain a common eye position, as the range from 5th to 95th percentile of pilot seated eye height is 9.5 cm. (The HIAD standard for vertical seat adjustment is 12.7 cm).

The seat pan is flat and parallel to the aircraft floor line. The seat pan and cushion assembly is shown in Fig. 3.

Pilot discomfort is caused by a ridge protruding from the back of the seat pan assembly. This triangular shaped ridge extends 3.9 cm out horizontally from the back of the pan and its top is 7½ cm above the seat pan floor. The seat cushion is approximately 13 cm thick and the light foam construction permits 5 cm or more compression. As a result, all pilots complain about their buttocks hitting the ridge. The only apparent function of this ridge is to help hold the seat cushion in place.

2. Pilot's arm rests

The pilot's seat has attached arm rests. These move with the seat and have a separate vertical adjustment range of 3 cm. (Adjustment requires a wrench.) The armrests, when adjusted full down, are 27 cm above the seat reference point. The seat reference point is defined as the intersection of the seat surface (compressed) with the plane of the backrest surface in the mid-line of the subjects body. The recommended height for nonadjustable arm rests is 20½ cm (5). Therefore, if the seat cushion is built up to give the pilots additional seated eye height the arm rests will be at the recommended height unluss the additional height exceeds 10 cm.

3. Pilot's head clearance

The vertical distance from the seat reference point to the cockpit ceiling, with the seat full up, is 118 cm. This distance is measured on a line parallel to the seat back and 13 cm forward of the seat back line. The 13 cm displacement is imposed to establish clearance for the highest point on the crown of a flight helmet (6).

The seated height of a 95th percentile pilot is 98.2 cm. After allowing 3 cm for slump, adding 1½ cm for winter flight clothing and 4½ cm for a flight helmet with visor the height of the helmet top of the 95th percentile seated pilot is just 101.2 cm. Room remains to raise the head position by 12 cm without causing clearance difficulty for any pilot. The only obstruction in the region of the pilot's head is a small fan which could be relocated if it proved objectionable. In sum, head clearance is not considered to present a problem.

4. Rudder and brake operation

The rudders have a full adjustment range of 12 cm. With the present seat assembly it is possible for a 5th percentile pilot to operate the rudders and brakes with the seat full back and up, and rudders adjusted forward one half way (neutral position.) A 5th percentile pilot raised 13 cm above the present seat referenee point could still effectively operate the rudders and brakes by adjusting the rudders toward himself and moving his seat forward.

Taller pilots reported some difficulty in comfortably operating the rudders and brakes because of the close location of the pedals to the seat. With the seat full up and back and the rudders adjusted full forward, the 95th percentile pilot has a knee angle of approximately 110^{o}. The taller pilots regard this as being uncomfortable and some have similar complaints concerning the proximity of the control wheel which forces them to fly with their elbows angled outwards. These problems affecting the tall pilot cannot, however, be described as serious though they may contribute to fatigue on long flights.

5. Reach to emergency controls

In the ongoing anthropometric survey of Canadian Forces aircraft , there is a requirement to list all emergency controls out of reach of a pilot seated full back in his seat with restraint harness locked. This requirement if primarily intended for jet aircraft in which a pilot is often restrained back in his seat during an emergency or high 'g' force manoeuvers.

In every aircraft regardless of type, all critical controls should be within easy reach of the pilot with the restraint harness fastened and locked.

The Twin Otter is utilised as a light transport and general utility aircraft. The restraint harness incorporates an automatic inertial reel. This inertial reel locks the harness when the pilot is thrown forward rapidly and unlocks when he moves back in the seat. There is no provision for manually locking this harness. Therefore even when so restrained the pilot has the capability in flight of rotating his shoulders, twisting his trunk and even bending forward to reach and adjust all controls.

The standard flight controls are within easy reach of the pilots from 5th to 95th percentile in body size. The only additional emergency controls which might have to be operated with the pilot or co-pilot full back in the seat and locked in this position are the emergency fire extinguisher pull handles. These controls are located in the upper center of the main instrument panel. These controls are within the functional reach envelope of pilots down to the 5th percentile in body size with the pilots fully back in the seat.

6. Internal vision

The pilots of 424 Sqn. had numerous complaints about the radio compass in the Twin Otter. One major problem with this instrument is the large viewing angle which results in occlusion of the upper dial by the instrument casing, and makes the compass graduation marks difficult to discriminate.

Problems in internal vision must be considered with reference to a standard position of the eyes. As mentioned earlier, with the present seat configuration and adjustment range, all pilots from the 5th to 95th percentile in size can attain a common eye position, which is considered here as the standard eye position. With the seat full back and full up, this position is 73 cm above the seat reference point and 13 cm forward of the seat back line.

The visual angle from the standard eye position to the centre of the vertically mounted compass is 33°. The viewing distance is 89 cm. Moving the seat reference point upwards moves the standard eye position upwards by an equal amount. For each 2.5 cm of vertical change in the standard eye position, the viewing angle to the compass increases by approximately 1 1/3 degrees (Fig. 4).

It is evident that the present cockpit layout makes for poor visibility of the radio compass. The visual angles are so large that a necessary component of any solution entails tilting this instrument upwards to align the dial closer to the pilot's direct line of sight.

7. External vision

The pilots did not report any problems with exterior vision during normal transport flying duties but, as mentioned, the shorter pilots complained that they have inadequate vision downwards over the nose when flying in the search and rescue role. This suggests that in this aircraft the standard eye position is adequate for transport flying but in the search and rescue role, a higher eye position would result in superior search performance by short pilots.

The visual angles from the standard eye position to the upper and lower edges of the windscreen and to the lower centre of the windscreen are diagrammed in Fig. 4. The angle to the upper edge is 7°, the angle to the lower edge 18° (and the angle to the lower centre is 16°). These angles are only to the edges of the windscreen and do not relate directly to th e visibility over the nose of the aircraft. The effect of raising the seat reference point, and therefore the standard eye, is shown in Figure. 2. The result of raising the eye position 7½ cm to increase to 21° the visual angle to the lower edge of the windscreen. (That is the low centre of the windscreen increases to 19°.) The pilot's visibility upwards becomes zero, since his eyes are then level with the top of the windscreen.

The shorter pilot may achieve a slight increase in downward visibility by adjusting his seat forward, thus bringing his eyes closer to the windscreen (Fig. 5).

DISCUSSION AND CONCLUSIONS

1. Crew comfort

The simplest and most economical solution to the pilot's complaints about the uncomfortable seat is to remove the ridge which causes the trouble. An alternate method of keeping the seat cushion in place, if one is needed, is to fasten velcro tape to the seat pan and to the bottom of the seat cushion. In addition to these recommendations, note that the present seat cushion is of light foam construction. The experience of DCIEM personnel involved in seat cushion design suggests that a firmer cushion is not only more comfortable but gives better impact protection in case of an accident (6).

2. Problems in adjusting the eye position

Shorter pilots are hampered in flying search and rescue missions due to inadequate over-the-nose vision, yet all pilots report difficulties in reading the radio compass. These two problems are interrelated since, in raising the eye position to give better over-the-nose vision, the compass becomes more difficult to see, due to the increased viewing angle. The entire instrument panel should be tilted at least 10 degrees to reduce the visual angles to all instruments. An easier solution would be to tilt only the radio compass by 15 to 20 degrees and thus alleviate the worst internal visual problem in this cockpit.

Assuming that the compass is tilted for better visibility, the pilot's eye position could be raised a maximum (and desirable) 7.5 cm above it's present location. If it is moved any higher, the pilot's vision upward and possibly even directly forward would be restricted.

There are two methods of achieving this increase in seated eye height. One is to add 7.5 cm of vertical adjustment to the present seat assembly. This is considered the better solution as it would enable each pilot to select one eye position for search and rescue and another for normal transport duties. Unfortunately, this proposed solution would be expensive as it would necessitate extensive modifications to the present seat.

The other (simpler) solution, proposed in the UCR on this problem (3), is to add a thicker cushion to the seat. This change will move the standard eye position upwards by the same amount as the (compressed) cushion thickness. However, if the new eye position is located 7½ cm higher than it is at present, the 95th percentile pilots will not be able to achieve any lower eye position than is shown in Fig. 2(B). This eye position is higher than required for transport operations and restricts upward vision. This solution could be successfully implemented in a modified form. If a cushion of very firm (low compressibility) material were manufactured to a thickness of 7.5 cm when compressed, it could be fitted with velcro tape on top and bottom and placed under the present seat cushion when required.

This type of supplementary cushion could be stowed in the aircraft until required by a squadron pilot of short stature flying a search and rescue mission.

Summary of Recommendations

1. Remove the ridge in the seat pan.
2. Add velcro tape to the seat pan and to the bottom of the existing cushion.
3. Supply the squadrons using these aircraft with several 7.5 cm thick (when compressed) removable pads which will fit under the existing seat cushions. Velcro tape is recommended as a means of holding the pads in place.
4. Tilt the radio compass 15° to 20° from vertical to alleviate the viewing problem.

REFERENCES

1. DCIEM 9400-20 25 June 1971. (Tasking DCIEM with cockpit anthropometric surveys.)

2. Cockpit Anthropometric Survey; LCDR H. Gregoire, Naval Air Test Centre Technical Report ST-1204-717 July 1971.

3. L 11500-1 (DAE 4-5) 8 Dec. 1971.

4. UCR 1310/A457 18 Oct. 1971.

5. The Human Body in Equipment Design: Damon, Stoudt and McFarland, Harvard University Press, Massachusetts, 1966.

6. Evaluation of seat cushions for CH112 NOMAD Helicopter: F.O. Gartley, CFIAM Technical Memorandum 66-TM-3.

~~LIST OF CAPTIONS~~

Figure 1 a and b. Anthropometer

Figure 2. Visual angle to windshield from eye reference points.

Figure 3. Twin Otter pilots seat.

Figure 4. Visual angle to compass from eye reference points.

Figure 5. Effect of moving eye closer to windshield.