Cockpit accommodation study of the King Air multi-engine trainer

Pierre Meunier

Defence R&D Canada – Toronto

Technical Report
DRDC Toronto TR 2003-056
March 2003

Author

Pierre Meunier

Approved by

Lochlan Magee, PhD

Head, Simulation & Modelling for Acquisition, Rehearsal and Training Section

Approved for release by

K. M. Sutton

Chair, Document Review and Library Committee

Abstract

An anthropometric assessment of the King Air multi-engine training aircraft was performed to determine the limits of accommodation of the cockpit. Ten subjects were recruited from the pool of students and instructors located at the Canadian Forces Flying Training School (CFFTS) in Southport, Manitoba. Each subject underwent a series of tests to assess vision over the nose, reach to controls (including rudder pedals), and cockpit clearance issues. Since the King Air cockpit is relatively small, reach to pedals and controls were adequate for all test subjects. All subjects were able to obtain full yoke authority, although the knees of two subjects interfered somewhat with the yoke when performing simulated left and right bank turns with the yoke full forward. Anthropometric limits were found at the lower end of the anthropometric spectrum concerning minimum eye height, with smaller subjects not being able to obtain a sufficient amount of vision over the nose. However, the limitations of the aircraft were found to be almost exactly in line with the Canadian Forces aircrew anthropometric selection criteria. At the other end of the spectrum, the data also show that the aircraft's seat adjustment will accommodate individuals larger than specified in the aircrew selection standard.

Résumé

On a effectué une évaluation anthropométrique de l'avion d'entraînement multimoteur King Air afin de déterminer les limites de l'espace disponible dans le poste de pilotage. Dix personnes ont été recrutées en provenance du bassin d'élèves et d'instructeurs de l'École de pilotage des Forces canadiennes (EPFC) de Southport (Manitoba). Chaque sujet a subi une série d'épreuves visant à déterminer la vision vers le bas par-dessus le nez de l'appareil, l'atteinte des commandes (y compris le palonnier), ainsi que le dégagement dans le poste de pilotage. Comme le poste de pilotage du King Air est relativement petit, tous les sujets ont pu atteindre facilement le palonnier et les commandes. Tous les sujets étaient en mesure d'obtenir la pleine autorité du manche à volant, quoique les genoux de deux des sujets interférait quelque peu avec le manche lors des simulations de manœuvres de virages inclinés à gauche et à droite avec le manche complètement à l'avant. On a constaté que les limites anthropométriques se situaient à l'extrémité inférieure du spectre anthropométrique en ce qui concerne la hauteur minimale des yeux, les plus petits sujets ne parvenant pas à obtenir un champ de vision suffisant par-dessus le nez de l'appareil. Cependant, on a également constaté que les limites de l'avion correspondaient presque exactement aux critères de sélection anthropométrique des équipages de conduite des Forces canadiennes. À l'autre extrémité du spectre, les données indiquaient également que les réglages des sièges de l'avion permettaient d'asseoir correctement des personnes de plus forte taille que ce que précisent les normes de sélection des équipages de conduite.

This page intentionally left blank.

Executive summary

The DND is in the process of addressing its future flying training needs and is investigating various options to deliver its training programme. One of the aims of the Contracted Flying Training Support (CFTS) project is to "address known deficiencies in each of the (training) phases" (CFTS, 2001), including pilot accommodation or "cockpit size" issues.

The King Air aircraft is currently being used by the Canadian Forces as a multi-engine training aircraft, but the limits of anthropometric accommodation are not known. Since one of the mandates of the CFTS is to address cockpit size issues, DRDC-Toronto was tasked to determine these limits.

Ten subjects were recruited from the pool of students and instructors located at the Canadian Forces Flying Training School (CFFTS) in Southport, Manitoba. Each subject underwent a series of tests to assess over the nose, reach to controls (including rudder pedals), and cockpit clearance issues.

Since the King Air cockpit is relatively small, reach to pedals and controls were adequate for all test subjects. All subjects were able to obtain full yoke authority, although the knees of two subjects interfered somewhat with the yoke when performing simulated left and right bank turns with the yoke full forward. Anthropometric limits were found concerning small individuals and their inability to obtain sufficient downward vision over the nose. However, the limitations are almost exactly in line with the current CF anthropometric selection standard, which means that this should only affect a limited number of individuals. The data show that, at the other end of the spectrum, the aircraft's seat adjustment will accommodate individuals larger than currently allowed by the standard.

Meunier, P, 2003. Cockpit accommodation study of the King Air multi-engine trainer. DRDC Toronto TR 2003-056. Defence R&D Canada – Toronto.

Sommaire

Le MDN a entrepris d’évaluer ses besoins à venir en regard de l’entraînement au pilotage et il évalue diverses possibilités pour dispenser son programme d’entraînement. L’un des objectifs du projet de Soutien contractuel à l'entraînement au pilotage (SCEP) est de « corriger les lacunes connues dans chaque phase d’entraînement » (SCEP, 2001), y compris la question de l’espace disponible pour les pilotes ou de la « grandeur des postes de pilotage ».

Les Forces canadiennes utilisent présentement le King Air comme avion d’entraînement multimoteur, mais les limites anthropométriques ne sont pas établies. Comme l’un des mandats du SCEP est de traiter de la question de la grandeur des postes de pilotage, on a confié au DRDC Toronto la tâche de déterminer ces limites.

On a recruté dix personnes en provenance du bassin d’élèves et d’instructeurs de l’École de pilotage des Forces canadiennes (EPFC) de Southport (Manitoba). Chaque sujet a subi une série d’épreuves visant à déterminer la vision vers le bas par-dessus le nez de l’appareil, l’atteinte des commandes (y compris le palonnier), ainsi que le dégagement dans le poste de pilotage

Comme le poste de pilotage du King Air est relativement petit, tous les sujets ont pu atteindre facilement le palonnier et les commandes. Tous les sujets étaient en mesure d’obtenir la pleine autorité du manche à volant, quoique les genoux de deux des sujets interférait quelque peu avec le manche lors des simulations de manœuvres de virages inclinés à gauche et à droite avec le manche complètement à l’avant. On a déterminé des limites anthropométriques en ce qui concerne les plus petites personnes et l’incapacité de ces dernières à obtenir un champ de vision vers le bas suffisant par-dessus le nez de l’appareil. Toutefois, les limites de l’avion correspondaient presque exactement aux normes de sélection anthropométrique actuelles des Forces canadiennes, ce qui signifie que ces limites ne devraient toucher qu’un nombre restreint de personnes. Les données révèlent également qu’à l’autre extrémité du spectre, les réglages des sièges de l’avion permettraient d’asseoir correctement des personnes de plus forte taille que ce que précisent les normes actuelles.

Meunier, P, 2003. Cockpit accommodation study of the King Air multi-engine trainer. DRDC Toronto TR 2003-056. Defence R&D Canada – Toronto.

Table of contents

List of figures

List of tables

Acknowledgements

The author gratefully acknowledges financial support for this study under the Contracted Flying Training Support office, Major David Ross, and the technical assistance provided by Robert Mertens.

This page intentionally left blank.

1. Introduction

The Department of National Defence, through the Contracted Flying Training Support (CFTS) project, is in the process of defining its future flying training needs for fixed and rotary wing aicraft. One of the important aspects being considered at the outset is the ability of the cockpits to accommodate the population of students and instructors that will operate these aircraft. In this context, this means that all operators must be able to:

i) reach and operate all controls under appropriate conditions,

ii) see all instruments, displays, cautions and warnings (internal vision)

iii) have sufficient external vision to carry out all flight tasks, including, but not limited to, the ability to see the landing aim point from the cockpit over the nose of the aircraft at the worst case angle of attack approach.

In August 2002, DRDC-Toronto was tasked by the CFTS project to determine the limits of accommodation of the Jet Ranger (Meunier, 2003) and King Air cockpits. The study, which was coordinated with the Canadian Forces Flying Training School (CFFTS) in Southport, Manitoba, took place on the week of September 23rd 2002.

2. Method

2.1 Subjects

Ten subjects were recruited from the pool of students and instructors located at 3 Canadian Forces Flying Training School (CFFTS). The anthropometric characteristics of the personnel were obtained from the database of their measurements taken during the recruitment process at the Central Medical Board (CMB) in DRDC-Toronto. Stature and weight, which are general indicators of lengths and circumferences, were used as the subject selection variables. Figure 1 shows that the subjects covered a reasonable range of statures, but were on the light side of the weight distribution compared to the general pilot population as characterized by the 1985 survey of aircrew (Stewart, 1985). It should be pointed out that although the 1985 survey contains pilot and navigator data, only pilot data were used in the graphs below.

Figure 2 compares the test subject pool to the 1985 survey of pilots in terms of their proportion of torso length to leg length. Again, the plot shows a reasonable distribution of sitting heights and a somewhat centralized leg lengths distribution devoid of extremes.

2.2 Test protocol

The test protocol for the King Air was established with the help of an instructor from 3 CFFTS. The usual flight-essential accommodation criteria were discussed. These included: external and internal visibility requirements, reach to pedals and controls, and clearances. A short list of items was identified that assessed the essential elements of this cockpit. It was quickly determined that the main issue with this cockpit had to do with external visibility, which is a function of seat adjustment range.

In terms of reach, the King Air has a relatively small cockpit, making it easy to reach most if not all controls. Although this aircraft is rated single pilot (from the left seat), which means that circuit breakers on the right hand side must be reachable from there, it is seldom flown that way in its training role. For that reason, this study assumed a two-pilot scenario. Reaches were assessed from the left seat to the conditioning levers, and from the right seat to the trim. A complete list of items assessed is provided as Annex A.

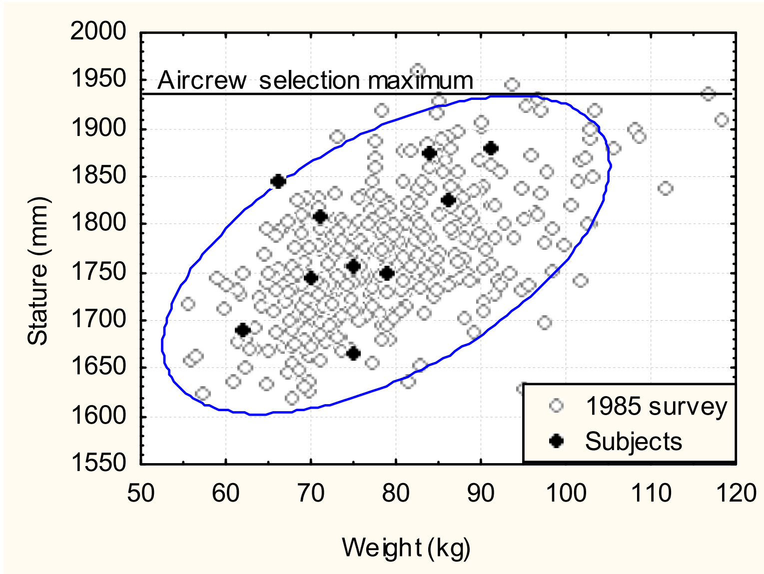

Figure 1. *Stature vs. weight of test subjects relative to1985 survey of pilots.*

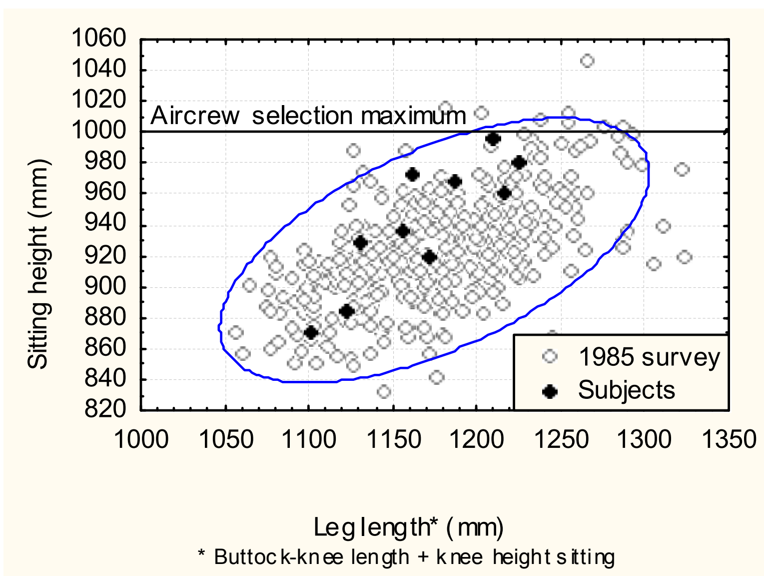

Figure 2. *Sitting height vs. leg length of the test subjects, relative to1985 survey of pilots.*

Anthropometric measurements were taken of each subject upon arrival to the hangar. The measurements included (see Annex B for details and definitions):

- Weight
- Stature
- Sitting height
- Top of helmet height
- Eye height sitting
- Acromial height sitting
- Knee height sitting
- Buttock-knee length
- Hip breadth sitting
- Biacromial breadth
- Bideltoid breadth
- Functional reach
- Thigh circumference
- Span
- Waist depth

After being measured, the subjects wore their flying coveralls and flight jacket for the trial. The subjects sat in the left seat, strapped in, and adjusted their seat and rudder pedals as required. The seat was adjusted as per standard operating procedures, which requires pilots to see the bottom of the windshield wiper spring while achieving a comfortable flying posture. The final adjustment positions were recorded. Subjects were then asked to aim a sight tube (Crosman Copperhead laser sight) fitted to a digital inclinometer (Lucas AngleStar model DP45) over the nose of the aircraft. Vision over the nose was measured as shown in Figure 3. The distance between the forehead and the aft edge of the glareshield was measured, as a means of capturing postural data for future modelling purposes. Then, the distance between yoke and the chest was measured at both extremes of yoke fore and aft position, and the minimum clearance between the yoke and the knees were measured through simulated left and right turns. The minimum clearance occurred when the yoke was full forward. Finally, reaches to conditioning levers (left seat) and trim (right seat) were assessed.

Figure 3. *Measurement of vision over the nose.*

3. Results and discussion

3.1 Seat adjustment and Vision Over the Nose (VON)

The relationship between anthropometry, seat adjustment, and vision over the nose, which is critical for accommodation, was analysed using multiple regression. However, since the seat of the King Air adjusts in two independent directions (vertically and horizontally), and since regression equations can only deal with one dependent variable at a time, a recursive approach had to be used. A first regression analysis was performed to predict the seat's vertical position, while a second one was performed to predict the seat's horizontal position. A final regression analysis was performed recursively to fine-tune the vertical position estimate given its predicted horizontal position.

Because of the aircraft's symmetry, left and right seat data were pooled. Seat height, as a first step, was satisfactorily predicted using eye height sitting and VON[1] as the variables ($F(2,15)=43.9$ $p<.05$). The regression equation obtained, which is shown in Figure 4 with 95% confidence bands, has a coefficient of determination $R^2 = 0.85$, which means that it explains 85% of the variability in the data. The equation obtained was:

$$\textit{Vertical Seat Position (\%)} = -0.004*Eye\_Height\_Sitting+0.068*VON+3.30 \qquad (1)$$

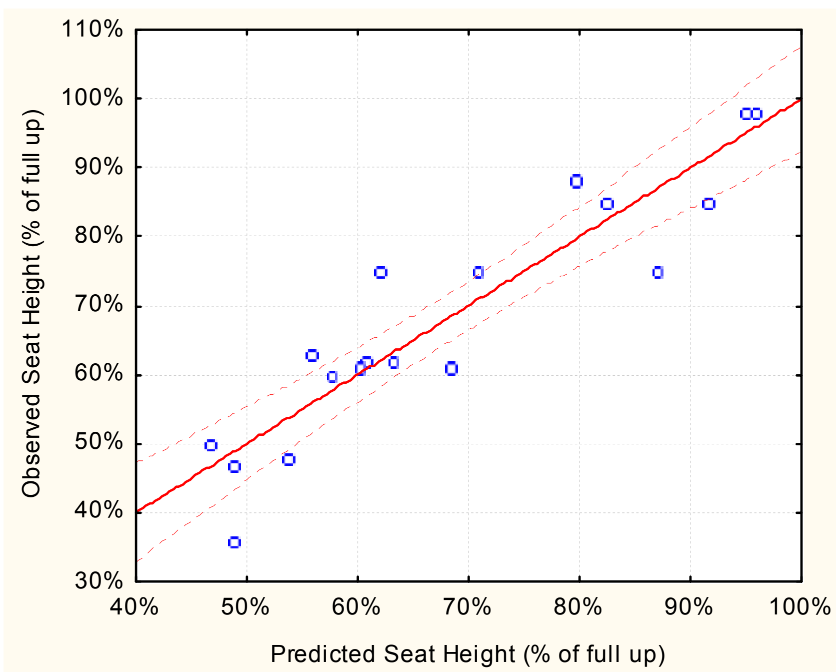

Figure 4. *Vertical seat height prediction.*

[1] One outlier was removed from vertical seat position data due to suspected improper sighting of inclinometer.

Horizontal seat position was predicted with similar performance results (R^2 = 0.83) using leg length[2] and seat height as input variables. The following equation was obtained:

*Horizontal Seat Position (%) = -0.594*Vertical_Seat_Height+0.0026*Leg_Length – 2.04 (2)*

The final determination of vertical seat position was obtained in a recursive fashion, by using the derived Horizontal Seat Position as an additional variable. The final regression equation, shown in Figure 5, has a coefficient of determination R^2 = 0.89. The equation was:

*Vert.Seat Pos. (%) = -0.003*Eye_Height_Sitting + 0.053*VON - 0.25*Hor.Seat Pos.(%)+ 2.86 (3)*

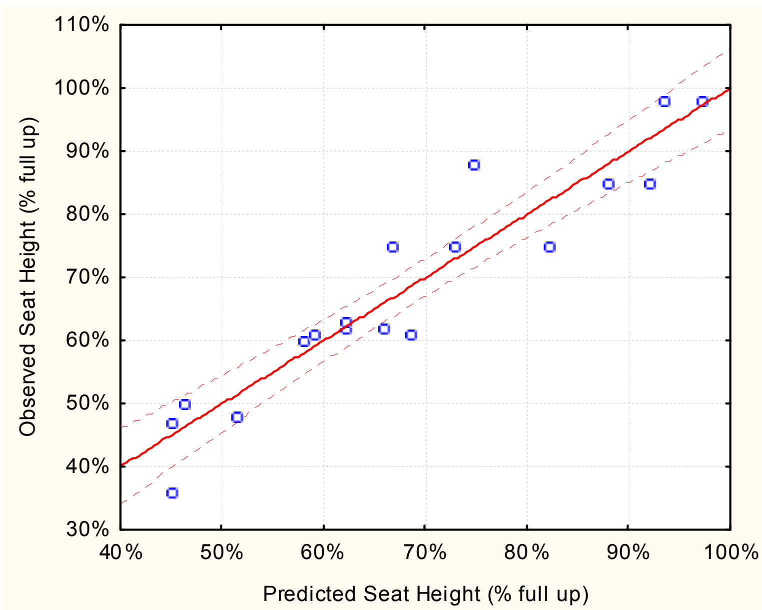

Figure 5. Final vertical seat height prediction.

The rule of thumb used by King Air student pilots (and instructors) is that they need to adjust their seat in a manner that allows them to see the bottom of the windshield wiper spring. This, presumably, places their eyes on the design eye line, which should be the ideal position from an internal and external vision standpoint. It should enable them to see the landing aim point on the final approach course from 2 nautical miles, at 500 feet AGL, at the worst-case angle of attack. Measurements of vision angles taken during the trial indicated that positioning the seat to see the bottom of the wiper spring results in a 9.7± 1.1 degrees[3] downward vision. This angle was used in the above equations to estimate the seat adjustment requirements for a population pilots. The anthropometric data used came from the 1985 survey of aircrew (Stewart, 1985) for males, and from the 1997 survey of the land forces (Chamberland et al., 1998) for females. Both sets of data were filtered to eliminate individuals that did not strictly

[2] Leg length is defined here as (buttock-knee length + knee height sitting)

[3] Measured relative to the flight deck.

meet the current CF pilot anthropometric standards (listed in Annex C). This resulted in a database of 374 males and 74 females.

Thus, using Eye Height Sitting, Leg Length, and 9.7 degrees VON as input variables, it was found that approximately 1% of male pilots and 5% of females (meeting pilot anthropometric requirements) would not be able to obtain the required vision over the nose. Since it is probably safe to assume that slight deviations from the established 9.7-degree downward vision angle would also be acceptable, a sensitivity analysis was performed to determine what effect a slight change in downward vision angle might have on population accommodation. Table 1 shows the effect of a change of ± 0.3 degree on the disaccommodation rate of males and females. It can be seen that the effect on males is relatively minor compared to the effect on females. This is due to the fact that the Eye Height Sitting cut-off value falls close to the middle of the normal distribution in the case females, whereas it falls at the lower end in the case of males. Therefore, any increase in this value will necessarily affect a higher proportion of females.

Table 1 Sensitivity analysis results

Downward vision angle* (degrees)	Disaccommodation (%) Males	Disaccommodation (%) Females
9.4	0.3	1.4
9.7	1.3	5.4
10.0	2.3	9.5

* relative to the flight deck

Overall, the analysis indicates that almost all male pilots will be able to adjust their seat in accordance with the rule of thumb, but that a small proportion of females may not. The exact figures depend on what can be considered the minimum safe limit for vision over the nose, as opposed to the design eye line, which is presumably what guides the rule of thumb. Flight tests would be required to establish this vision angle with certainty.

In terms of seat adjustment limits, the King Air seat has a vertical range of 100 mm and a horizontal range of 180 mm. It is interesting to note that the regression models predicts that the full range of seat height adjustment would never be used given our current aircrew selection limits. Figure 4 shows that males do not use the bottom 40% of the seat's adjustment range, implying that sitting heights of several millimetres beyond the maximum CF aircrew selection limits would easily be accommodated.

Figure 7 shows what might be expected in terms of horizontal seat adjustment. For instance, females will tend to adjust their seat in the first third of the adjustment range, whereas males will tend to use the second third. The graph also shows that the full range of seat positions is not likely to be used.

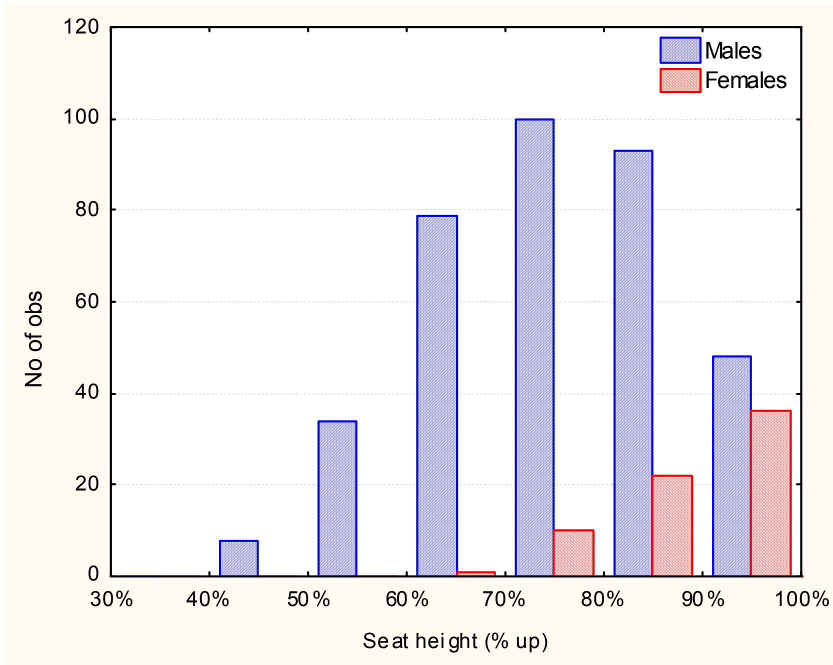

Figure 6. *Expected range of vertical seat adjustment for CF pilots.*

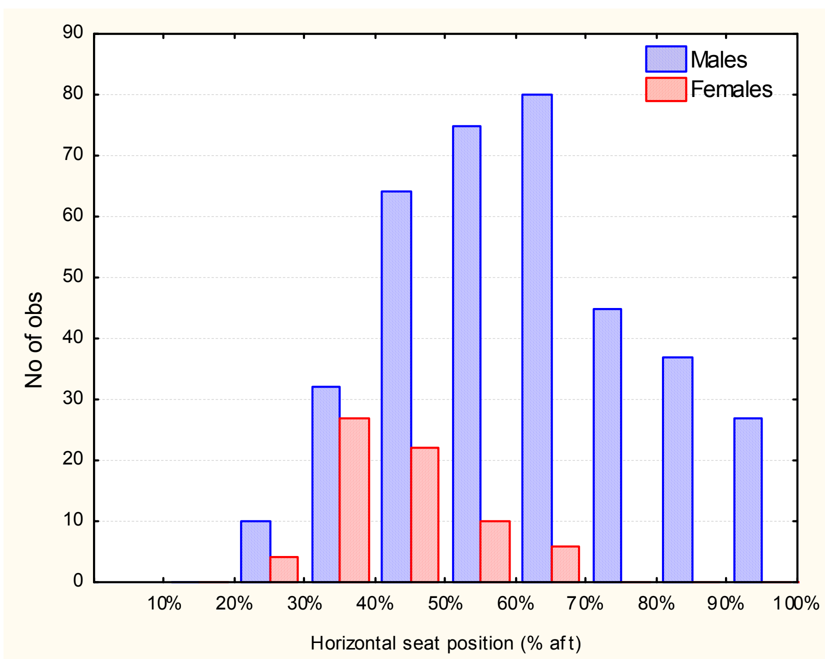

Figure 7. *Expected range of horizontal seat adjustment for CF pilots.*

3.2 Reach

All of the subjects tested were able to reach the necessary controls. In all cases, the preferred rudder pedal position was full forward[4].

3.3 Yoke clearance

There was sufficient clearance between the yoke and the body of all test subjects, with the yoke fully extended. In fact, none of the subjects had any less than an 80-mm clearance. A multiple regression analysis was performed using Waist Depth as well as horizontal and vertical seat positions as predictors of chest clearance; horizontal seat position was found to be the only significant variable. The regression equation, which is shown in Figure 8, predicts an average clearance of 30 mm with the seat full forward, which is sufficient to provide full control authority.

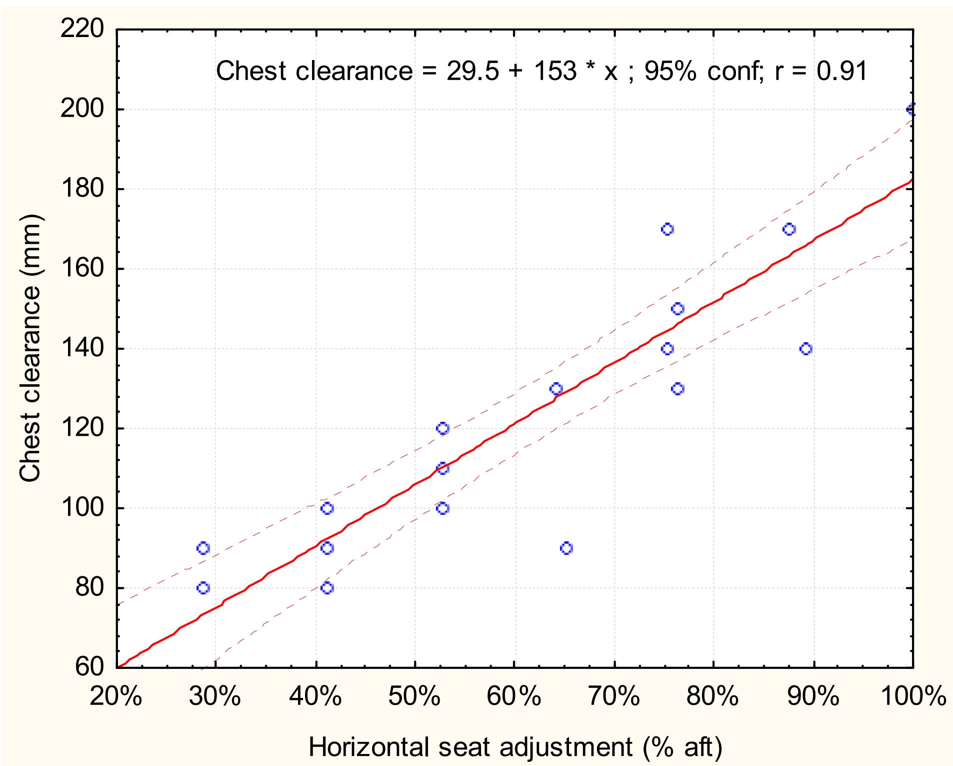

Figure 8. *Horizontal seat position versus yoke-chest clearance.*

In terms of clearance of the yoke with the knees, no linear association was found to exist between clearance and any of the anthropometric or seat position variables. All subjects were able to rotate the yoke fully, although two of the subjects had zero clearance. Clearances were found to range from 0 to 30 mm, with an average of 20 mm and a standard deviation of 10 mm. This appears to be acceptable since the clearances were measured in the absolute worst-case condition (full bank with yoke full forward), which is seldom used.

[4] The rudder carriage has only two adjustment positions, fore and aft, separated by 4.3cm.

4. Conclusions

The findings of this study can be summarized as follows:

1. The main anthropometric accommodation issue with the King Air aircraft affects smaller individuals and their ability to obtain a sufficient degree of vision over the nose. However, the limitations are almost exactly in line with the current CF anthropometric selection standard, which means that this should only affect a limited number of individuals.
2. The data show that, at the other end of the spectrum, the aircraft's seat adjustment will accommodate individuals larger than currently allowed by the standard.
3. All test subjects were able to reach critical controls with ease. This conclusion can be extrapolated to cover the population of CF pilots.
4. All test subjects were able to obtain full yoke authority, although two did so with zero clearance.

5. References

1. CFTS (2001). *Contracted Flying Training and Support (CFTS); Statement of Operational Requirements.* Draft version 10.0, Department of National Defence, Ottawa, Ontario
2. Chamberland, A., R. Carrier, F. Forest and G. Hachez (1998). *Anthropometric survey of the Land Forces (LF97).* 98-CR-15, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario
3. Meunier, P. (2003). Cockpit accommodation of the CH139 Jet Ranger training helicopter. DRDC Toronto TR 2003-005, Toronto, Ontario
4. Stewart, L. E. (1985). *1985 Anthropometric survey of Canadian forces aircrew.* DCIEM-TR-85-12-01, Defence and Civil Institute of Environmental Medicine, Toronto, Ontario

Annex A Data collection sheet, King Air

Tail number	905	
Date	24-Sep-02	
Subject		
		Left Seat
Basic position	Rudder pedal adjustment (cm)	
	Vision over the nose (bottom of spring) (degrees)	
	Seat height (cm)	
	Seat fore/aft (cm)	
	Forehead-glareshield dist (cm)	
Yoke-Chest clearance	Full fwd yoke (cm)	
	Full aft yoke (cm)	
Yoke-knee clearance	Full left -right (cm)	
Reach	Conditioning levers	
		Right seat
Basic position	Rudder pedal adjustment (cm)	
	Vision over the nose (bottom of spring) (degrees)	
	Seat height (cm)	
	Seat fore/aft (cm)	
	Forehead-glareshield dist (cm)	
Yoke-Chest clearance	Full fwd yoke (cm)	
	Full aft yoke (cm)	
Yoke-knee clearance	Full left -right (cm)	
Reach	Trim	

Annex B Anthropometric data

***Table 2** Anthropometric measurements of subjects (mm)*

Subject	1	2	3	4	5	6	7	8	9	10
Weight (kg)	70	75	86	66	71	91	75	84	79	62
Stature	1744	1756	1825	1845	1808	1880	1665	1875	1750	1691
Upper thigh circumference	553	702	692	580	577	658	630	620	594	613
Functional Reach	756	721	786	811	775	818	759	796	772	734
Span	1777	1680	1806	1826	1843	1878	1777	1936	1750	1666
Sitting height	929	937	961	968	973	996	870	980	919	884
Eye height sitting	808	835	837	855	863	886	733	865	793	763
Acromial height sitting	633	590	546	638	647	662	607	605	648	629
Knee height sitting	535	538	566	581	553	568	506	573	546	526
Biacromial breadth	415	370	422	408	405	436	406	420	407	339
Bideltoid breadth	473	459	513	438	483	511	480	493	491	389
Hip breadth sitting	342	395	385	354	364	396	367	372	369	383
Waist depth	203	199	238	206	228	241	214	250	247	193
Buttock-knee length	596	618	650	606	609	641	595	652	626	597

***Table 3** Anthropometric measurements of subjects (percentile)*

Subject	1	2	3	4	5	6	7	8	9	10
Weight (kg)	20	36	75	11	23	87	36	68	50	6
Stature	36	43	80	87	72	95	6	94	39	13
Upper thigh circumference	13	99	99	32	30	92	76	69	45	62
Functional Reach	16	3	41	66	31	72	18	51	28	6
Span	27	3	40	50	58	74	27	92	17	2
Sitting height	56	65	86	90	92	98	6	95	45	13
Eye height sitting	51	79	80	92	95	99	2	95	34	10
Acromial height sitting	83	30	2	87	93	98	52	50	93	79
Knee height sitting	12	14	51	73	31	54	1	61	23	6
Biacromial breadth	76	3	87	62	55	97	57	84	59	<1
Bideltoid breadth	29	12	89	2	46	88	41	64	61	<1
Hip breadth sitting	11	85	73	23	38	86	43	52	47	70
Waist depth	37	32	74	40	64	77	49	84	82	26
Buttock-knee length	32	62	93	45	50	87	31	94	72	33

Definitions

The following are some of measurement definitions used in this study (taken from Chamberland et al., 1998).

Sitting Height (4)

The vertical distance between a sitting surface and the top of the head is measured with an anthropometer. The subject sits erect with the head in the Frankfort plane. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The thighs are parallel and the knees are flexed 90 degrees with the feet in line with the thighs. The measurement is made at the maximum point of quiet respiration.

Eye Height, Sitting (154)

The vertical distance between a sitting surface and the ectocanthus landmark on the outer comer of the right eye is measured with an anthropometer. The subject sits erect with the head in the Frankfort plane. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The thighs are parallel and the knees are flexed 90 degrees with the feet in line with the thighs. The measurement is taken at the maximum point of quiet respiration.

Acromial Height, Sitting (157)

The vertical distance between a sitting surface and the acromion landmark on the tip of the right shoulder is measured with an anthropometer. The subject sits erect looking straight ahead. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The measurement is made at the maximum point of quiet respiration.

Knee Height, Sitting (164)

The vertical distance between a footrest surface and the suprapatella landmark at the top of the right knee (located and drawn while the subject stands) is measured with an anthropometer. The subject sits with the thighs parallel, the knees flexed 90 degrees, and the feet in line with the thighs.

Buttock-Knee Length (169)

The horizontal distance between a buttock plate placed at the most posterior point on either buttock and the anterior point of the right knee is measured with an anthropometer. The subject sits erect. The thighs are parallel and the knees flexed 90 degrees with the feet in line with the thighs.

Functional Leg Length (171)

The straight-line distance between the plane of the bottom of the right foot with the leg extended and the back of the body of a seated subject is measured with an anthropometer passing over the trochanter landmark on the side of the hip. The subject sits erect on a stool 40.8 cm high. The right leg is extended and the foot is on the base plate of the anthropometer, which rests on the floor. The measurement is made from the footrest surface of the base plate.

Span (10)

The distance between the tips of the middle fingers of the horizontally outstretched arms is measured on a wall chart. The subject stands erect with the back against a wall-mounted scale and the heels together. Both arms and hands are stretched horizontally against a back wall with the tip of the middle finger of one hand just touching a sidewall. A block is placed at the tip of the middle finger of the other hand to establish the measurement on the scale. The measurement is taken at the maximum point of quiet respiration.

Thumbtip Reach (189)

The horizontal distance from a back wall to the tip of the right thumb is measured on a wall scale. The subject stands erect in a comer looking straight ahead with the feet together and the heels 20 cm from the back wall. The buttocks and shoulders are against the wall. The right arm and hand, palm down, are stretched forward horizontally along a scale on the sidewall. The thumb continues the horizontal line of the arm and the index finger curves around to touch the pad at the end of the thumb. The subject's right shoulder is held against the rear wall.

Biacromial Breadth (47)

The distance between the right and left acromion landmarks at the tips of the shoulders is measured with a beam caliper. The subject sits erect. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The measurement is taken at the maximum point of quiet respiration.

Bideltoid Breadth (48)

The maximum horizontal distance between the lateral margins of the upper arms on the deltoid muscles is measured with a beam caliper. The subject sits erect looking straight ahead. The shoulders and upper arms are relaxed and the forearms and hands are extended forward horizontally with the palms facing each other. The measurement is made at the maximum point of quiet respiration.

Annex C CF aircrew selection limits

Table 4 Current pilot selection limits (mm).

	Stature	Sitting height	Buttock-knee length	Functional leg length
Minimum	1570	864	546	996
Maximum	1940	1003	673	1232

List of symbols/abbreviations/acronyms/initialisms

CFTS	Contracted Flying Training Support
CMB	Central Medical Board
DND	Department of National Defence

Distribution list

Project Manager for CFTS

DOCUMENT CONTROL DATA SHEET

1a. PERFORMING AGENCY DRDC Toronto 1b. PUBLISHING AGENCY DRDC Toronto	2. SECURITY CLASSIFICATION UNCLASSIFIED Unlimited distribution -

3\. TITLE

(U) Cockpit accommodation study of the King Air multi-engine trainer

4\. AUTHORS

Pierre Meunier

5. DATE OF PUBLICATION	6. NO. OF PAGES
March 27 , 2003	29

7\. DESCRIPTIVE NOTES

8\. SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY

Sponsoring Agency:
Monitoring Agency:
Contracting Agency :
Tasking Agency: CFTS

9. ORIGINATORS DOCUMENT NO.	10. CONTRACT GRANT AND/OR PROJECT NO.	11. OTHER DOCUMENT NOS.
Technical Report TR 2003-056		

12\. DOCUMENT RELEASABILITY

Unlimited distribution

13\. DOCUMENT ANNOUNCEMENT

Unlimited announcement

14. ABSTRACT

(U) An anthropometric assessment of the King Air multi-engine training aircraft was performed to determine the limits of accommodation of the cockpit. Ten subjects were recruited from the pool of students and instructors located at 3 Canadian Forces Flying Training School (CFFTS) in Southport, Manitoba. Each subject underwent a series of tests to assess vision over the nose, reach to controls (including rudder pedals), and cockpit clearance issues. Since the King Air cockpit is relatively small, reach to pedals and controls were adequate for all test subjects. All subjects were able to obtain full yoke authority, although the knees of two subjects interfered somewhat with the yoke when performing simulated left and right bank turns with the yoke full forward. Anthropometric limits were found at the lower end of the anthropometric spectrum concerning minimum eye height, with smaller subjects not being able to obtain a sufficient amount of vision over the nose. However, the limitations of the aircraft were found to be almost exactly in line with the Canadian Forces aircrew anthropometric selection criteria. At the other end of the spectrum, the data also shows that the aircraft's seat adjustment will accommodate individuals larger than specified in the aircrew selection standard.

(U) On a effectué une évaluation anthropométrique de l'avion d'entraînement multimoteur King Air afin de déterminer les limites de l'espace disponible dans le poste de pilotage. Dix personnes ont été recrutées en provenance du bassin d'élèves et d'instructeurs de l'École de pilotage des Forces canadiennes (EPFC) de Southport (Manitoba). Chaque sujet a subi une série d'épreuves visant à déterminer la vision vers le bas par-dessus le nez de l'appareil, l'atteinte des commandes (y compris le palonnier), ainsi que le dégagement dans le poste de pilotage. Comme le poste de pilotage du King Air est relativement petit, tous les sujets ont pu atteindre facilement le palonnier et les commandes. Tous les sujets étaient en mesure d'obtenir la pleine autorité du manche à volant, quoique les genoux de deux des sujets interférait quelque peu avec le manche lors des simulations de manœuvres de virages inclinés à gauche et à droite avec le manche complètement à l'avant. On a constaté que les limites anthropométriques se situaient à l'extrémité inférieure du spectre anthropométrique en ce qui concerne la hauteur minimale des yeux, les plus petits sujets ne parvenant pas à obtenir un champ de vision suffisant par-dessus le nez de l'appareil. Cependant, on a également constaté que les limites de l'avion correspondaient presque exactement aux critères de sélection anthropométrique des équipages de conduite des Forces canadiennes. À l'autre extrémité du spectre, les données indiquaient également que les réglages des sièges de l'avion permettaient d'asseoir correctement des personnes de plus forte taille que ce que précisent les normes de sélection des équipages de conduite.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) cockpit accommodation, anthropometry, king air, aircrew selection