National Defence Défense nationale

- STATEMENT OF WORK -
Task Authorization (TA) - 44

FOR SUB CONTRACT WITH CIMVHR

1. NUMBER – TITLE OF TASK AUTHORIZATION

TA 44 – Validation of a novel method to predict aircrew cockpit accommodation in RCAF aircraft

2. VALIDATION OF SCOPE OF CONTRACT

The following task(s), as written in the SOW of the main contract (W7714-145967/001/SV) apply to this Task Authorization (TA):

b. **Experimental and Clinical Studies** - Design and conduct of experiments involving both human and animal studies.

d. **Data Analysis** - Perform state of the art analysis of data from experimental studies, clinical trials, field studies or trials, and existing databases.

k. **Advice -** Provide recommendations on peer review research proposals, publications, experimental studies, surveys and scientific evidence.

3. ACRONYMS

BFOR	Bona Fide Occupational Requirement
CAF	Canadian Armed Forces
CFASC	Canadian Forces Aircrew Selection Centre
DFA	Discriminant Function Analysis
DRDC	Defence Research and Development Canada
LA	Logistic Regression
PASS	Pilot Anthropometric Selection Software
RCAF	Royal Canadian Air Force
SA	Scientific Authority
TA	Technical Authority
USAF	United States Air Force

4. REQUIREMENT

A validation and comparative analysis of an methodology used by the Canadian Forces Aircrew Selection Centre (CFASC) for pilot anthropometric screening is required to determine its relative effectiveness to alternate assessment methods.

5. BACKGROUND

As part of the aircrew selection process, the Royal Canadian Air Force conducts anthropometric screening to verify that a pilot candidate will be able to meet all physical constraints and perform key flight tasks in a given airframe. Anthropometric screening can affect a pilot candidates' employability as they may be rejected outright due to unsuitable body size or streamed towards certain aircraft where no accommodation limits are exceeded. For example, a candidate with a tall seated height or long thigh length can be excluded from flying fighter jets due to the possibility of knee/head strike on ejection. This same candidate may be suitable for a transport aircraft with a more accommodating cockpit interior.

Anthropometric standards for pilots are based on the ability of a candidate to meet specific Bona Fide Occupational Requirements (BFORs). BFORs are determined through consultation with subject matter experts (e.g. instructors, test pilots, system safety engineers) and reviewing flight procedures manuals. In practice, BFORs are generally related to flight control, ingress/egress and safety tasks and include reach (critical switches, controls and full actuation of the control column/yolk), vision (clearly read all gauges and displays and meet external field of view requirements) and clearance (ejection clearance, head canopy clearance etc.) task criterions.

An accommodation evaluation of an airframe cockpit is achieved by employing a "fit mapping" process whereby test participants (dressed in full flight gear – helmet, life support equipment, flight suit, winter or immersion garments) are assessed on their ability to achieve the key operator requirements identified from the BFOR evaluation. Based on the results of this evaluation, a statistical model is developed to predict task performance as a function of pilot anthropometry and seat position. Cockpit accommodation models are unique to each airframe and typically consist of sub-models, addressing reach, vision and clearance task criterions. For example, an accommodation model for an airframe may include three sub-models that evaluate a pilot's ability to a) achieve full control column actuation, b) maintain adequate head clearance and c) reach critical circuit breakers. A prospective pilot is only deemed anthropometric fit to fly if a seat position can be identified where all standards contained in the cockpit accommodation model are successfully achieved.

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Traditionally, cockpit accommodation models were universal across a fleet and were based on univariate limits such as maximum stature or minimum seated height (ref). As cockpit accommodation requirements are unique to each airframe and is often dependent upon the simultaneous accommodation of multiple body measures, the USAF moved to a multivariate modeling approach in the late 1990's, where multiple regression models of accommodation were developed for each airframe (Kennedy, 2001; Zehner, 2001). Following these developments, multivariate-based accommodation models for RCAF aircraft was initiated by DRDC and the RCAF in the early 2000's. In 2006, these models were instantiated in a software tool named the Pilot Anthropometric Selection System (PASS) (Bridges, 2006) and adopted as RCAF aircrew selection standards.

During the development of the RCAF multivariate accommodation models, a new analytical approach was introduced based on Discriminant Function Analysis (DFA) modeling. DFA differs from linear regression in that it predicts dichotomous group membership based on continuous dependent variables. In the case of cockpit accommodation, a DFA model would predict if an aircrew candidate simply meets or does not meet a task criterion, whereas linear regression would predicts "how much" the criterion is met or not met by. The DFA approach has the potential to dramatically simplify the fit-mapping evaluation as the evaluator would only have to record whether the pilot was able to successfully achieve a task. In comparison, the regression approach requires the direct measurement of the performance for each seat position (e.g. seat 40% aft position - rudder depressed 80%, 2cm reach beyond control). Currently, 9 of the 14 (65%) airframes evaluated by the PASS software are enumerated using the DFA methodology. Unfortunately, no documentation exists that describes or substantiates the use of this modeling technique. There are also potential concerns regarding the number of participants used to develop the model and violation of assumptions related to multicollinearity and independent of predictor variables.

Based on the concerns identified, further investigation is required to determine if DFA is a valid analytical approach to predict cockpit accommodation and providing meaningful predictive power and simplifying cockpit fit mapping of the traditional linear regression approach. A second question is whether other classifying statistical techniques such as logistic regression are more suitable or robust than DFA. The outcomes of these analysis will inform the development of a proposed replacement to the PASS software and influence future aircrew selection and cockpit accommodation modeling for the RCAF.

6. OBJECTIVES

Validate a novel statistical model to assess workspace anthropometric accommodation and compare to the traditional method and other classifying statistical techniques.

7. SCOPE

The collection of data and reporting must be completed by end of May 2018.

8. APPLICABLE DOCUMENTS & REFERENCES

Kennedy, K. W. (2001). Anthropometric Accommodation in Aircraft Cockpits: Methodologies for Examination. Retrieved July 25, 2017, from http://www.humanics-es.com/KennethKennedyCockpitAccommodation.pdf.

Zehner, G.F. and J.A. Hudson (2002) Body Size Accommodation in USAF Aircraft. AFRL-HE-WP-TR-2002-0118. Human Effectiveness Directorate Crew System Interface Division Wright-Patterson AFT OH 45433-7022.

Bridges, H. (12 April 2006). Air Force First in World to Change Body Measurement Standards for Pilots. The Maple Leaf, Vol 9(15), p. 18.

9. TASKS TO BE PERFORMED

The Sub Contractor must perform the following tasks:

9.1 Develop a workspace mock-up similar in configuration to an aircraft cockpit, including adjustable seat with harness, simulated flight controls, windscreen, and instrument/overhead panel with simulated switches and dials.

9.2 In consultation with the Scientific Authority (SA) develop an experimental protocol in accordance with Tri-Council Policy Statement guidelines on Guidelines for Ethical Research Using Humans. This protocol will detail an anthropometric accommodation study of the workspace mock-up according to methods designed to permit regression and discriminant function analysis (DFA) analysis. Accommodation tasks must assess reach, clearance and vision against defined performance objectives. This protocol must be reviewed and approved by both DRDC Human Research Ethics Committee and any Institutional Research Ethics Board to which the Sub Contractor is responsive to.

9.3 Conduct a quantitative assessment to determine the minimal sample size required to perform linear regression and DFA.

9.4 Conduct a workspace accommodation study following methodology outlined in experimental protocol. Male and female participants of a wide range of body shapes and sizes should be recruited.

9.5 Analyze the data collected to develop linear regression and DFA models of workspace accommodation, providing an assessment of the relative efficacy of each approach.

9.6 Assess the suitability of additional classifying statistics (e.g. Probit, Logistical Regression) for workspace accommodation analysis. If a suitable statistical technique is identified, compare its predictive output to the linear regression and DFA model.

9.7 Based on the conclusion of the results of the workspace accommodation experiment and comparative data analysis (paras 9.4 and 9.5), provide a comparative evaluation of the relative utility and effectiveness of the linear multiple regression method and DFA techniques for evaluating workspace accommodation. Include any additional candidate classifying techniques that are identified and evaluated (as per para 9.6) in this assessment.

10. DELIVERABLES (DESCRIPTION AND SCHEDULES)

The Sub Contractor must create and submit the following deliverables to CIMVHR:

Deliverable Number	Task reference	Description (Quantity and Format) and Schedule
10.1	9.2	Experimental protocol – One electronic copy (MS-Word) for submission to DRDC HREC. Due four weeks after the approval to begin work is received.
10.2	9.5	Preliminary/progress report by end of January 2018 - One electronic copy (MS-Word). One electronic copy (MS-Word).
10.3	9.7	Provide a draft final report by March 2018 for review.
10.4	9.7	Provide the final report by May 2018 – One electronic copy (MS-Word).
10.5	9.4	All raw data. One copy in electronic (.csv or MS Excel) format. Due May 2018.
10.6	9.5, 9.6	Any code generated in the analysis of data using commercial or open source software – one electronic copy (e.g. R, Matlab, Python). DueMay 2018.

11. MANDATORY SELECTION CRITERIA

The successful team will collectively have the following minimum qualifications:

a. One or more senior investigators with a PhD in a relevant discipline;
b. Demonstrated subject matter expertise and recent productivity in anthropometry and multivariate workspace accommodation modeling and analysis;

12. LANGUAGE OF WORK

Documentation and deliverables must be submitted in the English language.

13. LOCATION OF WORK

The collection of data must be performed at the Sub Contractor’s facilities.

14. TRAVEL

This task authorization may include the following travel requirements:

The Sub Contractor may be required to travel to attend study planning meetings and progress review meetings, to perform data collection and to present research findings at scientific meetings;

All travel must have the prior written authorization of the Scientific Authority and the Technical Authority, and must be undertaken in accordance with the *National Joint Council Travel Directive* and with the other provisions of the directive referring to "travellers", rather than those referring to "employees".

15. MEETINGS

One (1) meeting is anticipated within two weeks of contract award to introduce team members, review SOW and objectives and plan project activities. This meeting will be held by tele or video conference.

The Scientific Authority will travel to the location of the Sub Contractor to inspect workspace accommodation mock-up and provide support and advice to preparation and collection of study pilot data. It is expected that this meeting will occur within one month of protocol approval by the Institution Research Ethics Board. The SA’s travel will be supported by external funds and shall not be included in the costing for this task.

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Monthly meetings will be held between the Scientific Authority and Sub Contractor to review progress of project activities. These meetings will be conducted by tele or video conference.

It is anticipated that one (1) Sub Contractor will travel to DRDC Toronto Research Centre for one (1) meeting to present the final study findings. This meeting will be of one day duration and is expected to be held during the third or fourth week of May 2018.

16. GOVERNMENT SUPPLIED MATERIAL (GSM)

None

17. GOVERNMENT FURNISHED EQUIPMENT (GFE)

None

18. SPECIAL CONSIDERATIONS OR CONSTRAINTS

Experimentation involving human participants is subject to review and approval by DRDC Human Research Ethic Committee.

19. SECURITY

The Sub Contractor will not require access to PROTECTED and/or CLASSIFIED information or asset, nor to restricted access areas.

X Not applicable ☐ RELIABILITY STATUS ☐ PROTECTED A ☐ PROTECTED B

20. INTELLECTUAL PROPERTY (IP) OWNERSHIP

The Sub Contractor will own any Foreground IP created by virtue of the main contract (W7714-145967/001/SV).

21. CONTROLLED GOODS

X Not applicable
☐ Applicable

22. BUDGET

The Sub Contractor will be paid by CIMVHR as per the terms of Contract # W7714-145967 between Defence Research and Development Canada and CIMVHR. The amount of funding available is allocated by fiscal year (April 1 - March 31st) and is approximately $23,700 for FY 2017-18 and $3500 for FY 2018-19 (plus applicable overhead). Details TBD upon award.

A draft budget must be submitted with the proposal along with a budget justification. A detailed budget will be developed post award in consultation with CIMVHR. Interested parties should request budget documents and information on creating their budget from Jocelyne Halladay.