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TITLE

HUMAN ENGINEERING ACTIVITIES WITHIN THE CANADIAN FORCES

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Human Engineering Activities within the Canadian Forces

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ABSTRACT

Human engineering is the application of knowledge about human capabilities to the design of systems and equipment to ensure effective and safe use. Human engineering activities in the Department of National Defence (DND) date from the 1950s. The Directorate of Technical Airworthiness (DTA) is responsible for the application of human engineering to Canadian Forces (CF) aircraft systems. DTA is supported by a human engineering research program at DCIEM. One major activity in that program is the development of tools and techniques for use by DTA and DND project management staff. This development started with the acquisition of a three-dimensional CAD system with a mannequin able to represent the normal range of male and female operator sizes in a specified workspace. To this was added a library of 3-D representations of current CF aircrew stations. This is being matched with a library of representations of the displays and control panels associated with specific aircrew stations developed using a commercially-available rapid prototyping system. Complementing these tools, which permit a detailed review of the physical aspects of aircrew stations, is a suite of tools for analyzing aircrew tasks. The most difficult research problem has been to develop the means for expressing operator 'workload' in terms that can be used in design. A model of operator capability based on the information processing rate has been developed and is being implemented within the task evaluation tools. The whole suite of tools is being improved and expanded. The next step in this development will add the capability to create simple representations of aircrew stations for man-in-the-loop evaluations.

RÉSUMÉ

L'ergonomie est l'utilisation des connaissances acquises sur les capacités humaines dans le but de concevoir des systèmes et un équipement qui assurent une utilisation efficace et sécuritaire. L'ergonomie au sein de la Défense nationale (MDN) date des années 1950. La direction de la navigabilité technique (DTA) est responsable de l'utilisation de cette discipline dans les systèmes

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Human factors research has provided a considerable body of information on human capabilities and limitations that is relevant to aerospace operations. It is the aim of human engineering (sometimes known as human factors engineering) to apply that knowledge to the design of systems and equipment that humans use, to ensure safe and effective operation. Human engineering is usually associated with the operator-machine interface, and, in aircraft, this usually means the cockpit and related aircrew stations.

Human engineering was practised in the 1950s at the parent organizations of DCIEM. Human engineering specialists at the RCAF Institute of Aviation Medicine in Toronto established a preferred design for an altimeter to avoid the well-documented reading errors associated with the three-pointer altimeter; scientists at the Defence Medical Research Laboratories worked on low-level navigation and pilot workload problems. Both organizations worked with the human factors specialist employed by Avro for the design of the Arrow cockpit.

Although no major aircraft are now designed specifically for the Canadian Forces, human engineering is still required within the Department of Defence (DND). An active program of human engineering applications is run by the Directorate of Technical Airworthiness (DTA) supported by research conducted at DCIEM. Although some of the human engineering research effort at DCIEM is devoted to specific operational problems, much of it is aimed at providing support to DTA projects. One major activity is the development of tools and techniques for use by DTA in its human engineering applications or to enable DND project managers to act as informed buyers of new systems and equipment.

These human engineering tools have been developed over the past 15 years. In 1982, DCIEM acquired a commercially available computer program that can represent the normal range of male and female operator sizes and their workspace in a Computer-Aided Design (CAD) environment. The System for Aiding Man-Machine Interaction Evaluation (SAMMIE) was evaluated for the accuracy with which it represents the reach envelopes of Canadian Forces (CF) personnel.[1] DCIEM then had developed software routines that modify the reach envelopes to represent reach with a locked and unlocked seat harness and that automatically locate the human-model in the crew-station seat.[2] Under contract to DCIEM, de-Havilland Aircraft Co. collected three-dimensional information on the geometry of all CF aircraft crew-stations using a sonic digiti-

d'aéronefs des Forces canadiennes. La DTA profite du soutien d'un programme de recherche ergonomique à l'IMCME. L'un des principaux aspects de ce programme est la mise au point d'outils et de techniques que peuvent utiliser le personnel de gestion de projet de la DTA et du MDN. Ces activités ont débuté par l'acquisition d'un système CAO tridimentionnel muni d'un mannequin qui pouvait représenter la gamme normale des tailles d'opérateurs, hommes et femmes, dans un environnement de travail précis. On y a ajouté une bibliothèque de représentations en 3-D des postes actuels des équipages de vol des FC. On y a aussi intégré une bibliothèque de représentations des affichages et tableaux de commandes de divers postes d'équipages que l'on a mis au point à l'aide d'un système commercial de prototypage rapide. Pour compléter cette gamme d'outils, qui permettent d'étudier en détail les postes d'équipages de vol, on a intégré une gamme d'outils permettant d'analyser les tâches de ces équipages. Le plus difficile problème que pose cette recherche consiste à élaborer un moyen d'exprimer la charge de travail de l'opérateur et l'utiliser en conception. Pour les besoins des outils d'évaluation de tâches, on met actuellement au point un modèle des aptitudes de l'opérateur fondé sur la vitesse de traitement de l'information. On améliore et on augmente constamment la gamme complète des outils. Ensuite, on prévoit ajouter une option qui permette de créer de simples représentations des postes d'équipage pour les évaluations des interventions humaines.

zation technique.[3] These data were used to develop a library of CF cockpits for use with SAMMIE (**Figure 1**). DTA then adopted the library for use in its projects, many of which involve refits and upgrades of existing CF aircraft.

The initial CAD system has evolved into a suite of tools for use in aircraft crew station design. This facility is currently operated for DND by Canadian Marconi Co., under a Technical Investigation and Engineering Support (TIES) contract to provide human engineering support to DTA. The aircrew station design facility now consists of two main groups of tools. One group, the Human Engineering Analysis and Requirements Tools (HEART), supports the development and evaluation of the physical aspects of the aircrew station. The original CAD tool has been improved and expanded. It is complemented by a rapid prototyping tool for generating representations of crew station displays and controls. The VAPS prototyping software program produced by Virtual Prototypes Inc. was selected for this. The potential use of a rapid prototyping facility within the design process was investigated through a survey of VAPS users.[4] A library of VAPS representations of CF aircraft displays and controls is being developed to complement the CAD library of crew-station geometry (**Figure 2**).[5] In addition, a hypertext library of human engineering guides and design standards for crew station displays and controls is being developed.[6] This will provide human engineering criteria to designers using the VAPS and SAMMIE-CAD tools.

The second group of tools, the Systems Operator Loading Evaluation (SOLE), supports the systematic analysis and evaluation of aircrew tasks. A review of 10 major acquisition projects concluded that the integration of human engineering efforts with other systems development activities can be facilitated by systematic analyses of aircraft missions, functions, and aircrew tasks.[7] Typically, human engineering activities in

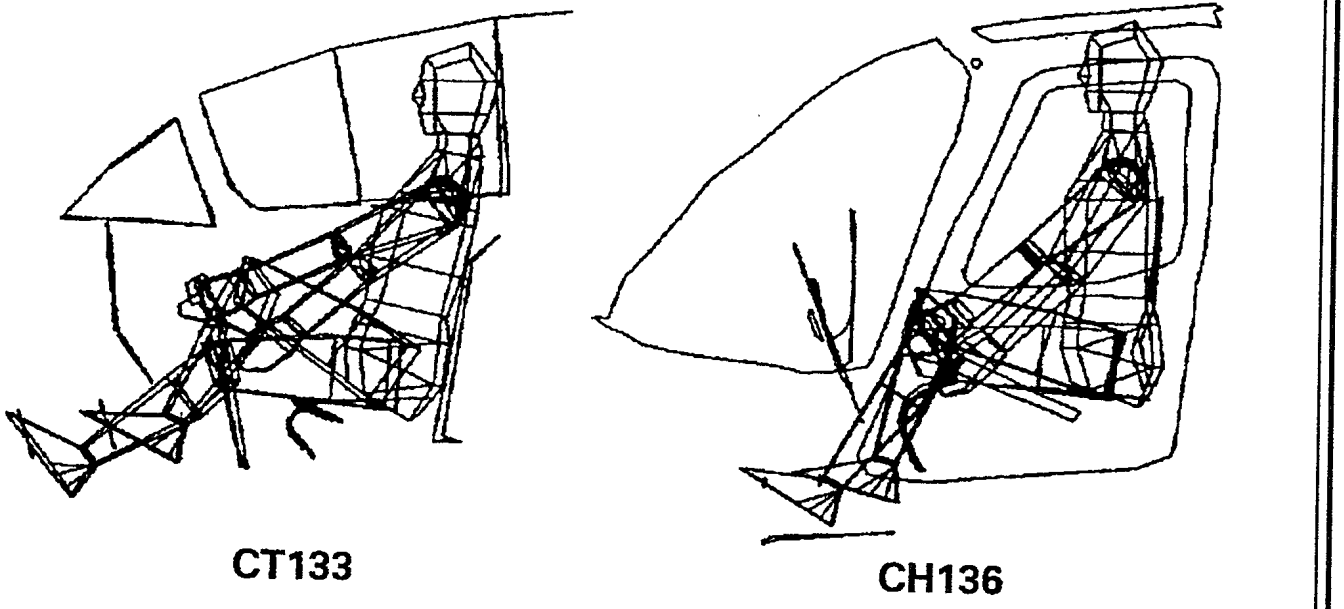

Figure 1.
Example from library of CAD representations of CF aircraft cockpits.

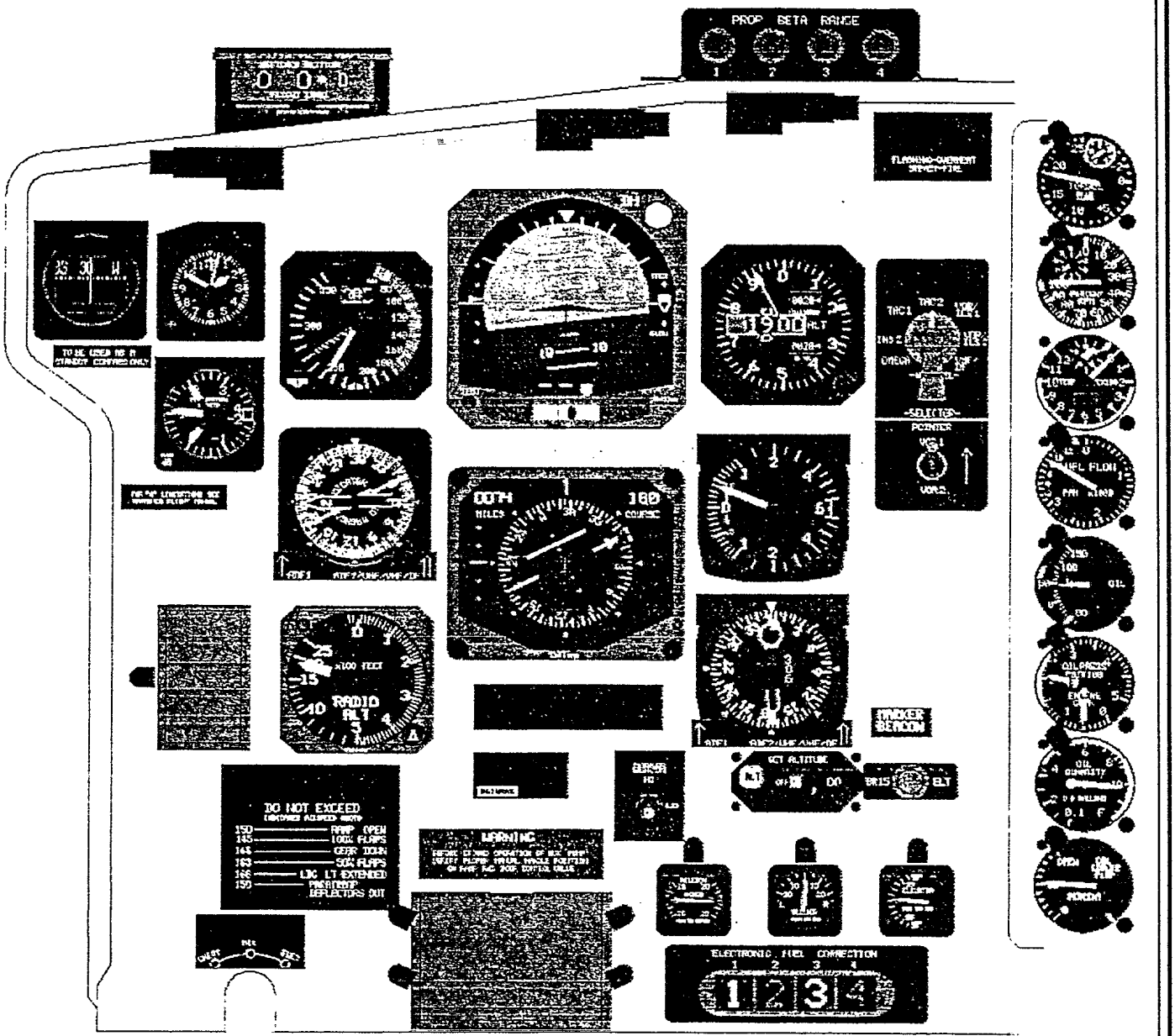

Figure 2.
Example from library of virtual prototypes of CF aircraft instruments.

support of the design of a large system are based on operator task analyses. These are developed by decomposing system functions into successive levels of detail. This results in between 5,000 and 10,000 separate items of information, much like the instructions for a computer (**Figure 3**). Keeping track of all this information is labour-intensive. Canadian Marconi Co. adopted a relational database for this work, thereby making it easier to track and update the information.[8]

The task database is linked to a software module for predicting operator workload which uses human information processing as the metric. Computer-based prediction and evaluation of operator workload was adopted for reasons of cost-effectiveness: the small size of CF aircraft projects cannot support extensive man-in-the-loop simulations to investigate human engineering issues such as crew workload. Computer simulation of operator tasks was implemented by Canadian Marconi Co. using the Systems Analysis by Integrated Networks of Tasks (SAINT) simulation language, which had been developed for the U.S. Air Force.[9] The most challenging human engineering research has been the development of metrics for evaluating operator workload based on the analyses of aircrew tasks. A model that relates human information

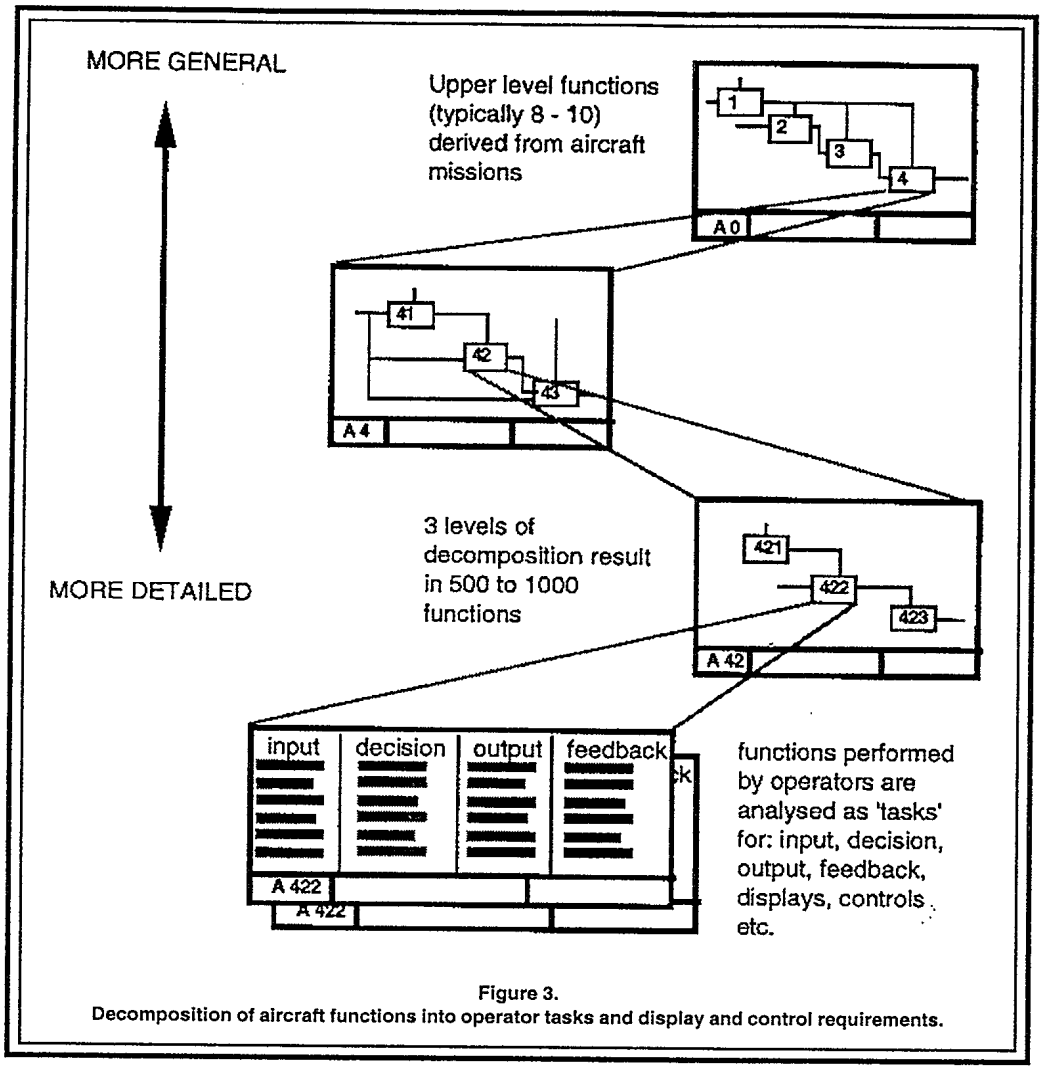

Figure 3.
Decomposition of aircraft functions into operator tasks and display and control requirements.

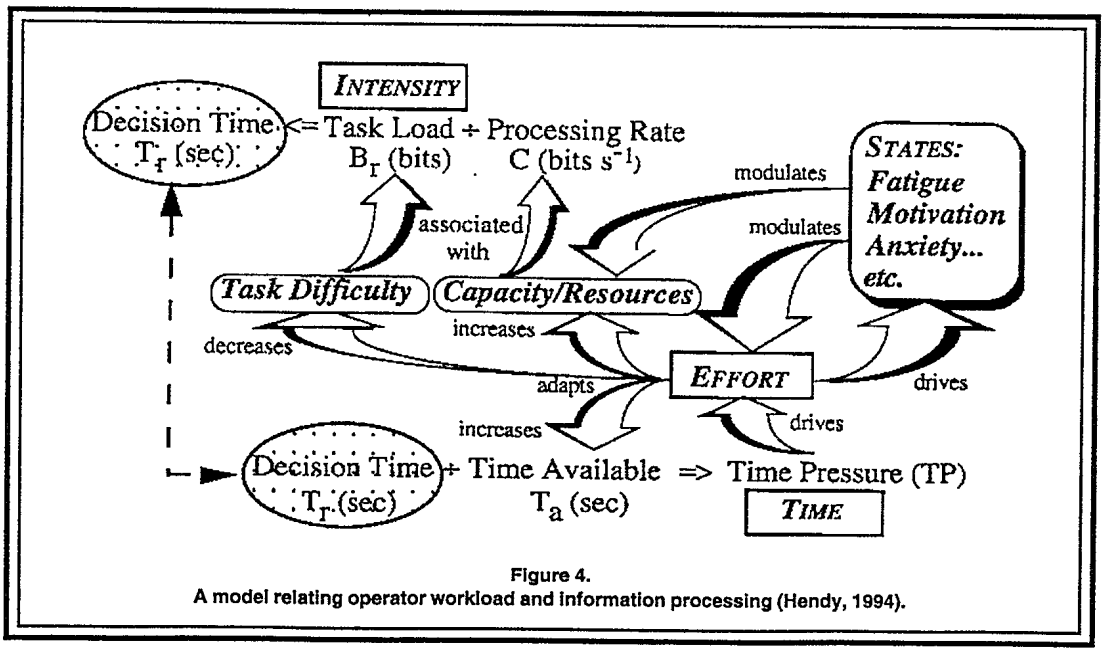

Figure 4.
A model relating operator workload and information processing (Hendy, 1994).

processing to operator workload has been developed through research at DCIEM (**Figure 4**).[10,11]

This suite of tools has been developed and used to investigate operator workload and system effectiveness through a succession of DTA projects. These include: a light tactical helicopter project; the New Shipborne Aircraft project; Aurora Update and Aurora Life Extension projects;[12] Coastal Patrol Aircraft;[13] and the CH-146 Griffon helicopter.

Currently, the Chief of Research and Development is supporting:

- improvements to the software to improve its ease of use and its ability to import data from other CAD systems; and
- the addition of a library of flail envelopes to the 3-D CAD man-model for checking the crash-worthiness of designs.

In addition, a scoping study has been completed to add a modest man-in-the-loop capability to the suite of tools, which will draw on the VAPS representations of the aircrew station interfaces. This development should proceed in the next year. When completed, these additions should provide the tools required to implement human engineering programs in CF aircraft projects for the next decade. At the same time the human engineering research program at DCIEM will continue to support and upgrade the facility to deal with the problems that future generations of technology will pose.

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