


# Image Cover Sheet

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**TITLE**  
HUMAN FACTORS ENGINEERING AND THE COTS ACQUISITION LIFE CYCLE FOR  
PERSONAL CLOTHING AND EQUIPMENT

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# HUMAN FACTORS ENGINEERING AND COTS ACQUISITION LIFE CYCLE FOR PERSONAL CLOTHING AND EQUIPMENT

By Captain Leo Donati and Captain Harry Angel

Designing clothing and equipment for the military requires extending the engineering concepts of "systems integration and sub-system compatibility" to include the user. The aim is to match system demands to human capabilities and limitations, and to human variability. Good operability is "invisible" in the same way that good structural analysis or good materials analysis is not always readily apparent: the only evidence is that the system works satisfactorily and does not fail.

The Defence and Civil Institute of Environmental Medicine (DCIEM) supports the Canadian Forces acquisition system through the provision of Human Factors Engineering (HFE) support. Located on the outskirts of Toronto, DCIEM is one of five Defence Research Establishments in the Canadian Department of National Defence (DND). DCIEM serves all Canadian Forces environments through multi-disciplinary teams dedicated to providing soldiers, sailors, and airforce personnel with system integration advice and performance enhancement. DCIEM is Canada's centre of expertise for Defence Research and Development in operational medicine, human performance and protection, and human-systems integration.

For the Land Forces, there has been a recent paradigm shift from purchasing clothing and equipment as individual items for soldiers, to viewing the individual soldier and attendant equipment as a "system." The systems approach is also fundamental to the discipline of human factors engineering.

Another change in the acquisition process is the increase in Commercial Off-the-Shelf (COTS) acquisitions, which meet essential military specifications and standards. The increase in COTS products was mandated in the 1994 Defence White Paper.<sup>1</sup> The shift to COTS and non-developmental items (NDI) in Canada requires the use of more performance-oriented specifications rather than technical engineering specifications. This approach significantly affects the way in which the Canadian Forces acquires new items of personal clothing and equipment. Traditionally, technical drawings and sealed samples for personal clothing and equipment were developed. Now the emphasis will be for industry to forward COTS contenders that meet specific user performance requirements.

To ensure that a COTS item meets the defined need, a detailed knowledge of for whom the original COTS item was designed, and what the specific task environments were, is most important. The unqualified adoption of COTS would assume that the Canadian Forces users have the same capabilities, training, experience, and physical attributes as those for which the COTS item was designed, and that they use the

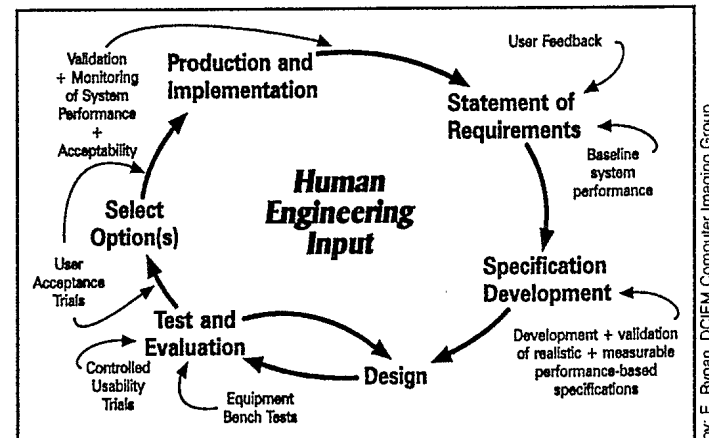
same doctrine and procedures. Clearly this is seldom the case. This means that the users and their capabilities and skills, as well as the system performance goals, must be clearly defined to bidders in terms that are relevant and definable.

DCIEM's support to the Canadian Forces' acquisition process will increase with the shift to COTS acquisitions. The following sections describe the process and instruments employed in providing HFE support to COTS acquisitions of personal clothing and equipment items. Figure 1 is an overview of the HFE inputs into the COTS acquisition process. This approach will be applied to clothing and equipment acquisitions for the Canadian Forces in the future.

## Human Factors Engineering Support to the Statement of Requirements

The acquisition and development process occurs in direct response to a requirement for a specified capability in the Canadian military. Activities associated with the acquisition process commence with a Needs Analysis and conclude with the acceptance of the new or modified system. The first phase of the life cycle concludes with the preparation of the Statement of Requirements (SOR). The SOR describes the operational needs, and states the minimum essential performance requirements that DND has determined necessary. Since the SOR is the initial step in a long process, it is critical that this document reflect the users' requirements and that the information contained can be validated.<sup>2</sup>

With projects developed by DND, the SOR is allowed to evolve as the project undergoes the various phases of devel-



HFE input into the COTS acquisition process for personal clothing and equipment

by: E. Rypan, DCIEM Computer Imaging Group

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opment. With COTS acquisitions, the development phase is severely shortened, or does not occur at all. As a result, greater care must be taken to validate the SOR in the early stages of the project. While there have been numerous tools and approaches to improve the application of HFE in the concept development and design phase of a system, few tools have been identified for addressing user requirements at the outset of projects.<sup>3</sup>

The main focus of the HFE effort during the first phases of the acquisition process is to assist in writing the SOR. The HFE input helps to define operational needs, validates the SOR, and provides information regarding baseline system performance. These activities involve a detailed consideration of all the needs of the equipment users. The areas addressed are: the users, the tasks performed, the tools and equipment used, and the environment.

### Users

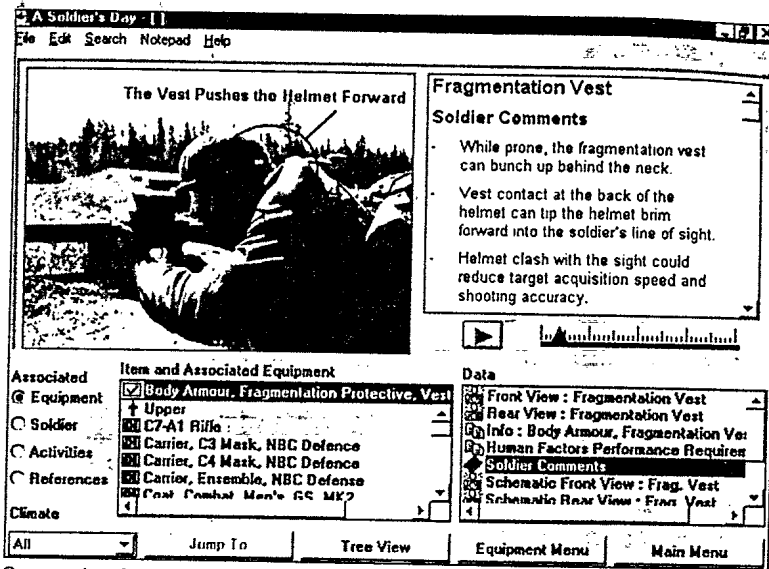
It is essential to consider the diversity of users and the impact that this may have on equipment design; what is their size and shape, what is their strength, what levels of experience do they have, what is their education, are they left or right-handed, do they have any colour vision defects? Failure to consider colour vision, for example, when acquiring a target acquisition system that makes use of colour symbology could result in a system that cannot be used by a portion of the intended population.

### Tasks

Soldiers make use of a variety of instruments and equipment. It is essential early in the process to establish the compatibility requirements among all pieces of equipment. This is particularly true of COTS acquisitions, where there will be no room for changes once a contract has been set. Failure to consider equipment compatibility could result in embarrassing acquisitions. Take, for example, three hypothetical COTS acquisitions: a new weapon, a new pair of combat gloves and a new combat jacket. Accessing the trigger and firing the weapon may be acceptable in temperate climate without gloves. However, if the compatibility between combat glove and the rifle had not been considered, it is possible that in colder climates, when the glove is added, there would no longer be adequate clearance to access the trigger. What about the combat jacket? What if gloves had not been considered during the design (perhaps because they were being acquired separately under a different contract) and the cuffs of the combat jacket were too restrictive to allow the gloves to be worn? Would the soldier be expected to go bare-handed in the winter?

### Environment

Finally, it is essential to consider the environment in which the soldier operates. Not only must the physical environment (noise, illumination, etc.) be considered, but also the training and organization environment. Military personnel operate in severe physical environments. Personal clothing and equipment should not only protect soldiers from these threats, but as well should not be the cause of new problems. It is essential to determine the trade-offs between protection and increased burden to the soldier. If training will be limited, then the new equipment item must reflect this by being easier to learn how to use and to operate. Organizational issues can also impact



Screenshot from the Soldier's Day database, a user specification tool.

on how equipment items will, or will not, be used, and should be considered wherever possible. For example, existing Standard Operating Procedures and doctrine may not be compatible with new equipment items.

Armed with an understanding of the context within which the equipment will be used, it is possible to begin to detail baseline system performance. Given how soldiers are currently performing tasks, what level of performance can be observed? For instance, for a given piece of equipment, used in a given situation, it may be possible to detail timings or accuracy. This will form the basis for the performance specification and eventually the bid evaluation criteria.

How then is the appropriate information gathered? A number of techniques can be used both to help elicit user needs and also to involve users and other stakeholders, thus resulting in a more participative process:

- Focus groups - Small group discussions with users of varying rank and from various locations around the country are conducted to ascertain the needs of soldiers in the field
- Questionnaires - questionnaires and surveys may be administered; and
- Task Analysis - If possible, the tasks performed by the soldiers with the proposed clothing or equipment item may be analyzed either through documentary sources or through observation.

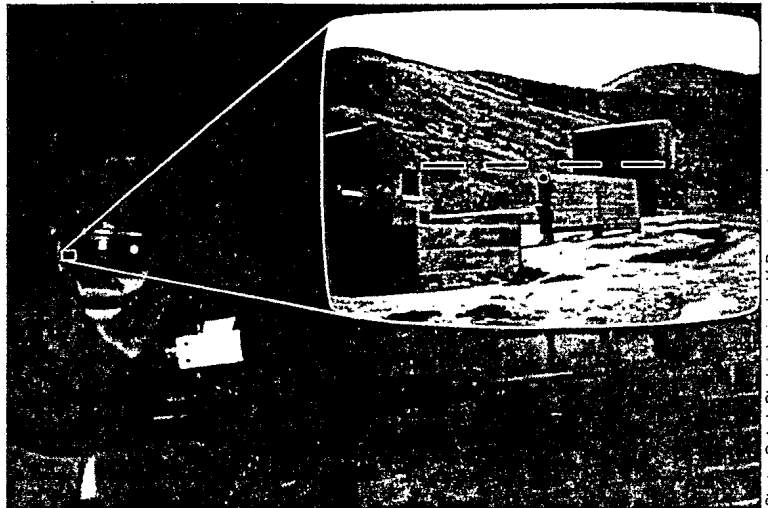
In many cases, it is not possible for the project management office to conduct detailed *a priori* analyses for every equipment item. One aid the authors have developed to provide all participants in the acquisition process — from staff officers to potential bidders — with a common frame of reference as to who the soldier is and what the required performance is, is the Soldier's Day database. This PC-based database consists of four smaller databases which contain information about soldier clothing and equipment, missions, tasks and roles, organization of soldiers, and human factor references. The databases can be accessed individually, or it is possible to access each laterally. For example, while looking at a C7 rifle, it is possible to ask, "who uses this weapon?", and move laterally to the organization database and retrieve information associated with the user.

### Human Factors Engineering Support to Specification Development

The SOR leads to the development of a specification. One of the problems with much of the development and acquisition process is that it emphasizes technical areas and pays little or no attention to the context in which the equipment will be used. The problem inherent in this process can be illustrated in the example of the operational need that a 105 mm Howitzer Field Gun be "accurate." Accuracy, from a human factors engineering perspective, is quite different from that of the engineering discipline. The strict engineering interpretation of accuracy is based on quasi-laboratory tests with the gun thoroughly supported or "bedded-in," carefully calibrated, and with the operators taking plenty of time to aim. This particular weapon system may prove exceedingly accurate in the lab. However, the same equipment may be very inaccurate when fired by soldiers in the field. The bottom line from the HFE perspective is the level of accuracy which can be achieved in the field under normal operational circumstances.

With COTS acquisitions, there has to be a move away from technical specifications towards performance-based specifications or mixed performance-based and technical specifications. DCIEM's role is to contribute to the development and validation of realistic and measurable performance-based specifications. The performance-based specification is a document which defines the minimum level of performance that a soldier, wearing all required equipment, with the appropriate training, will be able to perform in the field, given a set of climatic conditions. It relies on an understanding of the user/task/tool/environment relationship developed during the validation of the SOR, and flows logically from this. Once the key performance issues are defined, then appropriate test criteria and laboratory and field tests are developed and validated.

DCIEM has a number of state-of-the-art laboratory facilities which are used to support soldier system projects, ranging from climatic chambers, to a noise simulation facility, to a firearms training simulator. Field trials are conducted in collaboration



Evaluating a HMD in the firearms training simulator.

Photo: Cpl. J. Clark / design by V. Praesegard

with the Test and Evaluation Unit at the Combat Training Centre at Canadian Forces Base Gagetown, or at various locations throughout the country.

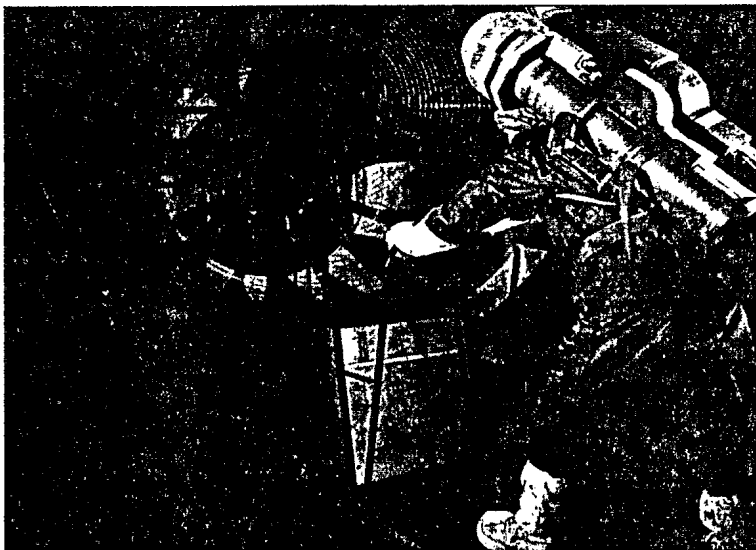
### Human Factors Engineering Support to the Selection of Options

DCIEM is involved in certain aspects of test and evaluation. In particular, objective "bench tests" are performed in the laboratory to help measure the performance of contender items. In the field, controlled usability trials of one to two weeks duration are conducted. During usability trials, both objective data such as timings and accuracy and subjective data on issues such as compatibility, comfort, ease of use, and fit are collected. They are followed by user acceptance trials which are of a longer duration and traditionally conducted by the Test and Evaluation Unit at CFB Gagetown. DCIEM's involvement in user acceptance trials is restricted to the provision of expertise in the areas of experimental design and questionnaire design and administration.

### Human Factors Engineering Support to Production and Implementation

The process does not end once the item has been produced and implemented. It is necessary to validate and monitor the item's performance and acceptability once it has been introduced into service. The manner in which we are addressing this is through the Army Combat Clothing Evaluation Survey System (ACCESS). ACCESS is a personal clothing and equipment survey system which makes use of automated data scanning equipment to facilitate data capture and entry. The survey results will provide the Canadian Forces with a means of monitoring user satisfaction with clothing and equipment items over the long term. Changes in the operational context which impact on clothing and equipment items should be reflected in the respondents' ratings to specific items in the questionnaires. These findings can be used to better direct acquisition funds in the future.

**HFE Support to the Clothe the Soldier Project**  
During Canada's recent United Nations deployments



Physical work capacity being evaluated in the climatic chambers at DCIEM.

Photo: MCpl R. Glaeser, DCIEM Photo Arts



Photo: DCIEM Operational Human Engineering Group

Soldier at a compatibility stand during a controlled visibility trial



Photo: DCIEM Operational Human Engineering Group

Soldiers on a forced march during a user acceptance trial.

to the Former Republic of Yugoslavia, a number of operational deficiencies with clothing and equipment were addressed with the purchase of COTS equipment through Unforecasted Operational Requirement (UOR) funding. Although new items such as GORETEX jackets and ballistic eye protection were issued to troops in the Former Yugoslavia, they were not issued in Canada. The Minister of National Defence and the Chief of the Defence Staff noted the deficiencies of the Land Forces' clothing and directed that the issue be resolved.<sup>4</sup> As a result, the Clothe the Soldier Project was initiated. The aim of this project is to address specific and immediate Land Force clothing and equipment deficiencies expeditiously.

The Clothe the Soldier Project has subsequently become the Army's top priority. It has the ambitious goal of developing technical and performance specifications for each deficiency item, evaluating COTS contenders, and then awarding contracts for over 20 personal clothing and equipment items in the next two to three years. The Clothe the Soldier Project will address the majority of the Army's clothing and equipment issues until the Integrated Protective Clothing and Equipment (IPCE) Program is implemented after the year 2005. Many of the Clothe the Soldier items are expected to remain in service until the year 2015.

**Future**

The shift towards COTS, and the success of the Clothe the Soldier Project, will require an increased HFE effort. DCIEM is examining the possibility of collaborative arrangements with Canadian industry aimed at encouraging and developing HFE expertise in military sys-

tems. The success of COTS acquisitions will surely depend on greater cooperation between Canadian industry and the Canadian Forces.

**NOTES**

- <sup>1</sup>. Department of National Defence, *1994 White Paper on Defence*, p. 41.
- <sup>2</sup>. A. Sheherd and T.C. Ormerod, *Development of a Formal Method of User Requirements Specification Process for Plant Displays*. Research Report for British Gas, Loughborough University of Technology, 1992.
- <sup>3</sup>. K. Eason, *Information Technology and Organizational Change*. (London: Taylor and Francis, 1988)
- <sup>4</sup>. 3136-5 (VCDS) 30 June 1995 Memorandum - *Clothe the Soldier Project*.

**Human Engineering Support to "Clothe the Soldier"**

**Ballistic Protection**

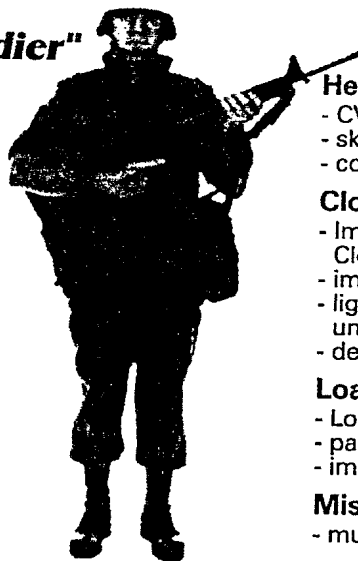
- Gen III Frag Vest
- ballistic plates
- ballistic visor
- ballistic eyewear

**Handwear**

- temperate combat glove
- cold/wet glove
- extreme cold glove
- CVC glove
- mortarman glove

**Footwear**

- temperate combat boot
- cold/wet boot
- NBC overboot
- sock system



**Headwear**

- CVC helmet
- skull cap
- combat cap

**Clothing**

- Improved Environmental Clothing System (IECS)
- improved underwear
- light-weight thermal underwear
- desert combat

**Load Carriage**

- Load Carriage Vest (LCV)
- patrol pack
- improved rucksack

**Miscellaneous**

- multi-tool

Photo: Cpl J. Clark, DCIEM Photo Arts

Clothing and equipment items comprising the Clothe the Soldier Project.

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