**Human Factors Engineering Team Experience**

The CMC HFE Team's clients include government agencies, commercial aerospace companies, a number of critical system development agencies, firms and Integrated Project Teams (IPT). A partial listing of clients and IPTs includes: the Atlantis Aerospace Corporation, BAE SYSTEMS, Dassault Aviation, Department of Fisheries and Oceans, Galaxy Scientific Corporation, Lockheed Martin Canada, MicroAnalysis and Design, MacDonald Dettwiler Associates, National Aeronautics and Space Administration, National Sciences and Research Council, Options Inc., Transport Canada, the University of Toronto Institute of Aerospace Studies, the United Kingdom Ministry of Defence, the United States Department of Defense and Canada's Department of National Defence (including: Defence Research Development Branch, Defence Research Establishments Atlantic, Ottawa & Valcartier, the Defence and Civil Institute of Environmental Medicine, and the Navy, Army and Air Forces).

The CMC HFE Team maintains tight project management on each of its HFE programs through the rigorous planning, tracking, reporting and controlling of all activities related HFE contract fulfilment. A short profile, of a few of its past and current programs, are provided to demonstrate the depth of the CMC HFE Team's administrative and technical support, and systems and human factors engineering capabilities. They are, as follows:

- HUMAN ENGINEERING ANALYSIS AND REQUIREMENTS TOOLS INTEGRATION PROGRAM;
- ENHANCED AND SYNTHETIC VISION SYSTEM FOR COMMERCIAL AIRCRAFT;
- CF-18 'HORNET' HEAD DOWN DISPLAYS HUMAN FACTORS ENGINEERING STUDY;
- CH-146 'GRIFFON' AVIATOR NIGHT VISION HEADS UP DISPLAY;
- CH-146 'GRIFFON' ELECTRO-OPTIC RECONNAISSANCE, SURVEILLANCE AND TARGET ACQUISITION SYSTEM; and
- LAND FORCE COMMAND AND CONTROL INFORMATION SYSTEM OPERATIONAL REQUIREMENTS AND INFORMATION SYSTEM ARCHITECTURE MODELLING STUDY.

**HUMAN ENGINEERING ANALYSIS AND REQUIREMENTS TOOLS INTEGRATION PROGRAM**

In order to properly assess operator interfaces at the conceptual phase of equipment and systems design, a requirement existed within the Canadian Forces (CF) for an efficient Human Factors Engineering (HFE) concept and design evaluation process. To meet this original requirement, the System Operator Loading Evaluation (SOLE) facility was developed. SOLE is a set of HFE tools which may be used to systematically identify system missions, functions, and tasks, produce a task network simulation based on the identified tasks, and evaluate operator performance requirements and workload using task performance simulation. The SOLE facility is maintained for the CF by the CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team.

There was, and remains, a requirement within the CF for a quick, reliable and inexpensive method of evaluating proposed crewstation designs in terms of operator/crewstation compatibility and the adequacy of operator interfaces. Such a method has great value for assessing proposed modifications to existing CF crewstations. To fulfil this requirement, the Directorate Aerospace Support Engineering (DAS Eng) supported the development of the Human Engineering Analysis and Requirements Tools (HEART) facility, based on research at the Defence and Civil Institute of Environmental Medicine (DCIEM). This capability was transferred to the CMC HFE Team, who now provides HEART and SOLE services to the CF under a Technical Investigation and Engineering Support (TIES) contract.

The HEART and SOLE facilities have shown great potential and have been employed successfully on several occasions by the CF in assessing proposed designs. Further development and integration of these facilities was necessary to decrease the time required for data analysis, to reduce operating costs and to expand the toolsets capabilities. It was also necessary to continue the development of these facilities to create valid tools capable of utilising the most current human engineering research conducted by DCIEM.

The intent of this effort was to improve the existing HEART and SOLE facilities by expanding their capabilities, increasing their efficiency and integrating them onto a single platform.

Given the requirement of the CF to respond to changing roles, and the trend to keep existing systems and equipment in service as long as possible, the capability to modify existing equipment is paramount. In the past, HFE aspects of such work were undertaken using time-consuming paper and pencil methods supplemented by mock-ups and trials with actual aircraft. The HEART and SOLE facilities provide the basis for a suite of Human Engineering (HE) tools which would enable DND to evaluate and redesign equipment and crewstations prior to procurement or modification. As HEART and SOLE have developed, the potential value to the CF of an improved, integrated human engineering facility has become apparent.

SOLE is a set of computer-based tools which integrate network analysis procedures with other front-end human engineering methods such as mission analysis, functional analysis and allocation, task analysis, and operator performance prediction. SOLE has been developed in stages, through application in the New Shipborne Aircraft (NSA), Canadian Forces Light Helicopter (CFLH), and Aurora Update projects. From the outset, DCIEM and DAS Eng had been involved with the CMC HFE Team in a working-group relationship to define the direction of the development of this capability. The associated version of SOLE permitted users to track and update hundreds of system functions, tasks, and task characteristics which are identified through human factors and engineering analyses. To ensure that the performance prediction and workload analysis tools incorporated into SOLE remained appropriate and usable by the CF customer, it was important that further work be completed in the areas of validation, scope of analysis, data entry and the presentation of results.

The HEART facility was initiated through a TIES contract in March 1991 to install the results of DCIEM research at CMC. This original facility consisted of three separate technologies: digital 3-

dimensional (3-D) cockpit and workstation mapping, mathematical man modelling in 3-D, and virtual prototyping of operator interfaces. Sonic digitisation was used to establish a 3-D digital representation of the existing crewstation. Through the use of engineering data, this 3-D model was then updated to incorporate changes to the crewstation imposed by the proposed modification. For a new crewstation, the digital model may be produced entirely from engineering data. A model of the human operator was then generated using the System for Aiding Man-Machine Interface Evaluation (SAMMIE) Computer Aided Design (CAD) facility. The human operator model was manipulated within the proposed crewstation model to evaluate the ability of the anticipated operator population to perform adequately within the crewstation environment. Performance was assessed in terms of reach, vision, and clearance criteria. The final technology used in the HEART facility was a Virtual Avionics Prototyping System (VAPS) software program installed on a Silicon Graphics workstation. This rapid prototyping facility allowed for the quick design, modelling, and evaluation of new or modified controls and displays prior to their incorporation into modification or development programmes.

Prior to the release of this program, the HEART and SOLE facilities had been developed based on separate research thrusts at DCIEM. In so far as these applications had begun to mature, it had become obvious that there was a requirement for the integration of these facilities into a single tool, enhancing their capabilities synergistically. The benefits associated with the integration of the HEART and SOLE programmes onto the same hardware platform included:

- Cost, integration, and maintenance savings associated with utilising common support programs such as the Relational Database Management System (RDBMS), library of drawing subroutines and anthropometric man modelling program;

- A common thrust to future development because both packages will be overseen by the same DND or DCIEM programme manager;

- Ease of transportation of the complete package from one agency to another; and

- The requirement to establish and maintain only one hardware and software configuration.

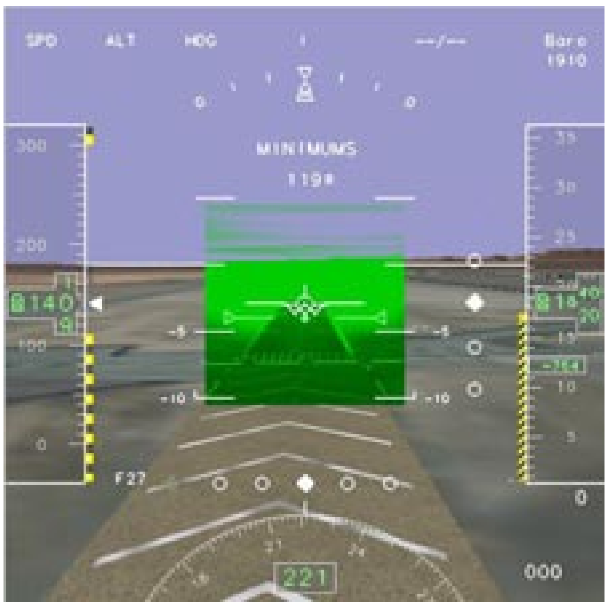
The proposed integrated facility provided the CF with a flexible suite of human engineering and crewstation design tools for the evaluation, development, and modification of CF crewstations early in concept development, without the time and costs associated with mock-ups and trials using actual aircraft. It improved the CF's ability to act as an informed buyer, and improved the approach taken to crewstation design and development.

This program was initiated April 1994 and was completed in March 1998. It ensured ensure the preliminary HEART technologies developed by DCIEM and DAS Eng remained available to DND. The CMC HFE Team provided recommendations and is now instituting measures to further augment these capabilities within the HEART umbrella.

**ENHANCED AND SYNTHETIC VISION SYSTEM FOR COMMERCIAL AIRCRAFT**

The CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team, BAE SYSTEMS CNI Division and BAE SYSTEMS Controls have been collaborating in a cost-sharing research and development project with the National Aeronautics and Space Administration (NASA) to develop an Enhanced and Synthetic Vision system for commercial transport aircraft flight decks. The project is being implemented in three phases.

Phase I of the project commenced in January 2000 and its objectives, successfully implemented in April 2001, included: development of an Operator Interface (OI); definition of a system architecture; definition of a navigation subsystem architecture; proof of concept for image fusion between a millimetre Wave (mmW) radar and a Forward-Looking Infrared (FLIR) camera; development of the business case; and, initiation of certification activities.




The OI development includes synthetic and enhanced vision components, and effectively integrates all information elements on the flight deck to provide significantly enhanced pilot Situational Awareness (SA) in all flight and ground visibility conditions. In the completion of this work, the CMC HFE Team conducted a human engineering analysis, completed a requirements definition and preliminary design of the OI, and built a rapid prototype model of the OI in a Boeing 757 Aircraft Crewstation Demonstrator (ACD). At each stage of the development, emerging OI requirements and design concepts were demonstrated to and discussed with the System Engineering development team to ensure that the requirements were included in the overall requirements tracking process, and could be accommodated by the emerging architecture definition. The OI display format development addressed inclusion of both enhanced and synthetic vision elements as primary flight reference on commercial air transport flight decks. Following internal review the rapid prototype model was provided to NASA Langley for independent evaluation.

The System Architecture Definition work defined a system architecture concept suitable for the high speed/bandwidth requirements of the proposed system, which will be cost-effective to implement in a wide variety of new and retrofit aircraft. In the completion of this work, the CMC HFE Team analyzed system requirements, implemented a requirements tracking process, investigated candidate architectures, conducted a trade-off analysis, and derived requirements specifications for hardware and software. Throughout the process, , the CMC HFE Team liased closely with the OI development team to ensure that potential system capabilities and limitations were clearly understood, and that a suitable match with OI requirements was achieved. CMC produced a revised Statement of Work for Phase II activities and a detailed Phase II Engineering Development Plan based on the results of the system architecture definition and inputs from those responsible for other Phase I tasks.

The Navigation Subsystem Definition work defined a cost-effective positioning and attitude reference subsystem to achieve the accuracy, integrity and reliability required to support use of synthetic vision as a primary flight reference. In the completion of this work, the CMC HFE Team analyzed navigation requirements, developed a requirements tracking process, investigated candidate navigation solutions, conducted a trade-off analysis, and derived a navigation system requirements specification.

The specific aim of the Sensor Image Fusion work was to complete development of image fusion algorithms and processes that will provide an optimal image from mmW imaging radar and a FLIR sensor for all visibility conditions.  This work was conducted by BAE SYSTEMS Controls.  The CMC HFE Team monitored the progress of the work to ensure that the enhanced vision element was effectively accommodated within the overall system architecture.

The specific aim of the Airline Cost-Benefit Analysis work was to develop the business case for a wide variety of airline operations to support implementation of the future flight deck information management and display system.  CMC corporate staff lead the effort by all the participating companies and developed the cost-benefit models for inclusion of enhanced and synthetic vision on the flight deck.

The specific aim of the Certification work item was to initiate activities to ensure that timely certification can be achieved for the system, and that standards are developed for system elements for which no current certification standards exist.  During the conduct of this work, the CMC HFE Team's technical and engineering support staff investigated certification requirements and establish a draft plan.  CMC conducted a Preliminary System Safety Assessment.  Membership was sought on committees with a mandate to develop appropriate certification standards, such as the Air Radio Incorporated (ARINC) Systems Architecture and Interfaces (SAI) Sub-committee, and Society of Automotive Engineers (SAE) G-10.

The CMC HFE Team, in collaboration with its partners, is currently embarked on the second and third phases of the project.  Phase II primarily addresses the initial prototype build and test in a laboratory environment, migration of the OI rapid prototype to a fully functional configuration in a NASA high fidelity moving-base simulator, and continuation of the business development and certification tasks.  Phase II is scheduled for completion in June 2002.  Phase III calls for installation and evaluation of the prototype system in the NASA 757 ARIES, and finalization of the certification plan.  The combined project team is scheduled to conducted this work from July 2002 to June 2003.

**CF-18 'HORNET' HEAD DOWN DISPLAYS HUMAN FACTORS ENGINEERING STUDY**

The Deputy Scientific Advisor, Air of the Defence Research and Development Branch adopted a systems approach to address the needs of the operational client and in late January 2000, while addressing the integration of new capabilities and enhanced mission effectiveness for its CF-18 fighter aircraft, DND contracted the CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team to conduct an HFE of the CF-18 weapon system, associated displays and interfaces. The specific objectives of this HFE study, as a whole, were to establish a rapid prototype of advanced Head Down Displays (HDD) within the HFE test and evaluation apparatus, the Aircraft Crewstation Demonstrator (ACD), and to develop a subsequent High-Level Architecture (HLA) distributed simulation to assist in the development and evaluation of new generation HDD display formats and operator interfaces.

CMC conducted a traditional mission, function and task analysis, utilising the System Operator Loading Evaluation (SOLE) facility to investigate and document all aspects of CF-18 weapons system employment in Counter Air Operations, including defining an operational equipment suite, and agreed-upon capabilities represented in the omnibus CF-18 Incremental Modernization Program and other selected capital programs intended to deliver a modernized, supportable, interoperable and survivable CF-18.  The CMC HFE Team documented CF-18 roles and tasks, identified and decomposed operationally related functions to the task level, allocated tasks to operator or machine, compiled a database of task and workload information, and generated task networks or operational sequence diagrams.  In this analysis, the CMC HFE Team detailed the essential functions of the modernized CF-18, along with data to describe mission segments, each with discrete initiating conditions, task completion times and information, action, and feedback requirements allocated to the pilot.  CMC assigned all functions to either a human or a machine, in order to maximize overall system effectiveness within the constraints imposed by human, technological and/or cost considerations under review and, finally, depicted mission segments against a timeline, including an analysis of the information and decision making requirements of identified critical task sequences.

From the foregoing analyses, CMC catalogued a number of display integration, interpretation and mission impact concerns, used to later formulate the design objectives for the development of new rapid prototype displays elements for the CF-18.  In order to implement the display element design objectives, the CMC HFE Team made modifications to the HFE test and evaluation apparatus to support a simulated CF-18 operational environment.  These included the generation and implementation of complex mission scenarios, the introduction of new operator Hands on Throttle and Stick (HOTAS) cockpit switchology, the integration of the Litton Systems Canada Multi-Purpose Display Group (MDG) Active Matrix Liquid Crystal Display (AMLCD), the addition the new display formats and the testing of system functionality. Finally, the CMC HFE Team developed and implemented a distributed simulation between the CMC-supported ACD and the Defence Research Establishment Ottawa Simulator for Advanced Fighter Radar ECCM (SAFIRE) development, using High Level Architecture to define the functional components and interfaces. The HLA Federation Architecture included a Federation Object Model (FOM) to define the attributes of each federate, interaction and association, and a Simulation Object Model (SOM) to define the attributes of the objects modelled. These object models defined the overall class hierarchy and class interaction facility between the ACD at CMC and the SAFIRE radar simulation model at DREO. Finally, an Integrated Services Digital Network (ISDN) line was established between CMC and DREO facilitated data communications, employing a Run Time Infrastructure to define the services and management of the interactions between SAFIRE and CF-18 ACD federates. The distributed simulation was used extensively during the display evaluation period.



The CMC HFE Team extensively adapted the CF-18 ACD system architecture, displays and HOTAS functionality constructed and configured under a separately funded CF-18 ACD Upgrade project, to accommodate new and advanced displays, rapidly prototyped for this project and for the CF-18 weapon system identified for analysis. Moreover, considerable effort was expended to write and implement software code for the various applications to support project test and evaluation objectives.

The CF-18 project culminated in the development of a test scenario, a successful formal evaluation of the prototyped displays by operationally experienced CF-18 aircrew, and the measurement, retrieval and analysis of data. Composite scenarios, representing the roles, missions and tasks of Counter Air Operations were suitably represented in the simulation tactical environment, and were flown during April 2001. The experimental design evaluation and its subsequent analysis were implemented in collaboration with the Carleton University Centre for Applied Cognitive Research (CACR). The OMI evaluation provided an expert-user assessment of the functionality and mission effectiveness of the HDDs prototyped for the CF-18 by the CMC HFE Team. During the evaluation experienced CF-18 aircrew flew a simulated CF-18 aircraft through a series of tactical missions designed to exercise the capabilities of the prototyped cockpit displays.


The CMC HFE Team integrated these various sources of data into a coherent analysis to support findings relating to display symbology effectiveness and sensor use. The user assessment methodologies, including data measurement and retrieval, were proven to effectively index expert user performance and behaviour in the simulation environment. The CF-18 expert user assessments showed that the displays and display elements were effectively designed and implemented. The CF-18 expert users indicated that the new mission suite and prototyped display formats eased workload, added functionality, and considerably enhanced mission effectiveness and situational awareness. The CF-18 expert users also expressed a high expectation that the display elements would be applicable and transferable to the operational environment, enabling aircrew to fly safe and meet tasking objectives.

The CMC HFE Team issued to DND, at successive phases of project implementation, a series of reports documenting the project methodologies, analyses and results. In summary, the CF-18 HDD HFE Project successfully demonstrated the use of an HFE-based low-cost, low-fidelity test and evaluation facility for rapid prototyping, modelling and simulation, and associated analyses, as a prime risk-reduction activity in acquisition processes aimed at replacing or enhancing operational capability and improving human performance.

**CH-146 'GRIFFON' AVIATOR NIGHT VISION HEADS UP DISPLAY**

In the late 1990s, DND began procuring Night Vision Goggles (NVG) for use in CH-146 Griffon operations. The Program Management Office (PMO) Canadian Forces Utility Tactical Transport Helicopter (CF UTTH) adopted a development path to facilitate the evaluation of proposed symbology sets prior to implementation in the NVG systems. In February 1999, PMO CF UTTH contracted the CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team to evaluate a proposed symbology set in a prescribed experimental flight environment within the Griffon Aircraft Crewstation Demonstrator (ACD). Any major deficiencies in the prescribed symbology set were to be identified and documented.

To support the evaluation, CMC configured the ACD with an immersive Helmet Mounted Display (HMD) system and a library of virtual operational environments. A preliminary Aviator Night Vision (ANVIS) Heads Up Display (HUD) symbology set for the CH-146 was derived and documented by Department of National Defence (DND) personnel. The CMC HFE Team developed a symbology set within the ACD HMD, replicating the look and feel of the prescribed ANVIS/HUD symbology, and then conducted an interface development working group, with CH-146 operational staff and personnel from PMO CF UTTH and Carleton's University's Centre for Applied Cognitive Research (CACR), to review its subsequent implementation. Following this, in collaboration with the CACR, the CMC HFE Team developed a usability study protocol for the evaluation and then performed simulation flight trials in the ACD, employing experienced CF Griffon Helicopter pilots (recruited from 3 different operational units). These aircrew exercised the symbology set in a series of mission profiles and provided comments on various aspects of the ANVIS/HUD symbology. The CMC HFE Team documented the results, along with suitable recommendations and conclusions.

The ANVIS HUD that was implemented and evaluated in this study was an important step toward providing useful symbology for NVG contexts. The evaluation showed, however, that there were numerous aspects of the ANVIS/HUD that needed to be modified and re-assessed. The CMC HFE Team recommended that the modifications should be completed and assessed in a timely fashion, such that the participant pilots could be engaged to participate in an evaluation of the modified set.


Participant pilots indicated that, compared to ANVIS alone, the ANVIS/HUD enhanced flight performance, situational awareness and flight safety. Although the pilots who participated in this study believed that the ANVIS/HUD would advance NVG flight performance, as summarised in the symbol-by-symbol review documented for DND, several deficiencies in the ANVIS/HUD symbology set were identified. An important issue that emerged from the evaluation concerned the variety of attentional demands that are placed on the pilot when using the ANVIS/HUD. Pilots' ratings and comments suggested that they experienced substantial difficulty controlling shifts of attention between the outside world and the ANVIS/HUD symbology. To achieve maximum efficiency, it was recommended that those demands be fully identified, assessed and taken into account when developing future HUDs. It was also emphasized that there might well be situations where the demands associated with using the ANVIS/HUD diminish, rather than serving to enhance pilots' performance and that these, too, require further identification and analysis. Given the pilots' reports of attentional capture and cognitive tunnelling in the evaluation study, the potential for a negative impact of the ANVIS/HUD could not be ignored.

The effort conducted under this contract by the CMC HFE Team expanded on previous work to examine the suitability of HMD symbology sets for flight in the apparatus to support the demonstration of an Enhanced Synthetic Vision System (ESVS) flight displays, developed by the Defence Research and Development Branch (DRDB), the National Research Council (NRC), and a number of private and public sector contributors under separate programs. A follow-on DND-sponsored program, entitled Helmet Mounted Display (HMD) Symbology Research, was established to research the contribution of various attitude reference display elements to a flight maintenance task. The CMC HFE Team, in collaboration with the CACR, was contracted to extend the original HUD Symbology Review experiment. The CMC HFE Team developed a functional ANVIS HUD symbology set within the ACD and established a usability study protocol for its evaluation. A series of user trials were conducted in this facility to augment the body of knowledge on symbology set development, and to substantiate and validate the specification to be utilized during the ANVIS/HUD procurement process.

**CH-146 'GRIFFON' ELECTRO-OPTIC RECONNAISSANCE, SURVEILLANCE AND TARGET ACQUISITION SYSTEM**

In September 1999, DND contracted the CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team to conduct a Human Factors Engineering Study (HFES) in support of the development of an Electro-Optical Reconnaissance and Surveillance Acquisition (ERSTA) system Airborne Control Station (ACS). The specific objectives of the study were to conduct a Mission, Function, and Task Analysis (MFTA) for the ERSTA missions, to determine the required Operator-Machine Interface (OMI) and to define the OMI specifications for the ACS.

Building on previous work completed through other CH-146 mission analyses and related OMI design efforts, the CMC HFE Team expanded the body of knowledge by conducting a traditional MFTA to investigate and document all aspects of CH-146 employment in anticipated ERSTA missions. Working with operational DND Subject Matter Experts (SME), the CMC HFE Team defined the characteristics of an assumed air vehicle equipped for the ERSTA missions. The CMC HFE Team used information from a previous Operator Performance Prediction Study (OPPS) and input from SME sessions to identify and decompose operationally related functions to the task level, allocate tasks to human or machine, compile a database of task information, and generate task networks in the form of Operational Sequence Diagrams (OSD). In this analysis, the CMC HFE Team documented the details of the specific ERSTA related missions, compiling data to describe mission segments, discrete initiating conditions, estimates of task completion times, action required, feedback, internal and external communications requirements, and task allocations among a crew complement of four. The CMC HFE Team allocated tasks either to operator or machine in order to maximize system effectiveness within constraints of known technology, safety and mission effectiveness.

Building on this analysis, the CMC HFE Team prototyped the preliminary design concept, in three phases, and these prototypes were reviewed by a number of potential ACS operators selected by DND. Their feedback was used to develop and refine the rapid prototypes. The rapid prototype designs began as paper-and-pencil descriptions, moved onto computer screens presented in a proportionally correct cabin mock-up affixed to the Griffon Aircraft Demonstrator (ACD) and, finally, were represented in an airborne prototype fitted into an operational helicopter for formal flight trial evaluation by DND, as well as by CMC.

The CMC HFE Team conducted anthropometric analyses throughout the development of the rapid prototypes. A Computer Aided Design (CAD) representation of the CH-146 cabin area was created and, together with a digitised measurement of the ACS station mock-up, was imported into SAFEWORK for evaluation. Using data from the 1997 Anthropometric Survey of the Land Force (LF), the CMC HFE Team conducted a multivariate analysis of potential ACS configurations. Subsequent reach, vision, and clearance assessments were conducted in both the ACD mock-up and in a CH-146 with the airborne prototype ACS installed.

The airborne prototype ACS included sensor functionality for camera pan and tilt, zoom, simulation of laser range finding, auto-track, auto-slew, polarity control, and simulation of target recording and target designation. Additional functionality was provided in the form of a moving map display, image capture, and mission product management software modelled specifically for the ERSTA mission. Links between the map display and the mission product management allowed the operator to enter data into forms by selecting objects or positions on the map. A database built into the mission product management software allowed for the capture and post-flight analysis of operator activities. The model allowed ACS operators to conduct interactive evaluations of the airborne prototype OMI while executing typical ERSTA tasks in the context of a mission. The CMC HFE Team integrated the flying prototype with the CH-146 through the MIL-STD-1553 data bus to obtain aircraft heading and position information. Specific software was developed to control the installed Thermal Imaging System (TIS). The TIS was further modified to provide relative tilt and pan angle information to the operator through the ACS map display.


After completion of the airborne prototype evaluation, the CMC HFE Team incorporated the results of both the laboratory and airborne evaluations into a Human Factors Specification for the ACS and a Human Engineering Design Analysis Document - Operator (HEDAD-O) to support DND's procurement of the ERSTA system.

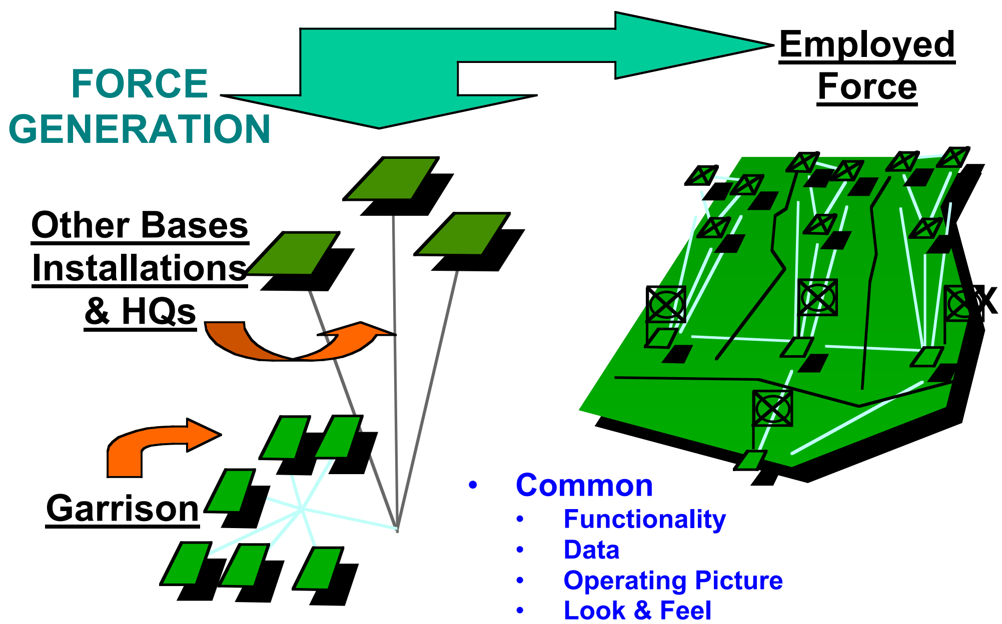
The OMI represented in both the ACD and airborne prototypes was well received by the ACS operators. Results of SME evaluations show that the OMI is quickly learned, easy to use, and intuitive.

Subsequent to the completion of the ERSTA HFES, CMC was contracted by DND to prepare and facilitate an industry information session to present the findings of the study and demonstrate the airborne prototype in a static environment. The one-day session provided a forum for DND to explain the concepts for the ERSTA system and their procurement strategy to potential industry vendors.

**LAND FORCE COMMAND AND CONTROL INFORMATION SYSTEM OPERATIONAL REQUIREMENTS AND INFORMATION SYSTEM ARCHITECTURE MODELLING STUDY**

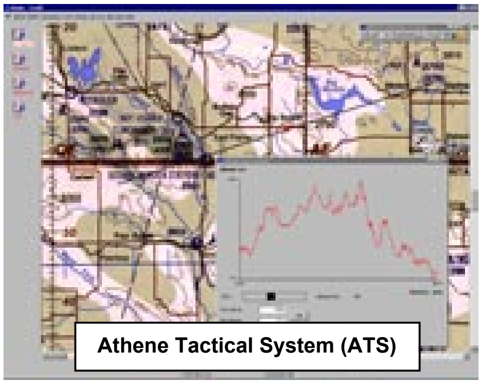
The Department of National Defence (DND) wishes to develop and evolve an integrated Land Force Command and Control Information System (LF C2IS) that will improve the effectiveness and efficiency of commanders and staffs in performing command and control to achieve their assigned missions. Although the LF is currently in the process of fielding its first digital C2IS (version 1), some elements of which are illustrated in this article (Athene), a variety of interface, network and integration issues remain unresolved. In the past the LF has addressed the garrison and deployed domains separately, with respect to the provision of information systems to support commanders and staffs. DND wishes to examine the information system requirements of commanders and staffs in both these domains, to determine what data and automated tools commanders and staffs need access to, in order to support them in the performance of their command and control related tasks in both domains.

In March 2001 the CMC Electronics Inc. (CMC) Human Factors Engineering (HFE) Team was awarded a contract by DND to conduct a Project Identification Study in support of the LF Project L2717, LF C2IS. The objective of this study is to identify, validate and prioritise the requirements for a C2IS at the LF Area HeadQuarters (HQ), Brigade HQ, and Battle Group HQ and below. This project, entitled "LF C2IS, Operational Requirements and Information System Architecture Modelling Study", will seek to identify requirements for both the garrison and deployed domains




for all phases of operations.

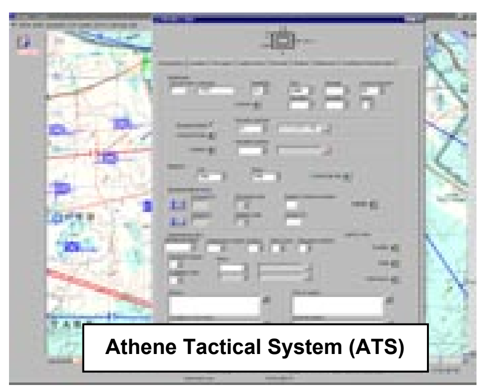
The CMC HFE Team's successful analysis of requirements for a deployed Battle Group under the Tactical Battlefield Command System (TBCS) study, conducted between September 1998 and December 1999, became the precursor to the LF C2IS Project Identification Study. The current LF C2IS study consists of two parallel analyses, an HFE Requirements Analysis and a Systems Engineering Requirements Analysis, and is scheduled for completion in March 2002. The HFE Requirements Analysis will define the human end user (e.g. Operator and Maintainer) requirements for the LF C2IS.  The Systems Engineering Requirements Analysis will examine overall system requirements and will produce the Information System Architecture for the LF C2IS. The Requirements Analysis Phase will provide DND with the information necessary to develop a comprehensive Statement of Capability Deficiency (SCD) and Statement of Requirement (SOR) for a future LF C2IS.


Athene Tactical System (ATS)

In order to best meet the objectives of the project, CMC has subcontracted MacDonald Dettwiler Associates (MDA), systems analysis and definition specialists, to conduct the systems engineering elements of the project and MicroAnalysis and Design, developers of the Integrated Performance Modelling Environment (IPME), to assist the CMC HFE Team's analysts in the development of network models, workload analysis and identification of Measures of Performance and Effectiveness (MOPE).

During the HFE analysis phase, the CMC HFE Team is conducting a traditional HFE analysis to comprehensively identify and describe deficiencies with respect to the current Command and Control System (C2S) and, in particular, its Command and Control Information System (C2IS) and the C2IS maintenance system.  This process includes mission, function, task, information flow and cognitive processing analyses and performance prediction.  The CMC HFE Team will employ the Systems Operator Loading Evaluation (SOLE) and IPME suite of tools to conduct these analyses in accordance processes defined within MIL-HDBK-46855.  The CMC HFE Team will use this information to develop a comprehensive list of specific MOPEs, to identify deficiencies/issues inherent to the current system.  Although the operator and maintainer analyses are treated as separate tasks, all analysis activities involving operator functions will be closely integrated with those of the maintainer.

The results from the task, information flow and processing, MOPEs and performance prediction analyses will be used to identify C2S/C2IS and maintenance system deficiencies and clearly define the C2IS requirements that will resolve any deficiencies that have an adverse impact on human performance or system effectiveness.  The CMC HFE Team will document the analyses results in a comprehensive HFE analysis report due for delivery in 2002.


Athene Tactical System (ATS)

The Systems Engineering Analysis Phase will define the information systems architecture for the LF C2IS and determine how well the current system supports the commander and staff in planning, directing and monitoring their operations.  This work will identify the key deficiencies in the existing C2S, employing proven systems engineering techniques to model the current C2S, determine system MOPEs and identify system deficiencies.  The key difference with the Systems Engineering Analysis is that the focus is on the overall system issues associated with the Data, Processes, Interfaces and Networks that make up the system, whereas the HFE Tasks were focused on the requirements to support the operator and the maintainer.  The CMC HFE Team will deliver the results of these activities in a System Analysis Report in March 2002.

Concurrent with the Human Factors Engineering and Systems Engineering analyses, the CMC HFE team is conducting an HFE Design Phase to develop a preliminary design for an operator workstation based on the results from th workstation will consist of a Human-Com support applications, and automated fun go through several iterative phases. The prototype and prepare an accompanying