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The Development and Validation of a Human Systems Integration (HSI) Program for the Canadian Department of National Defence (DND)

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Abstract

From 2000 to 2004 the Defence Research and Development Canada establishment conducted multi-year Research and Development (R&D) activities under contract to develop, demonstrate and validate a Human Systems Integration (HSI) approach for the Canadian Department of National Defence (DND) with the aim to transition this approach to an operational program within the DND's Material Acquisition and Support community. The foundation of an HSI Program was applied to 31 Defence acquisition projects from 2001-2004. Various components of the HSI Program were researched, developed, demonstrated, and iteratively improved. A cost-benefit analysis derived from this effort was used to determine whether a permanent HSI Program within the DND would be worthwhile. $3,331,000.00 was spent on exercising a full or partial HSI process. This resulted in $3,515,000.00 in immediate savings based on observed data, providing a 106% payback. The cost of HSI application compared with immediate savings plus at least $133,000,000.00 in extrapolated savings (based on the impact the application of HSI had on projected life cycle costs) resulted in a 4000% payback, suggesting that HSI is a worthwhile investment. The possibility in hundreds of millions of dollars in further downstream savings based on lives saved or re-engineering costs avoided also existed but was not calculated. In this study it was found that HSI costs ranged from 4-20% of a project's engineering budget and that Canada's integrated approach to HSI, whereby analyses are shared between HSI domains, can save up to 25% of HSI costs. This R&D effort developed and validated the Canadian HSI approach and supports the implementation of a formalized and enhanced HSI program within the Canadian DND.

Résumé

De 2000 à 2004, l'agence Recherche et développement pour la défense Canada a mené, en vertu d'un contrat, des activités de recherche et développement (R & D) pluriannuelles pour élaborer, démontrer et valider une approche d'intégration humain-systèmes (IHS), pour le compte du ministère de la Défense nationale (MDN) du Canada. Le but consiste à transformer cette approche en un programme opérationnel au sein de la communauté de l'acquisition et du soutien du matériel du MDN. De 2000 à 2004, 31 projets d'acquisition de la Défense ont été fondés sur un programme d'IHS. Différents éléments du programme d'IHS ont fait l'objet de recherche, de développement, de démonstration et d'amélioration itérative. Une analyse coûts-avantages issue de cet effort a servi à déterminer la rentabilité d'un programme d'IHS permanent au MDN. Les dépenses engagées pour la conduite à bon terme d'un processus complet ou partiel étaient de 3,3 millions de dollars, ce qui a permis de réaliser 3,515 millions de dollars d'économies immédiates, d'après les données constatées, soit une retombée de 106 %. Le coût de l'application de l'IHS par rapport aux économies immédiates plus au moins 133 millions de dollars d'économies extrapolées (selon les incidences de l'application de l'IHS sur les coûts du cycle de vie prévus) a entraîné une retombée de 4 000 %, ce qui suppose que l'IHS constitue un investissement intéressant. Il y a eu également la possibilité d'économies d'aval s'élevant à des centaines de millions de dollars, mais dont le calcul n'a pas été fait. Dans la présente étude, il s'est révélé que le coût de l'IHS variait de 4 à 20 % du budget d'un projet technique et que l'approche intégrée d'IHS du Canada, par laquelle les analyses sont partagées parmi les domaines de l'IHS, peut épargner jusqu'à 25 % des coûts de l'IHS. Ce travail de R & D a engendré et validé une approche d'IHS canadienne et soutient la mise en œuvre d'un programme d'IHS formel et amélioré au sein du MDN canadien.

Executive Summary

From 2000 to 2004 the Defence Research and Development Canada establishment conducted Research and Development (R&D) activities under contract to develop, demonstrate and validate a Human Systems Integration (HSI) approach for the Canadian Department of National Defence (DND) with the aim to transition this approach to an operational program within the DND's Material Acquisition and Support (MA&S) community.

The foundation of an HSI Program (developed from 1998 to 2000) was applied to 31 "case studies". These case studies were categorised as: case studies directly involved in HSI program development, case studies that exercised most of the HSI process, case studies that exercised a sub-set of the HSI process, case studies that focused on HSI tool evaluation and case studies that involved the provision of HSI and project definition support to programs. For the work conducted under this contract, HSI was defined as "the technical process of integrating the five HSI domains, Human Factors Engineering , Manpower and Personnel, Training, System Safety , and Health Hazard Assessment with a materiel system to ensure safe, effective operability and supportability" (North Atlantic Treaty Organization [NATO] AC/243 [Panel 8] TR/7, 1992).

A total of $5,600,000 of HSI effort was conducted and/or observed. $1,573,000 was invested in HSI program development, $3,148,000 was invested in case studies that exercised a majority of the HSI process, $183,000 was invested in case studies that exercised a sub-set of the HSI process, $117,000 was invested in case studies focused on HSI tool evaluation and $607,000 was invested in the provision of HSI and project definition support to programs.

A cost-benefit analysis derived from this effort was used to determine whether a permanent HSI Program within the DND would be worthwhile. There were three categories of savings included in these assessments: immediate savings (the HSI approach saved resources [time or money] during the execution of the work), extrapolated savings (the application of the HSI process clearly resulted in decisions that will save money over time), and uncalculated savings (the impact of applying HSI resulted in decisions that would likely save lives and improve operational effectiveness). As the latter category of savings was difficult to quantify, it was not included in the overall cost-benefit calculations. However, recognition of the application of HSI's making systems safer and more effective is warranted.

The $3,331,000 invested in almost full or partial HSI application resulted in $3,515,000 of immediate savings (or a 106% "payback"); therefore, the HSI effort essentially paid for itself. Examples of immediate savings included savings in HSI domain analysis as a result of analysis synchronization and re-use across domains (such as the behavioural analysis that is generated from a Mission, Function and Task Analysis) and savings in analysis time using new HSI tools compared to historical tools for the same phases of analysis. During the course of this work, it was demonstrated that Canada's approach to HSI, whereby analyses are shared between HSI domains, can save up to 25% of HSI costs.

Some examples of extrapolated savings, where it was evident that the HSI analysis influenced decisions that will save money over time, included the validation of the removal of one person from a four person armoured vehicle crew (with an extrapolated life cycle savings of over $126,000,000) and the elimination of an unnecessary display on a shipboard system (which saved approximately $2,000,000 in engineering, equipment, installation, and maintenance costs). The cost of HSI application compared with immediate savings plus at least $133,000,000.00 in extrapolated savings (based on the impact the application of HSI had on projected life cycle costs) resulted in a 4000% payback, suggesting that HSI is a worthwhile investment.

In this study it was found that HSI costs ranged from 4-20% of a project's engineering budget. A comparison of three similar projects found that the level of HSI investment varied based on the extent to which the focus of the project addressed HSI concerns as its primary purpose. For example, approximately 10% of the engineering budget was spent on HSI in the development of an advanced fire control system, whereas 16% of the engineering budget was spent on HSI for a "next generation" interface to a fire control system (where new concepts for immersive displays with augmented reality and information fusion were being evaluated), and 20% of the engineering budget was spent on HSI for a "future system" project (involving an entirely new armoured vehicle concept), where the primary questions of the development and experimentation program focused on crew size, skill sets, organizational structure, and impact of the new concepts on career progression.

It was also found that the level of effort on HSI was consistent across both development and Commercial Off the Shelf (COTS) projects. For COTS or Military COTS (MilCOTS) procurements, the industrial team does not develop the design of the acquisition, as the product already exists. As a result, HSI does not "drive" the design; therefore, inputs to interface and workspace design, and iterative user testing is not required. However, an effective HSI Program is just as important on a COTS acquisition. Since the Department cannot influence the design of the system (as it already exists), the DND can only influence the deployment concept and associated impact. The deployment of a COTS solution includes consideration of the effect the acquisition may have on doctrine, policy, command and control, Standard Operating Procedures (and associated publications), as well as human performance, safety, skill levels, recruitment and training requirements, and the impact on the career progression of personnel. Properly managing these impacts becomes a focus for the DND and the CF on a COTS acquisition.

At the time of project completion, a number of additional tasks were required to formalize a DND HSI program. For example, the policy for HSI should be further developed and promulgated. Part of this process would include the development and finalization of ADM(Mat)'s draft HSI Concept of Operations; a formal Defence Administrative Orders and Directive (DAOD) for HSI within the MA&S community should also be created. Continued staffing of an HSI Team is required, the establishment of an HSI Support Supply Arrangement or Standing Offer(s) is recommended, HSI tools that support the sharing of information between HSI domains should be created and/or developed, and HSI SOW and DID templates should be made available to the ADM(Mat) community.

In conclusion, with minimal resources, a Canadianized HSI Program was initiated. In concert with HSI program initiation, a series of HSI case study projects were executed leveraging the investment of many programs across DND. This resulted in a foundation for the establishment and continuation of a formal HSI Program within the Canadian Defence community. This R&D effort developed and validated the Canadian HSI approach and supports the implementation of a formalized and enhanced HSI program within the Canadian DND.

Sommaire

Entre 2000 et 2004, l'agence Recherche et développement (R & D) pour la défense Canada a entrepris des activités sous contrat dans le but de développer, de démontrer et de valider une approche d'intégration humain-systèmes (IHS) pour le ministère de la Défense nationale du Canada (MDN) dans le but d'instaurer cette approche au sein d'un programme opérationnel du groupe Acquisition et soutien du matériel (ASM) du MDN.

On a appliqué les fondements d'un programme de l'IHS (élaborés entre 1998 et 2000) à 31 « études de cas ». Ces dernières ont été classées dans les catégories suivantes : portant directement sur le développement de programmes d'IHS, appliquant presque tout le processus de l'IHS, utilisant des parties du processus de l'IHS, portant sur l'évaluation des outils de l'IHS ou offrant l'IHS et le soutien des programmes relatifs à la définition des projets. Pour les besoins des travaux effectués dans le cadre du contrat, on a défini l'IHS comme étant « un processus technique d'intégration des cinq domaines de l'IHS, soit l'ergonomie, la main-d'œuvre et le personnel, la formation, la sécurité des systèmes et l'évaluation du danger pour la santé au sein d'un système de gestion du matériel dans le but de garantir une opérabilité et une soutenabilité sûres et efficaces. » (Organisation du traité de l'Atlantique nord [OTAN] AC/243 [Panel 8] TR/7, 1992).

On a effectué ou observé des activités reliées à l'IHS s'élevant à 5 600 000 $. On a investi 1 573 000 $ dans le développement de programmes d'IHS, 3 148 000 $ dans des études de cas appliquant presque tout le processus d'IHS, 183 000 $ dans des études utilisant des parties du processus de l'IHS, 117 000 $ dans d'autres portant sur l'évaluation des outils de l'IHS, et 607 000 $ dans d'autres offrant l'IHS et le soutien des programmes relatifs à la définition des projets.

Une analyse coût-avantage de ces activités a été effectuée afin de déterminer si un programme permanent d'IHS au MDN en valait la peine. Trois catégories d'économies ont été recensées : des économies directes (l'approche de l'IHS a fait économiser des ressources [temps ou argent] pendant les travaux), des économies extrapolées (l'application du processus de l'IHS a manifestement mené à des décisions qui feront économiser temps et argent) et des économies non calculées (l'impact de l'application de l'IHS a mené à des décisions qui auront probablement pour effet de sauver des vies et d'améliorer l'efficacité opérationnelle). Étant donné que la dernière catégorie était difficile à quantifier, elle n'est pas comprise dans les calculs de coûts-avantages. Il faut cependant reconnaître que l'application de l'IHS rend les systèmes plus sécuritaires et efficaces.

La somme de 3 331 000 $ investie dans l'application complète ou partielle de l'IHS a procuré 3 515 000 $ en économies directes (soit une retombée de 106 p.100). Donc, les activités relatives à l'IHS se sont autofinancées. Voici quelques exemples d'économies directes : des économies dans l'analyse de domaines de l'IHS résultant de la synchronisation des analyses et de la réutilisation dans plusieurs domaines (comme l'analyse de comportement provenant de l'analyse d'une mission, d'une fonction et d'une tâche), et des économies de temps d'analyse avec des outils de l'IHS par rapport aux outils traditionnels utilisés aux mêmes phases de l'analyse. Au cours de ces travaux, on a démontré que l'approche canadienne à l'IHS, suivant laquelle on partage les analyses entre les domaines de l'IHS, est susceptible de faire économiser 25 p. 100 des coûts de l'IHS.

Parmi les exemples d'économies extrapolées pour lesquelles, manifestement, l'analyse de l'IHS avait influencé les décisions et des économies seraient générées avec le temps, on note le retrait d'un membre de l'équipage d'un véhicule blindé de quatre personnes (des économies extrapolées de plus de 126 000 000 $ au cours du cycle de vie), et l'élimination de voyants

inutiles dans un système de bord (une économie d'environ 2 000 000 $ en frais d'ingénierie, d'équipement, d'installation et d'entretien). Le coût de l'application de l'IHS en regard des économies directes augmentées des quelque 133 000 000 $ en économies extrapolées (fondées sur l'effet de l'application de l'IHS sur les coûts prévus de cycle de vie) a généré des retombées de 4 000 p. 100, ce qui indique que l'IHS est un investissement intéressant.

D'après cette étude, les coûts de l'IHS se situaient entre 4 et 20 p. 100 du budget d'ingénierie d'un projet. La comparaison entre trois projets semblables a démontré que le niveau d'investissement variait en fonction de l'importance que le projet accordait à l'IHS en tant que but principal. Par exemple, environ 10 p. 100 du budget d'ingénierie ont été dépensés pour l'IHS à un circuit avancé de détection incendie, alors que 16 p. 100 du budget d'ingénierie ont été versés pour l'IHS à une interface de circuit de détection incendie de la « prochaine génération » (à l'occasion de laquelle on a évalué de nouveaux concepts d'images immersives fusionnées à de l'information et à une réalité amplifiée) et que 20 p. 100 du budget d'ingénierie ont été dépensés pour l'IHS relative à un projet de « nouveau système » (un concept totalement nouveau de véhicule blindé) dans lequel les enjeux principaux du programme de développement et d'expérimentation portaient sur la taille de l'équipage, l'ensemble des compétences, la structure organisationnelle et l'impact des nouveaux concepts sur la progression d'une carrière.

On a également constaté que le niveau d'activités relatives à l'IHS était semblable dans les projets de développement et les projets commerciaux sur étagère (COTS). L'équipe industrielle ne participe pas à la conception des COTS ou des véhicules militarisés en vente sur le marché (MilCOTS), puisque les produits existent déjà. En conséquence, l'IHS n'oriente pas la conception. On n'a donc pas besoin d'influer sur la conception de l'interface et de la zone de travail ni d'effectuer des tests itératifs. Néanmoins, il est tout aussi important d'établir un programme d'IHS relatif à une acquisition de COTS que pour un autre achat. Comme le Ministère n'est pas en mesure d'influencer la conception d'un système qui existe déjà, il doit se limiter à influer sur le déploiement et les effets qui en découlent. Le déploiement d'une solution COTS comprend la prise en compte de l'effet de l'acquisition sur les doctrines, politiques, commandement et contrôle, instructions permanentes d'opération (et autres publications connexes), ainsi que sur le rendement humain, la sécurité, les niveaux de compétence, les besoins de recrutement et de formation, et les répercussions sur la progression de carrière du personnel. Le MDN et les FC se focalisent alors sur la gestion de ces effets au cours d'une acquisition COTS.

Au terme d'un projet, un certain nombre de tâches supplémentaires sont requises pour officialiser un programme de l'IHS au MDN. Par exemple, la politique sur l'IHS devrait être développée plus avant et promulguée. Ce processus comprendrait l'élaboration et la finalisation de la version préliminaire du concept de fonctionnement de l'IHS par le SMA(Mat) de même que la rédaction d'une Directive et ordonnance administrative (DOAD) officielle pour l'IHS au sein du groupe ASM. Il faut doter en permanence une équipe de l'IHS. On recommande de conclure un arrangement ou d'émettre une ou des offres à commandes afin d'approvisionner le soutien en IHS. Enfin, on devrait créer ou développer des outils d'IHS pour soutenir le partage d'information entre domaines de l'IHS, et diffuser des modèles d'ÉDT et de DID pour l'IHS au sein du groupe du SMA(Mat).

En conclusion, on a lancé une version canadienne d'un programme de l'IHS avec un minimum de ressources. De concert avec le lancement du programme de l'IHS, on a réalisé des projets d'études de cas optimisant l'investissement de nombreux programmes de l'ensemble du MDN. Cela a donné à une base solide pour l'établissement et la continuation d'un programme officiel d'IHS au sein de la Défense canadienne. Ces activités de R & D ont servi à développer et à valider l'approche canadienne en IHS et à appuyer la mise en œuvre d'un programme officiel et amélioré d'IHS au MDN du Canada.

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1 Introduction

This Report outlines the past, present, and future position of Human Systems Integration (HSI) within the Canadian Department of National Defence (DND). The report documents the evolution of the HSI program, including the program's following elements: HSI Concept Definition, Team, Process, Tools, and Communication. The report also details a HSI cost-benefit analysis (CBA) justifying the implementation of a HSI Program within DND. This report presents several case studies that provide further evidence supporting the value of HSI.

1.1 Background

Human Factors Engineering (HFE) was initiated as a discipline during the period of 1945 through to 1960 as the demands of advanced weapon systems created the requirement for the US Army Air Corps and the US Navy to begin to systematically consider the interaction between humans and technology to avoid human failure in systems.

The field continued to mature during the period of 1960 through to 1980 as the creation of university programs, professional associations and research institutes began to focus on understanding human performance in complex systems (extending from military to space programs and industrial/workplace design), as well as the proceduralization of analysis and design activities within the Systems Engineering process to consider the optimization of human performance in system design.

From 1980 through to 1990, the advancement of computing technology and automation, combined with significant human error events such as nuclear power accidents, further accelerated the requirement for a systematic consideration of human centered design, and human-system interaction management in technology systems. Throughout the 1990's and early 2000's, as technological advances allowed engineers to "build anything", Human Factors (HF) variables such as utility, ease of use, task performance, workload management, and situational awareness, begun to become key drivers in system design, as well as product differentiators in the marketplace.

Throughout the evolution of the Human Factors Engineering field, the requirement for a "total systems approach" has increased in importance. The "total systems approach" has now extended beyond the human-system interface, and focuses on the role of the human within a "system of systems", such that Training, Personnel, and Safety impacts associated with all facets of human performance must be considered in the advancement of complex technology-based capabilities. The practice of HSI has evolved to meet this requirement, and at the same time continued to systematize and optimize the integration of human performance in the System and Capability Engineering (CE) process.

HSI arose from the recognition of the importance of Human Factors in system effectiveness. This importance was noted in the conclusion of the 1983 North Atlantic Treaty Organization (NATO) Defence Research Group (DRG) Symposium (on "Man as the Limiting Element in Military Systems") which identified the human element as an important system component and that "we should not rely on technology alone to solve our defence problems" (Naislin, 1983).

The goal of HSI is to incorporate human performance issues in the Materiel Acquisition and Support (MA&S) cycle for military systems to improve military performance. HSI can contribute to system effectiveness in a number of areas, including operability, safety, reliability, maintainability, availability and survivability. Support for a concrete HSI Program is evident within the Canadian Defence community as well as through the successful introduction of HSI Programs of Allied Nations (e.g., the United States and the United Kingdom) (Greenley, 2000a).

The application of HSI within the MA&S cycle increased when problems associated with Personnel, Training, Health and Safety, and Human Factors Engineering were discovered to be the limiting factors in enhancing systems effectiveness, as well as the driving factors of life cycle costs of military systems. This evidence identified that the proper application of HSI can result in significant life cycle cost savings (Beevis, 1999).

For these reasons, the Defence Research and Development Canada (DRDC) community decided to conduct a multi-year Research and Development (R&D) activity to develop, demonstrate and validate a HSI approach for the Canadian Department of National Defence community, and then to transition the HSI approach to an operational program within the MA&S community.

This document is the Final Report that summarizes the HSI initiative from 1998 through to 2005.

1.2 Objective

The objective of this report is to provide a review of HSI work completed during the period of 1998 through to 2005 within the DND HSI Program. This report was completed to provide evidence supporting the value of HSI, and to provide justification for a formalized and enhanced HSI capability within DND. The report has been prepared as a summary of the work completed, with detailed information on all activities available in the report Annexes, reference reports, or the deliverables created for the individual case study projects.

1.3 This Document

This document is structured as follows:

- Introduction: this section provides a brief overview of the background and overall objectives of the HSI project.
- Method: this section outlines the work activities conducted during the HSI project.
- Results: this section presents the results of the individual HSI work activities, and presents details regarding the future HSI Program elements, as well as justification for a HSI Program within DND.
- Conclusions and Next Steps: this section provides direction in terms of the next steps that should be taken by the DRDC and DND communities to ensure successful integration of the HSI Program into the Defence community.
- References: this section provides a list of references utilized for the preparation of the report.
- List of Acronyms: this section provides a list of acronyms presented throughout the report.

2 Method

The following activities were completed during this project:

1. Define Human Systems Integration
   The project team conducted a review of the HSI work completed by NATO, the HSI program definition activities completed by the United States military (Air Force HSI, Army Manpower and Personnel Integration (MANPRINT), Navy Manning Affordability and HSI), and the Human Factors Integration program developed by the United Kingdom.

   These reviews were combined with an assessment of the historical Human Factors Engineering approaches applied to Canadian Defence programs, as well as a review of the Defence Management System (DMS), resulting in an assessment of where the application of HSI would best suit the Canadian Defence community.

   The NATO definition was determined to be the most suitable and straightforward definition of HSI. Furthermore, the scope of the definition was considered most appropriate for within the Canadian context of an HSI program. The NATO definition was retained throughout the HSI project.

2. Develop HSI Program and Team Concepts
   A concept for HSI within the Canadian Defence community, along with a concept for staffing HSI within the Department of National Defence were developed. These documents were distributed throughout the DND and DRDC community for review and comment. Over the course of several years, the HSI Program Definition and the concept for a Government-based HSI Team evolved as more participants became involved, and the requirement for an HSI Office was identified with Office "options" defined, analyzed, and reviewed within the community.

3. Develop HSI Process
   The core element of a HSI Program is the process that is followed to technically integrate the HSI domains, and to integrate those technical activities with the linked systems and capability engineering activities.

   The Canadian HSI Process was initiated by conducting a review of the established processes in the areas of Human Factors Engineering (MIL HBK 46855A), Training (Canadian Forces Individual Training and Education System (CFITES) in DND), Safety (MIL STD 882D), and common processes used by DND personnel in the area of Personnel Analysis (within ADM[HR]) and Health Hazard Assessments (HHA) (in multiple areas across DND). These domain specific processes were reviewed for common analyses, dependencies across analyses, and opportunities to integrate/streamline analyses through a HSI approach. This work resulted in the definition of the first HSI Process.

   A review of the first HSI process by the DND community identified that the process was too complex and required simplification. This resulted in the development of a second version of the process, which was specifically targeted at the acquisition process (Defence Management System).

A third version of the process was then created to further integrate the process within the Defence Materiel Acquisition and Support processes within ADM(Mat), and to link the HSI process with processes currently defined on the Acquisition Desktop (a web-based repository for the DND Materiel Acquisition community). This was the ‘final’ version of the HSI process developed during the HSI project. However, the methodologies associated with HSI continued to evolve as the HSI project progressed, as a result of the need to further integrate HSI within the evolving Capability Engineering process within the DND/DRDC community.

4. Conduct HSI Case Study Application Projects
   Throughout the period of 2000 through to 2005, a series of case study projects were completed to exercise the HSI approach that was developed to attempt to document the cost-benefit of applying HSI, and to generate feedback for continual HSI program improvement. These case studies were “part-process” exercises, where neither the time scale nor the opportunity was available to exercise the complete HSI process throughout an entire design/development cycle. Instead, multiple projects were exercised, each of which trialed portions of the HSI process and different HSI tools, techniques, and procedures.

5. Finalize Program
   At project completion, the HSI Program was finalized for implementation within the DND community. These efforts focused on defining the role and structure for a necessary centralized HSI Office, updating all material on a HSI Program Web Site, ensuring the “hooks” into the evolving Capability Engineering Program were sound, and clearly documenting the next steps that must be taken to implement the HSI program within the Department of National Defence.

6. Develop Report and Familiarization Package
   This report, along with an associated Power Point™ presentation package was prepared as final deliverables for the HSI project.

3 Results

This section provides a brief description of the results of the HSI Program development project.

- HSI Concept and the Case for HSI in Canada (Section 4): The results of work completed early in the project to define HSI and the HSI sub-domains are provided. The results also highlight Canadian Defence Support for the HSI Program.
- HSI Program Development (Section 5): The results summarize the activities involved in the generation of a systematic HSI Program for the Canadian Defence community. The activities completed to further develop the HSI Program included: HSI program naming and branding, the definition of HSI program elements, and the HSI program communication strategy.
- HSI Team (Section 6): The results summarize the attempts to define and establish a HSI Team within the DND Community. The "HSI Team" refers to the team of Government personnel responsible for the implementation and/or coordination of HSI efforts within the Department, in combination with Industrial support. HSI Office Options Analysis results are also presented, identifying future HSI office requirements, as well as plausible "future" HSI Office location options.
- HSI Process (Section 7): The results summarize the efforts associated with the definition of a HSI Process, and the integration of the process into the core business processes of the Canadian Department of National Defence. The results specify the initial HSI Process objectives, and detail the HSI Process' three developmental iterations. The extension of the HSI Process within Capability Engineering is also presented.
- HSI Tools (Section 8): The results identify the efforts completed to formulate a repository of HSI tools.
- HSI Case Studies (Section 9): Case studies conducted as part of the HSI Program Development process are presented. The case studies are categorised according to: case studies directly involved in HSI Program development, case studies that exercised most of the HSI Process, case studies that exercised a sub-set of the HSI Process, case studies that focused on HSI tool evaluation and case studies that involved the provision of HSI and project definition support to programs. Lessons learned arising from the case studies are also presented.
- HSI Cost-Benefit (Section 10): The results summarize a framework for tracking the costs and benefits of applying HSI to a project. The results also summarize the cost-benefit (in dollar value) of applying HSI, as a CBA was performed for each case study.

4 HSI Concept and the Case for HSI in Canada

This section summarizes the results of work completed during the preliminary phase of the HSI project. The goal of the work activities was to define HSI, and develop a concept for implementing a HSI Program within the Canadian Defence community.

4.1 HSI Definition

The project team reviewed International literature regarding HSI, which became the core foundation for the definition of HSI, and the HSI sub-domains.

HSI arose from the recognition of the importance of Human Factors in system effectiveness. This importance was noted in the conclusion of the 1983 NATO DRG Symposium (on "Man as the Limiting Element in Military Systems") which identified the human element as an important system component and that "we should not rely on technology alone to solve our defence problems" (Naislin, 1983).

The goal of HSI is to incorporate human centric issues in the Materiel Acquisition and Support cycle for military systems to improve military performance. HSI can contribute to systems effectiveness in a number of areas including operability, safety, reliability, maintainability, availability and survivability.

HSI is defined as "the technical process of integrating the five HSI domains, Human Factors Engineering, Manpower and Personnel, Training, System Safety (SS), and Health Hazards (HH) with a materiel system to ensure safe, effective operability and supportability" (NATO AC/243 (Panel 8) TR/7, 1992) (Figure 1).

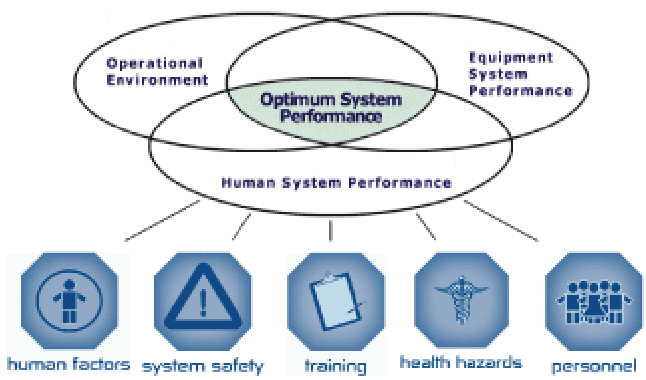

Figure 1: Conceptual Illustration of Canadian HSI

The Canadian versions of the five HSI domains are outlined below:

- Human Factors: the integration of human characteristics into system definition, design, development, and evaluation to optimize human-machine performance under operational conditions. The primary sub-areas of HF include:
    - Operator roles, functions, and tasks;
    - User system interface;
    - Workspace; and
    - Environment

- Personnel: focuses on the number of military and civilian personnel required and potentially available to operate, maintain, sustain, and provide training for systems, as well as the cognitive and physical capabilities required to train for, operate, maintain, and sustain these systems. The primary sub-areas of Manpower and Personnel include:

- Force Structure;
- Availability;
- Phasing;
- Manpower workload;
- Physical personnel factors;
- Cognitive personnel factors;
- Recruitment, retention and advancement;
- Cultural and social factors;
- Previous experience and training; and
- Human-human interaction.

- Training: includes the instruction or education, and on-the-job or unit training required to provide personnel with their essential job skills, knowledge, values and attitudes, as well as any constraints on such training. The primary sub-areas of training include:
  - Legacy transfer;
  - Type of training;
  - Availability of training; and
  - Frequency of training.

- System Safety and Health Hazards: identifies safety risks occurring when the system is set-up, used, dismantled, transported or maintained, and identifies short or long term hazards to health occurring as a result of normal operation of the system. These assessments also determine the requirement for protective clothing and/or equipment. The primary sub-areas of System Safety and Health Hazards include:
  - Error source;
  - User behaviour;
  - Environmental surroundings;
  - Noise and vibration;
  - Hazards substances (contact, inhalants etc.) ;
  - Electrical equipment;
  - Mechanical equipment;
  - Nuclear, biological, or chemical hazards;
  - Musculoskeletal hazards;
  - Heat or cold stress;
  - Optical hazards; and
  - Electromagnetic sources.

HSI ensures that the fundamental question is addressed early during the Acquisition Life Cycle process:

"Can the specified operators and maintainers, within the future operational and support concepts, accomplish their roles safely and effectively using the proposed equipment, with the proposed training and manning levels?"

Furthermore, HSI seeks to obtain the best possible performance (equipment, human, and operational) from the system while minimizing the system's life cycle costs. Within the acquisition cycle, the objective of HSI is to:

- Reduce life cycle costs: The proper application of HSI can result in costs saved, costs avoided, and new opportunities; and
- Enhance systems effectiveness: The proper HSI Analysis avoids development problems. A lack of attention to HSI issues can result in Human Factors issues not addressed, underestimated manpower requirements, underestimated requirement of skills and abilities, untested training, unavailable training devices, and incomplete doctrine or concepts.

4.2 A Planned Focus on Integration

A review of the International literature on HSI identified that many HSI programs in other nations had been established and implemented to ensure that each HSI domain was systematically considered in the definition and development of new defence systems.

Although the literature indicated that there was "integration" of these domains, there were few demonstrable examples. In majority of cases a separate leader oversaw each HSI domain, often at a senior level of organizational command. Each leader was running an effective program in the "stovepipe" of the HSI community (i.e., work was being conducted within many of the HSI domains but there was little integration between the domains).

In Canada, distinct organizational structures do not exist, nor are they staffed effectively. This is partly attributable to the relative size of the Department of National Defence when compared to other NATO countries. For example, within the US Department of Defence, there are entire Directorates in the Army, Navy, Air Force and Marines for System Safety and for Health Hazards Assessments in addition to established Human Factors, Training, Manpower and Personnel programs. As a result, in Canada, there is no opportunity to truly staff separate teams to focus on each HSI domain.

A review of International literature further identified that the opportunity for increased consideration of the human in the system and for more efficient analysis processes were possible, if the HSI domains were truly integrated into one "linked methodology".

The "linked methodology" became a focus of the Canadian HSI Program, with specific efforts to define, exercise, and evaluate an "integrated" approach to HSI. Figure 2 illustrates the initial concept, which involves the conduct of activities within the standard processes of each domain (horizontal axis of the matrix) at the different phases of the defence acquisition life cycle (vertical axis of the matrix). This is likely to result in a number of shared analyses or variables of common interest. It was hypothesized that there must be clear opportunities across these areas for the linkage of activities, tools, and techniques within a HSI approach that could improve the quality of analyses, while also saving time and effort.

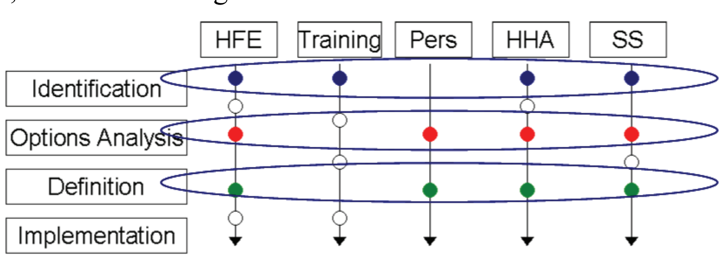

Figure 2: Integration of HSI Domains throughout the Defence Acquisition Process

4.3 Concept Linked to International Foundation for HSI

Early in the HSI project, it was important to identify that efforts to build a Canadian HSI Program were not simply the "whim" of the Canadian Defence R&D community, but rather, that the core concepts and foundation of HSI were worth future investment. Program support was realized through face validity in the construct and the realism of the cost-benefit model, as well as the International body of knowledge that the Canadian community could rely on and contribute to over time.

Figure 3 illustrates different HSI Program Offices in the International military community, including the Manning Affordability initiative in the US Navy (1), the Human Factors Integration program in the United Kingdom (2), the HSI Liveware initiative of the US Air Force (3), and the US Army MANPRINT program (4, 5).

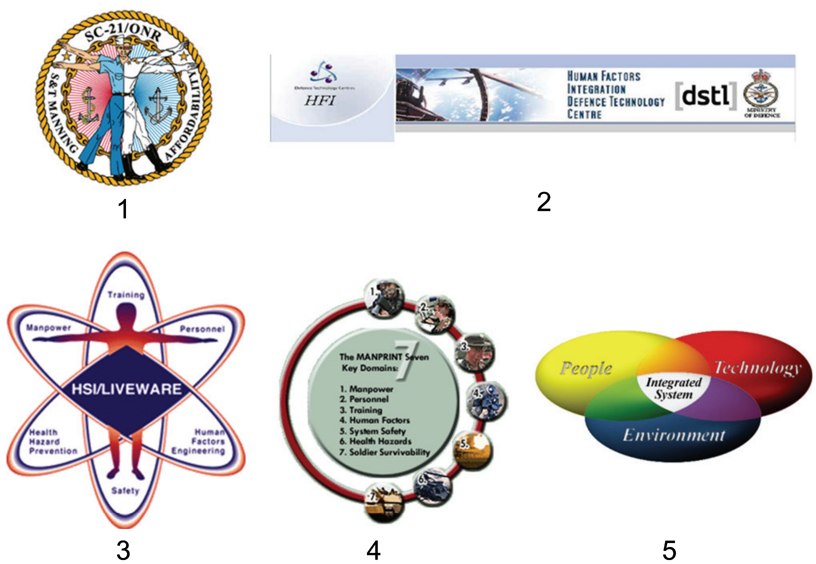

Figure 3: International HSI Programs

These International Defence HSI Program Offices facilitate Canada's participation in an evolving discipline, with International peers clearly working toward common objectives.

In addition to these military programs, a growing academic and research base for HSI in the international community was also identified. Examples of this academic foundation are illustrated in Figure 4, including (from left to right) Human Factors Integration training courses at Cranfield University, the Department of HSI Research at University of Central Florida, and the recently released Handbook of Human Systems Integration.

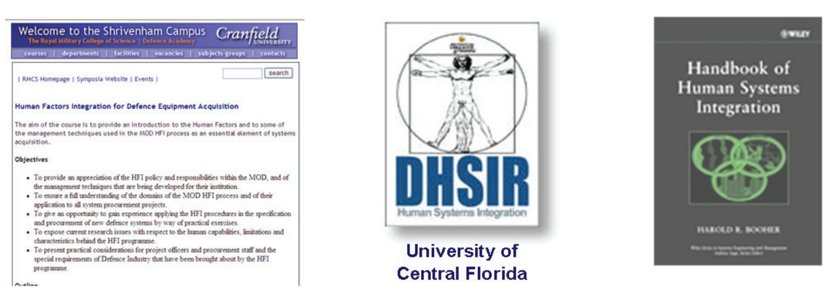

Figure 4: Educational and Academic Programs in HSI

4.4 Canadian Defence Support for HSI Program

In 1999, a HSI Concept Report was developed (Annex A), which was distributed throughout the DND and DRDC community for review and feedback. This initial concept paper was well received, and generated the necessary acquisition and operational project community enthusiasm and support for the creation of a Canadian HSI Program.

Supportive feedback from senior DND personnel is presented in the Concept Report; some key statements taken from the Concept Report include:

- *HSI plays a major role in determining support and sustainment of a proposed system and establishing personnel requirements to maintain and field the capability;*
- *HSI development will cost resources, but it is an investment that can feed and spill into the commercial world….far more resources should be shifted to HSI development…;*
- *… a fundamental change in thinking, with respect to the Materiel Acquisition and Support process must be promoted and achieved…the change is the acceptance that in many cases a virtual product must be procured before the final physical product is procured…;*
- *Support should be provided to "purple" or joint projects, and not just support to all three environments;*
- *..proposal to create a HSI/Modelling and Simulation (M&S) Support Team is very interesting, and likely will be an important step in efficient planning for these activities…currently a lack of sharing between projects…in many cases HSI is not adequately addressed due to a lack of awareness and knowledge…;*
- *Setting up a HSI support team is an effective way to ensure "reusability" of M&S tools through the whole equipment life cycle;*
- *the proposal in the paper is sound and should be pursued;*
- *…the psychological aspect should not be ignored…as our systems become more sophisticated it is imperative that the personnel recruited are capable of learning how to operate the equipment…selection criteria should be established before the equipment comes on line;*
- *..the thrust of the paper, that greater use must be made of human systems integration and M&S within the CF and DND, is logical and correct…;*
- *…the fact that the majority of CF and DND procurement is modified commercial off the shelf rather than development…must be considered;*
- *… cost effective project and life cycle management of any capability demands a full accounting of all of the Human Factors issues involved in meeting the requirement…including safety, training, performance, and recruiting issues…; and*
- *…no doubt in my mind that the practical help and the synergistic effects derived through a Human Systems Integration infrastructure within DND (and possible Government wide) will lead to a positive benefit/cost ratio.*

5 HSI Program Development

This section summarizes the results of activities involved in the generation of a systematic HSI Program for the Canadian Defence community.

5.1 HSI Program Naming and Branding

Several attempts were conducted throughout the course of the HSI Project to name and brand a Canadian HSI Program. An overall identity for the initiative was deemed most important, which led to the development of a Canadian HSI (Figure 5).

human systems integration
l'intégration des systèmes humains

Figure 5: HSI Program Logo

5.2 HSI Program Elements

From project initiation, it was immediately determined that there were three core elements that needed to be defined, developed, and deployed to create a HSI Program within the DND community. These three elements include (Figure 6):

- People: HSI technical support personnel and Points of Contact (POC) were required across DND, and within the Defence industrial community.
- Process: A defined HSI process was required to shape the application of HSI on defence projects.
- Tools: A suite of HSI tools, along with direction for their use, was required to help guide projects on the types of technology that would best support a systematic HSI Program.

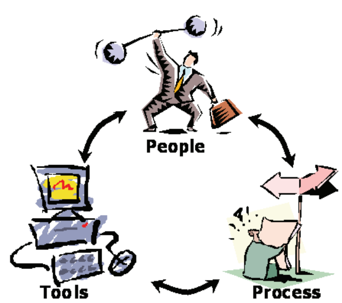

Figure 6: HSI Program Elements

5.3 Development Strategy: Policy versus Practice

While developing the method used to create the HSI Program a decision was required regarding the establishment of policy in the area of HSI. Two main options were apparent:

1. Establish Policy: All project offices would have to apply HSI. It was felt that policy could theoretically be established for project offices to execute.
2. Create Demand and Demonstrate Value Application: The HSI process could be applied across a range of projects to clearly demonstrate utility in order to create a "common practice".

A decision was made to proceed with Option 2: Common Practice. The reasons for this decision included: a) lessons learned from nations such as the United Kingdom, where policy implementation resulted in a flood of application practice, all of which could not be supported, and b) there was no structured HSI organization, nor a fully prepared industrial sector, to respond to a policy statement.

As a result of selecting Option 2, a "case study" approach was adopted, facilitating the application of the HSI concept, process, tools, and techniques to a variety of case study projects, while tracking impact and cost-benefit where possible to further build the HSI process, procedures and lessons learned. The option of establishing a policy would still be implemented if and when required/desirable.

5.4 HSI Program Communication Strategy

It was evident very early in the HSI Project that the community was a diverse community of practice. Methods of communicating within the community were therefore required. A primary tool for communication was a HSI Web Site, which was established by DRDC. Figure 7 illustrates the final version of the HSI Web Site, which evolved through several iterations during the HSI Project. The homepage of the HSI Web Site is shown in Annex K. The Web Site can be accessed at: http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/hsi_e.asp (English) or http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/hsi_f.asp (French).

Figure 7: The Homepage of the HSI Community Web Site

A web-based HSI Community Directory Registration Tool (Figure 8) was also created in order to define the overall HSI community, as well as to create a core list of HSI personnel. Further information regarding the HSI Registration Tool is provided in Annex G.

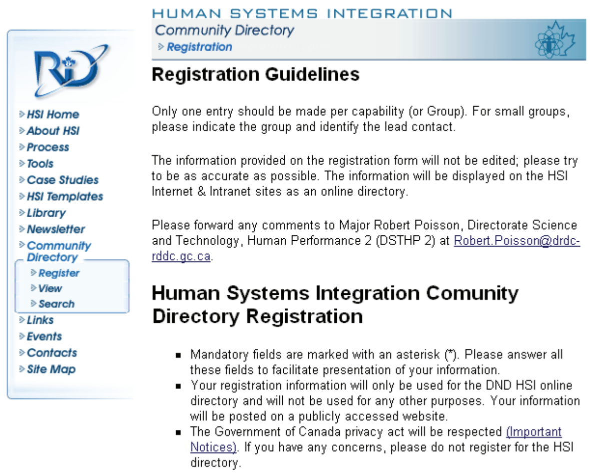

Figure 8: HSI Community Web-Based Directory Registration Tool. Note: The new contact is Mr. Walter Dyck, Directorate Science and Technology, Human Performance 7

In order to communicate regularly with the members of the HSI community, it was determined that a HSI Newsletter, in electronic format, was required. A web-based mechanism was created to generate and distribute a newsletter at regular intervals (refer to Figure 9 and Annex H for more information).

At project completion, the development and distribution of the newsletter was "held back" since the creation of a HSI Office and permanent HSI infrastructure to sustain and support the newsletter was in question. It was evident that personnel within the DND community would need to be assigned to maintain a focus on HSI, and to ensure the newsletter mechanism is available for use.

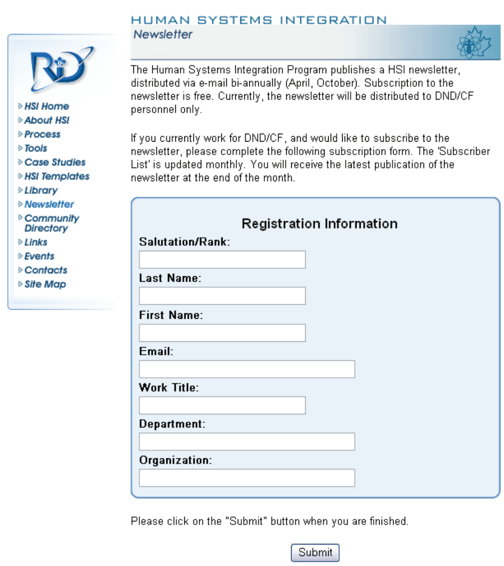

Figure 9: HSI Community Newsletter Mechanism

6 HSI Team

This section summarizes the results of the efforts made to define and establish a HSI Team within the DND community. The "HSI Team" refers to the team of Government personnel responsible for the implementation and/or coordination of HSI within the Department, likely to include some industrial support.

6.1 Original HSI Team Concept

In 1998, a document entitled "Way Ahead and Investment Strategy for Human Factors and Modeling and Simulation R&D in DND" (Angus, Beevis, Magee, Jacobs, Landolt, Wakefield, Foster, & Vallerand, 1998) was distributed throughout DND. This document proposed the first structured approach to the development of a HSI-related support team. DND representatives from research, operations, operational research, project management, engineering, strategic planning, medicine, safety and human resources provided feedback regarding the proposed HSI team. The feedback was supportive of the HSI project and the concept of establishing a HSI Virtual Support Team (Annex B provides further description). Based on the feedback provided, a list of potential individuals or groups who would be interested in participating on a HSI support team was developed.

In November 1999, a Letter of Invitation was sent to the list of potential HSI team candidates (approximately 25 individuals within DND). The Letter of Invitation prompted interviews with the potential candidates to further discuss the development of a HSI support team. Positive feedback was received supporting a HSI support team during the interviews. The prospect of a HSI Virtual Support Team was also presented during the interviews; this concept was also well received from the interviewees.

The interview results were used to define a Virtual Support Team. The description of the team concept, objectives, and goals were outlined, to provide an initial baseline from which a finalized concept of the HSI Virtual Support Team could evolve.

The initial concept for the development of the HSI Virtual Support Team involved the integration of four groups of personnel, including (Annex B provides further description):

1. HSI Coordinators: This role was filled by DRDC personnel during the HSI Project, with the intent that this role would eventually result in full time positions to coordinate/lead a HSI Program.
2. DND HSI Steering Board: It was proposed that the HSI Support Team be established as a virtual team due to the lack of human resources within DND, and the inability to significantly hire additional resources (Annex B provides further information). DND personnel with capabilities in one or more of the HSI domains would be established as HSI Points of Contact, and integrated into the Virtual Support Team. The active members would be involved in a HSI Steering Board; the Steering Board would convene on an annual or bi-annual basis to evaluate the HSI policy, HSI process, and the HSI tools, as well as to present HSI case studies. However, the HSI Steering Board would not be capable of approving processes or developing policy. The interview process identified that the HSI Steering Board should consist of eighteen personnel from a range of Departments and from industry (refer to Annex E).
3. Interested DND Personnel: This domain of personnel consisted of those individuals interested in, and who would like to stay current on, HSI issues. These personnel would be included in all public HSI-related communications.

The complete listing of these personnel would be located in the HSI Contact Database.

4. HSI Industrial Base: Within DND, the HSI work is generally performed by industry personnel. These personnel include scientists, consultants, or staff within defense system design and manufacturing firms. These individuals would be included in all public HSI-related communications, and would be registered in the HSI Contact Database.

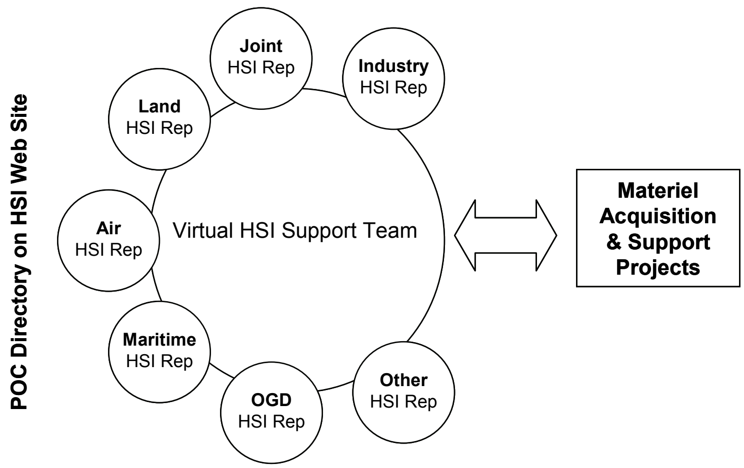

Figure 10: Original HSI Team Concept

The original HSI Team concept (refer to Figure 10 and Annex B) remained valid throughout the HSI project, but was never formally implemented. It was not formally implemented since it became evident that a full time centralized HSI Office was required to maintain central coordination/communication due to the volume of HSI activity being completed. Since the HSI Project was primarily executed by contracted personnel under the direction of DRDC personnel, there were no dedicated resources available within the DND community to staff the necessary centralized HSI Office during the project, resulting in the Virtual Team concept not being formally realized. However, two core actions did result including: a) the Virtual Team did operate on an ad-hoc basis, such that the identified personnel were consulted regularly throughout the program for inputs from their area in the Defence community, and b) the need for a centralized HSI Office resulted in the conduct of an Options Analysis to identify the structure and location of such an office (refer to Section 6.2).

6.2 HSI Office Options Analysis

It was evident through the HSI Project that a centralized, permanently staffed HSI Office was required if a structured HSI Program was to be implemented within the DND community.

To plan for the implementation of this office, an Options Analysis was conducted, reviewed, and revised several times throughout the period of 2003 through to 2005. The office requirements, the options considered, and the recommended solutions are summarized in Sections 6.2.1 through to 6.2.3.

6.2.1 HSI Office Requirements

Based on three years of HSI case studies, it was determined in 2003 that a HSI Office was warranted. The rationale for this office included:

- The DND community recognized the need for HSI and the benefits of HSI using an integrated process and M&S-based tools. This recognition was based on the continual flow of HSI technical support requests asked of the HSI Project.
- The results of the HSI Project were clearly going to include the integration of HSI into the core Defence Capability Planning and Materiel Acquisition and Support processes. This in turn would further increase the demand for HSI.
- During the HSI Project, there was at least $3M to $4M CDN spent per year on HSI-related projects and analyses being conducted, driven purely by demand to have HSI-related questions answered, and not because of a published program. It was therefore quite logical that the completion of the HSI Project would result in a further surge of HSI support requirements that would need to be centrally coordinated and managed (the acquisition community indicated as early as 1998 that they preferred a centralized point of contact and support).

A review of the activity surrounding the definition, management, and execution of over twenty HSI case studies by 2003 resulted in a set of functions that would be performed by a future HSI Office. These functions included:

- <u>HSI Community Co-ordination:</u> Web Site, newsletter, workshops, meetings, conferences, international liaison.
- <u>Policy and Process Maintenance:</u> Maintain policy and process and ongoing liaison with core DND process holders.
- <u>Tool Repository Maintenance:</u> Maintain tools, access to tools, and libraries of analyses for re-use.
- <u>Support to Project Teams:</u> Plan HSI Programs for projects, provide access to human resources to conduct HSI, including the management of Standing Offer contracts with firms who can provide HSI support.
- <u>Feed R&D Process:</u> Maintain a link with the R&D community in the HSI domains, both within DRDC, and within universities, to ensure that knowledge and methods are generated to advance an integrated field of HSI.

6.2.2 HSI Office Options

A number of logical candidate locations were identified along with two “blended” options as to where a HSI Office could be located. These were evaluated against criteria of required functions identified for the HSI Office. Table 1 outlines the potential office location options, the evaluation criteria, and the “scoring” of each option.

Table 1: HSI Office Options Analysis

HSI Office Option	Description	Criteria (see blow)							
		1	2	3	4	5	6	7	8
Distributed Across HSI Domains	Virtual Team connecting Subject Matter Experts (SMEs) across DND and DRDC, across all three military environments, in the areas of HFE, SS, HHA, Training, and Manpower / Personnel.	✓	✓	✓		✓			✓
Within Each Environment's Acquisition Community	Position HSI Offices within the engineering/acquisition communities of the Director General Aerospace Equipment Program (DGAEPM), Director General Maritime Equipment Program (DGMEPM), and the Director General Land Equipment Program (DGLEPM).								✓
Within Each Environments' Requirements Community	Position HSI Offices within the requirements cells for each environment including Director of Aerospace Requirements (DAR), Director Maritime Requirements (DMR), and Director of Land Requirements (DLR).								✓
Within DMASP	Position HSI Office at the top of the ADM(Mat) org chart, within the Chief of Staff structure in the Director of Materiel Acquisition and Support Programs (DMASP) with the functional authorities for Project Management, Engineering, Integrated Logistics Support (ILS), and Procurement.						✓	✓	✓
Within DFPPC	Position HSI Office at the top of the Vice Chief of Defence Staff (VCDS) org chart, within the Directorate of Force Planning and Project Coordination (DFPPC).						✓	✓	✓
DRDC Corp – DSTHP	Position HSI Office at Defence R&D Canada Corporate in Ottawa, within the Directorate of Science and Technology Human Performance (DSTHP).	✓	✓						✓
DRDC Toronto – Scientific Office	Position a HSI Office at DRDC Toronto, staffed by leading scientific personnel in the domains of HSI.	✓	✓	✓		✓	✓		
DRDC Toronto – Military Office	Position a HSI Office at DRDC Toronto staffed by military personnel with backgrounds in the domains of HSI, acting essentially as a "consulting office" with links out to the acquisition community and back to the R&D community.	✓	✓	✓	✓	✓	✓		
Within DGSP, at CFEC.	Position a HSI Office with the Deputy Chief of Defence Staff (DCDS) community, within the Director General Strategic Planning (DGSP) organization at the Canadian Forces Experimentation Centre (CFEC).	✓		✓	✓	✓	✓		✓
Blended Approach (1) DMASP Office with DCDS/CFEC	HSI Coordinator for Policy and Process within DMASP team reporting to Functional Authority for Systems Engineering within DMASP. HSI Support Cell within CFEC in DCDS.	✓	✓	✓	✓	✓	✓	✓	✓
Blended Approach (2) DMASP Office with DRDC Toronto Military Unit	HSI Coordinator for Policy and Process within DMASP team reporting to Functional Authority for Systems Engineering within DMASP. HSI Support Cell staffed with military personnel at DRDC Toronto.	✓	✓	✓	✓	✓	✓	✓	✓

Criteria:

1. Able to influence projects "up front and early" in the Capability Planning and Acquisition process;
2. Able to leverage established HSI expertise;
3. Access to a diverse HSI technology base (M&S based);
4. Minimal effort to staff the office;

5. Able to provide support across joint and environment specific projects;
6. Supports an integrated approach across the acquisition community;
7. Able to influence acquisition policy related to HSI; and
8. Geographic proximity to the acquisition community.

6.2.3 Recommended Solutions for a HSI Office

The Options Analysis identified two options for the future location of a HSI Office. These options are recommended for final implementation based on senior management's ability to staff the positions. Each option is a blend of two single options presented in Table 1:

1. <u>Blended DMASP Office and DCDS/CFEC</u>
   This option results in a Policy and Process function being filled by a HSI Coordinator within the DMASP team, reporting to the Functional Authority for Systems Engineering within DMASP. This person has the "reach" to influence the integration of HSI into the Defence Management System through links between DMASP and DFPPC, and has full coverage over the Materiel Acquisition and Support process. A HSI Support Cell should be staffed within the CFEC community in DCDS, leveraging the strong analysis, experimental, and modeling and simulation opportunities in that community, where some personnel, labs, and multiple contracts with industrial providers in the HSI field are managed by a HSI Office reporting to CFEC.
2. <u>Blended DMASP Office and DRDC Toronto Military Unit:</u>
   This option results in a Policy and Process function being filled by a HSI Coordinator within the DMASP team, reporting to the Functional Authority for Systems Engineering within DMASP. This person has the "reach" to influence the integration of HSI into the Defence Management System through links between DMASP and DFPPC, and has full coverage over the Materiel Acquisition and Support process. A HSI Support Cell should be staffed with military personnel at DRDC Toronto, building on the existing HFE and HHA structure, along with the addition of a Training Officer and a Personnel Officer. This cell should have access to a suite of M&S-based HSI tools within the DRDC lab environment, and should manage multiple HSI support contracts within industry.

An additional option evolved near project completion (2004/2005), as a result of advances in Capability Engineering. It appeared that CE initiatives were evolving to establish Capability Engineering Teams (CET) within the Department several years into the future, which included an initial pilot CET being established in support of the C4ISR community. These CETs would incorporate HSI sub-teams, and therefore CETs might become the logical location for permanent HSI teams. At present, these concepts were not developed enough to be identified as viable options for consideration in the Options Analysis. However, Options 1 and 2 (above) place DCDS personnel into HSI cells, which could logically be reconfigured or targeted at CETs in the future.

Figure 11 illustrates the location of the HSI cells in the options recommended. Feedback from the military operational community indicated that the HSI cell should be "as far left" on the diagram as possible (i.e., within the DCDS, VCDS organization), to ensure that HSI issues were considered "up front and early" in the military capability and system planning and definition processes. The three locations illustrated in Figure 11, are the best compromises to leverage existing capability, link to a modeling and simulation technology base, and have some "teeth" in the capability definition and acquisition processes.

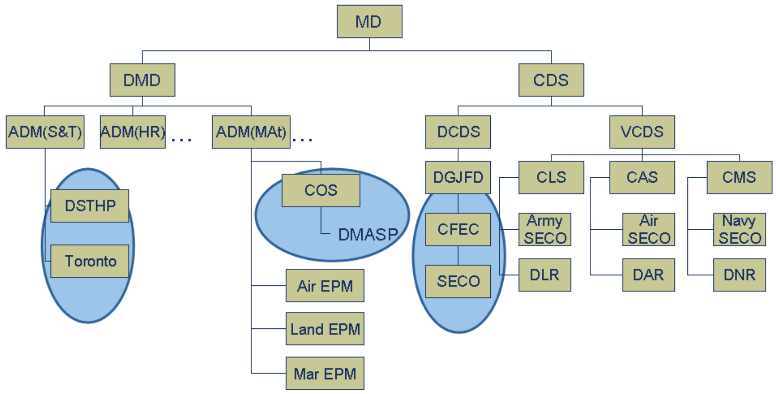

Figure 11: HSI Office Options (see text for explanation)

6.3 Influencing Industrial HSI Commitment: HSI Capability Maturity

It was identified early in the HSI project, and continually proven, that a strong HSI industrial base is required to ensure systematic consideration of HSI throughout the life cycle of military systems.

The need for industrial support has also been recognized by other nations, and a number of initiatives have begun around the world to investigate Capability Maturity Models (CMMs) for HSI. CMMs exist for many disciplines, such as systems engineering, software engineering, or project management. The typical levels of a generic CMM are illustrated in Figure 12:

- Level 1: An organization with a Level 1 capability has an initial process or concept of application;
- Level 2: A Level 2 capability involves a repeatable process that appears to be common practice;
- Level 3: A Level 3 is a defined and documented process that is trained;
- Level 4: A Level 4 involves a process that is trained and managed; and
- Level 5: A Level 5 adds senior management support and a continual improvement process to optimize the practice.

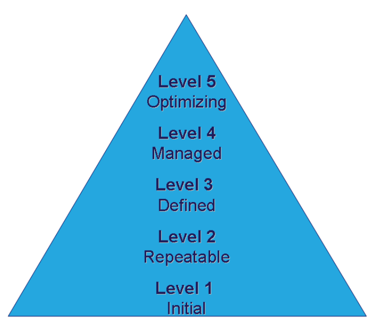

Figure 12: Levels of Most Capability Maturity Models (Used in HSI Program)

It was desirable to investigate if a CMM framework could be used to influence the behaviour of industry to ensure that HSI issues were addressed in the development of military systems, and during their deployment/delivery within the Canadian Forces (CF).

As a result, one case study was conducted focusing on this aspect of the HSI Program, the Maritime Helicopter Project (MHP). A high-level and generic HSI CMM was defined in the Statement of Work (SOW) and associated requirements for the helicopter program, with specific HSI Data Item Descriptions (DIDs) defined.

This CMM framework and the associated HSI DIDs were developed to focus on the "integrated" approach to HSI, with the "bar set high" at the 3rd CMM Level. This required the helicopter delivery team to have a defined process that was trained across the team, and required that the domains of HSI would be integrated in definable ways throughout helicopter development and delivery.

This approach was successful; a HSI Program was then required within the acquisition. Each bid team was required to develop an integrated approach and process, and then present and demonstrate the approach/process. The winning team conducted significant hiring and team organizational activities to support an integrated HSI approach. Early implementation phase activities indicated that the HSI CMM and associated DIDs required the HSI team to have high level access to senior systems engineering and project managers, to ensure HSI issues were considered "up front and early" in the process. The winning helicopter production team established a HSI Program, and the Program was successfully operating at HSI Project completion.

7 HSI Process

This section summarizes the results of the significant efforts associated with the definition of a HSI Process, and the integration of that process into the core business processes of the Canadian Department of National Defence.

7.1 Background – The Canadian Defence Acquisition Process

The highest level of planning that occurs within the Canadian Forces is Capability Planning, which occurs as a core component of the annual business cycle. Capability Planning results in the identification of deficiencies and/or opportunities required by the CF to be able to accomplish the missions that are established through Defence White Papers, and the Force Planning Scenarios contained within it. The Capability Planning cycle can lead to the identification of capability and/or system development projects, which can include major acquisitions.

The acquisition process within DND/CF is guided by two core processes, the Defence Management System and the Materiel Acquisition and Support Process. The DMS process involves a series of major phases including:

- Identification: Involves formally identifying the need for a new system, and obtaining approval to register a new project to acquire that system;
- Options Analysis: Involves an analytical comparison of major options to address the deficiency that the acquisition project is targeted to address, resulting in a selected option being approved;
- Definition: Generates a structured set of requirements (increasingly performance-based requirements) for the acquisition of the selected option. At the end of the Definition Phase, a contracting process is established, where multiple vendors bid a solution against the requirements, and a winning solution is selected (increasingly a Commercial Off The Shelf (COTS) solution); and
- Implementation: Involves the industrial team working with the DND acquisition team to produce the system, and transition the system into operation with military units.

Throughout the DMS cycle there is a change in leadership that occurs between the military requirements community, and the DND ADM(Mat) Materiel Acquisition community. This generally occurs within the Definition Phase of the DMS cycle. From that point forward, the Materiel Acquisition and Support community will lead the project through acquisition and then ongoing Life Cycle Support. The detailed process followed by ADM(Mat) community leaders is entitled the Materiel Acquisition and Support process.

Additional "feeds" into the acquisition cycle include the Concept Development and Experimentation (CD&E) and Research and Development processes. These processes and communities also provide support to the DMS and MA&S processes throughout the entire life cycle of a defence system.

The CD&E process is conducted by military CD&E centres, which are lead by military personnel within the CF community. At the Joint Level, the Canadian Forces Experimentation Centre operates in Ottawa under the Deputy Chief of Defence Staff organization, the Army Experimentation Centre (AEC) operates in Kingston under the Chief of Land Staff, the Maritime Warfare Centre (MWC) operates in Halifax under the Chief of Maritime Staff, and the Air Experimentation Centre (AEC) will operate as part of the evolving Canadian Forces Air Warfare

Centre (CFAWC), which is spread between Ottawa and Winnipeg. These experimentation centres conduct studies to evaluate new "concepts", which include a combination of technology, personnel, organizational structures, and associated doctrine, tactics, techniques and procedures. A "concept" will be explored to determine improved ways for the Forces to achieve their mission, and will result in requirements for acquisition projects, as well as in changes to doctrine, organizational structures, and types of personnel. The results arising from CD&E outputs influence many facets of the CF.

The R&D process is conducted by the laboratories of Defence R&D Canada, with labs in Suffield Alberta, Toronto Ontario, Ottawa Ontario, Valcartier Quebec, and Halifax Nova Scotia, and a headquarters (referred to as DRDC Corporate) in Ottawa Ontario under ADM (S&T). DRDC scientific programs research and develop new technologies and new knowledge. A new technology that is researched and developed may often be further explored in terms of its operational impact through CD&E centres, while a concept for a new technology that is suggested by CD&E activities may often be researched and developed by DRDC to further determine its technological feasibility. As a result, there is a natural iteration and interaction amongst the CD&E and R&D communities, and both serve to answer questions and generate inputs to the Defence acquisition process.

Figure 13 illustrates a very high-level summary of the Defence processes.

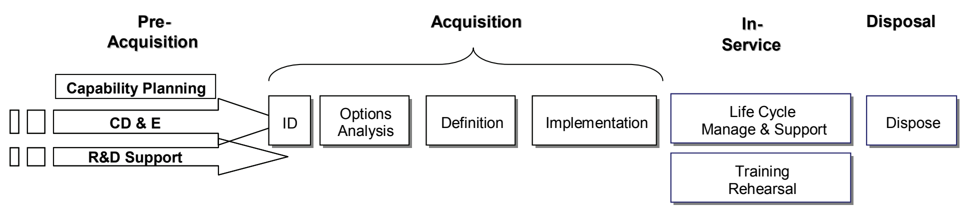

Figure 13: Overview of Defence Processes

7.2 HSI Process Objectives

While developing the Canadian HSI Process, a number of objectives were identified that shaped the resulting process definition. The HSI Process was required to:

- Integrate the domains of HSI into an overall HSI Process (an integrating process that had value beyond the "sum of the parts");
- Integrate with the Canadian Defence acquisition processes;
- Be affordable, considering that a "resource intensive" process was determined to be unsupportable in the Canadian context;
- Support Commercial Off the Shelf acquisition; and
- Ensure that members of the Canadian Defence community were enabled to continually answer the central question throughout the life of defence systems:

"Can the specified operators and maintainers, within the future operational and support concepts, accomplish their roles safety and effectively using the proposed equipment, with the proposed training and manning levels

In realizing these objectives, it was intended that a systematic integration of HSI throughout the life cycle of defence systems would occur (Figure 14).

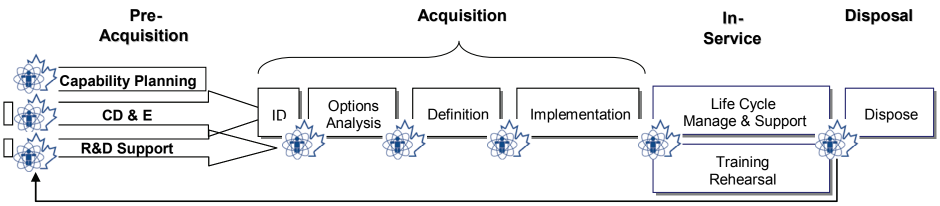

Figure 14: Objective - Integration of HSI through the Entire Life Cycle

7.3 Development of the HSI Process

7.3.1 HSI Process: Version 1

In the earliest years of the HSI project (1999-2000), the first version of the HSI process for Canada was generated. This first effort was focused on three variables:

1. Build on Existing Domain Processes: Existing standardized processes for HFE, SS, Training, HHA, Manpower and Personnel were reviewed in detail.
2. Focus on Integration: Common analyses, tools, data types, etc., across the standard HSI domain processes were identified.
3. Generic Application: The process should apply to both military and civilian personnel within DND in the early phases of the defence life cycle, and to defence contractors when completing their work during the Implementation Phase of the DMS.

The first version of the HSI process was originally developed as a five stage process, with each stage consisting of a series of sub-processes (refer to Annex C for details). The five stages included (Figure 15):

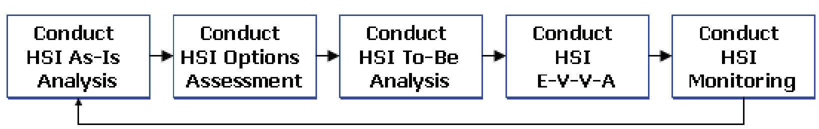

Figure 15: High Level Version 1 HSI Process

1. Conduct HSI As-Is Analysis: An understanding and description of the current system must be developed. The project description should include the Operators and Maintainers of the system, system deficiencies in each of the HSI domains, and HSI-related risks and requirements. A HSI plan should also be completed.
2. Conduct HSI Options Assessment: A series of Options Analyses should be performed where each "option" is considered as a solution to address the project's requirements. The assessment is used to provide further detail with respect to the HSI requirement and human centered system performance measures. The characteristics of each option that are considered during the analysis should include the system's operational and support concepts, the

organization, task flow, workspaces, and human machine interfaces incorporated into the system.

3. Conduct HSI To-Be Analysis: Once the proposed option is selected for the project, it undergoes further analysis to add more depth to performance requirements and evaluation criteria; the requirements and performance criteria are used as the basis of procurement. This analysis provides further detail to the operational and support concepts, organization, task flows, task performance levels, performance requirements, and the target audience. This stage of the process involves analysis mediums such as mock ups, models and simulations, and field trials.
4. HSI Evaluation, Verification, Validation, and Assurance: Requirements and evaluation criteria are often used to select a system among a set of proposed systems. When this occurs, the requirements and processes that have been specified for the project must be managed in terms of evaluating candidate systems against HSI requirements and performance specifications, verifying that HSI requirements have been satisfied, validating that HSI performance measures were accurate, acceptable and achievable, and assuring that overall HSI-related quality is maintained.
5. Conduct HSI Monitoring: HSI monitoring involves tracking all HSI-related variables, such as requirements, deficiencies, and risks.

This process is a sequential series of activities, however, the sub-processes contained within the high-level stages are actually a series of analyses that should be iterated and updated throughout the life cycle of a material system (Figure 16).

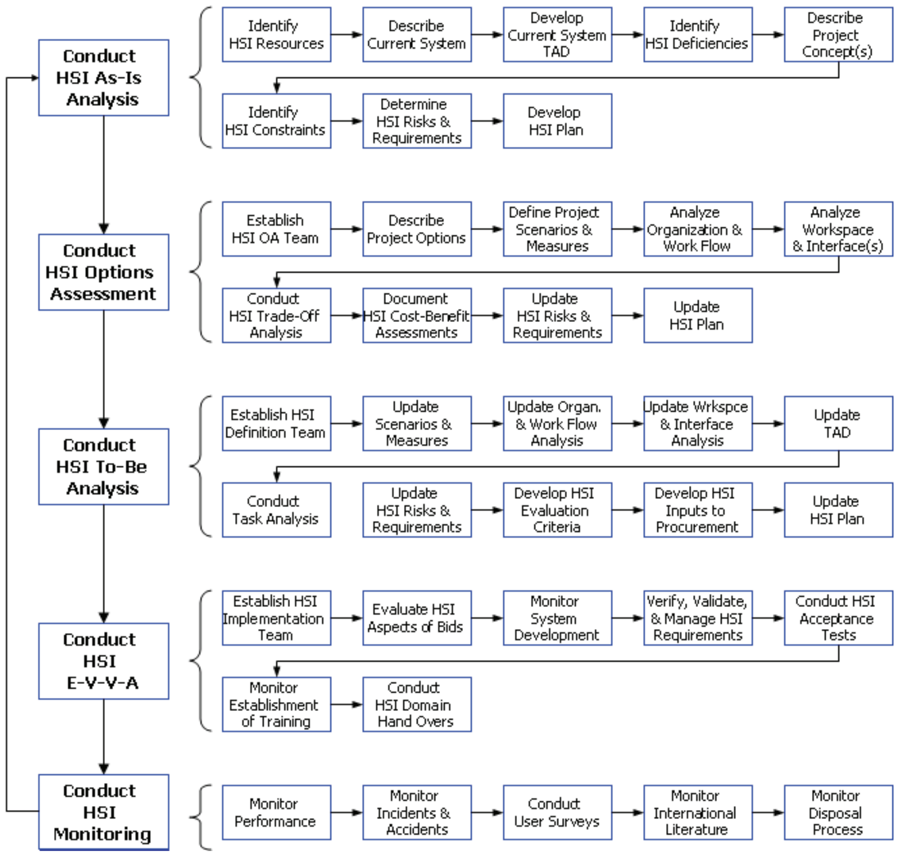

Figure 16: Detailed Version 1 HSI Process

The link between the HSI process and the Life Cycle Management System (LCMS) and the DMS was originally mapped as illustrated in Figure 17, where the overall life cycle management of a defence system involves DMS acquisition activities that in turn need to be supported by the HSI process, with on-going monitoring of HSI variables when an acquired system is in-service.

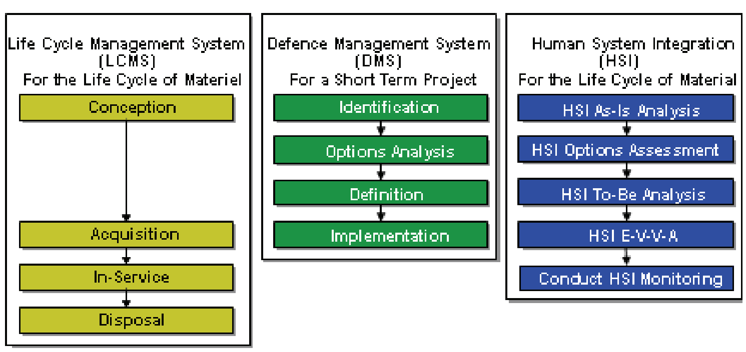

Figure 17: Linkage of HSI to Defence Processes

7.3.2 HSI Process: Version 2

The first version of the HSI Process was never formally released and exploited, however, it served as the most detailed version of the process with roots to the "pure intent of integration". The details of that process (outlined in Annex C), remained the sound foundation of the initiative throughout the remainder of the activities that were conducted.

The major challenge of the first version of the HSI process was that it was too complex, and it did not adequately address the objective of integrating the process with the DMS process, which was identified as the core defence process that required the most integration for HSI to impact detailed day-to-day acquisition project activities. Meetings with DRDC and DND indicated that to be effective, DND requirements officers and project officers needed the equivalent of the "10 Step Process for HSI" which could be viewed on one page and rapidly understood at the highest level, with more detailed information available for those who wanted to participate in the execution of the process elements.

The second version of the HSI process was created to address the deficiencies in the first version, with the result being a high-level process, as illustrated in Figure 18 (refer to Annex D for more details).

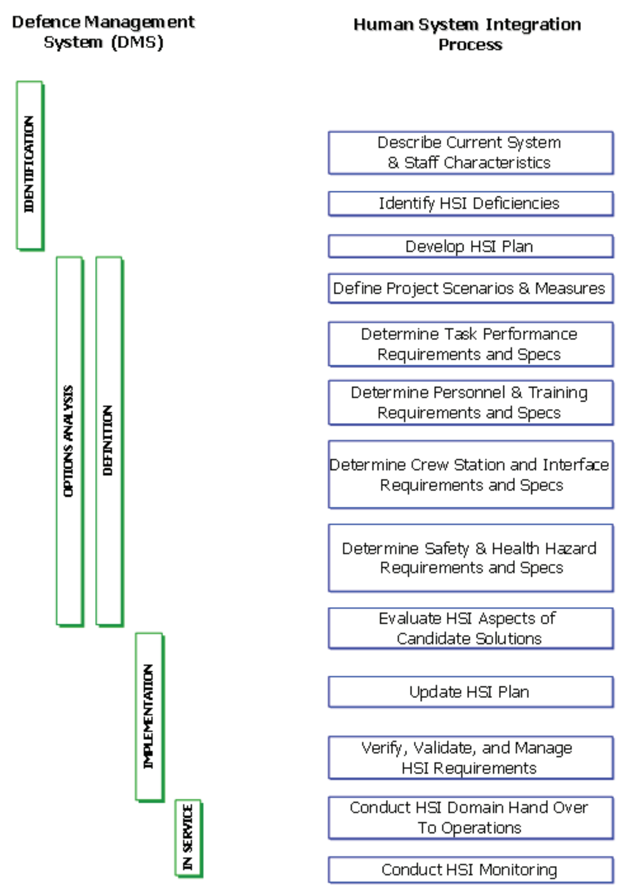

Figure 18: Version 2 HSI Process

The HSI process illustrated in Figure 18 guides a defence acquisition team through an integrated HSI analysis process, following a logical sequence of events, including:

1. Definition of the current system and the characteristics of the Operators and Maintainers involved with the system.
2. Identification of HSI deficiencies, including deficiencies from all domains of HSI.
3. Definition of representative operational scenarios, and key measures of system performance and effectiveness, that will be relevant to any and all studies conducted throughout the process.
4. Definition of Task Performance requirements and specifications, focused on a Task Analysis traceable back to the functions assigned to the human in the system, and traceable forward to the task-based requirements, specification, and measures to be used throughout the design and evaluation cycle.
5. Definition of Training Requirements and Specifications, where a system is evaluated in terms of its Training and Personnel requirements, and as a result, the requirements for the program are derived.
6. Development of Crew Station and Interface Requirements, utilizing the understanding of the users and their tasks, to drive the Requirements Analysis for crew stations and interfaces.
7. Definition of Safety and Health Hazard Requirements and Specification, enabled by an analysis of the physical and digital (software) environment in relation to the functions and tasks assigned to the human component in the system.
8. Systematic Evaluation of the HSI aspects of a candidate solution, where those evaluations are conducted in the Options Analysis Phase to compare the HSI aspects of options, and then again at the end of the Definition Phase to compare the HSI aspects of alternative bids from industrial teams.
9. Throughout the Implementation Phase a government team must focus on verifying, validating, and managing the HSI Requirements, as these requirements are further decomposed, analyzed, and met in the design by the industrial team.
10. A HSI Issue Handover must be conducted at the end of the Implementation phase to ensure that the “design basis” of any solution from a HSI perspective is properly passed to the Life Cycle Materiel Manager.
11. Ongoing HSI issue monitoring is required throughout the life of a system that is in-service, to identify HSI deficiencies, in order to feed into the next iteration of the process.

7.3.3 HSI Process Version 3

The second version of the HSI process served as the core process that provided the foundation for the application of the case studies conducted throughout the HSI Project. However, the process was still continually reviewed and improved, and some of the case study activities focused on further integration of the HSI process into the core DND businesses processes.

One of the main process integration initiatives that occurred near the end of the HSI development initiative, was the integration of HSI into the MA&S process within the ADM(Mat) community, and the creation of some preliminary material to be posted on the MA&S Desktop (an on-line repository for the processes, tools, techniques, and templates of the MA&S process).

To support MA&S integration, the personnel in the Directorate of Materiel Acquisition and Support Program Office funded the development of a HSI Concept of Operations (CONOPS) for the ADM(Mat) community. This CONOPS defined HSI, and linked the proposed HSI process with other project management, systems engineering, procurement, and integrated logistics and support processes already documented on the MA&S Desktop.

Therefore, the HSI CONOPS resulted in the official publication of the 3rd Version of the HSI process. A high-level illustration of this process is presented in Figure 19, with the complete 3rd version of the HSI process described in Annex F.

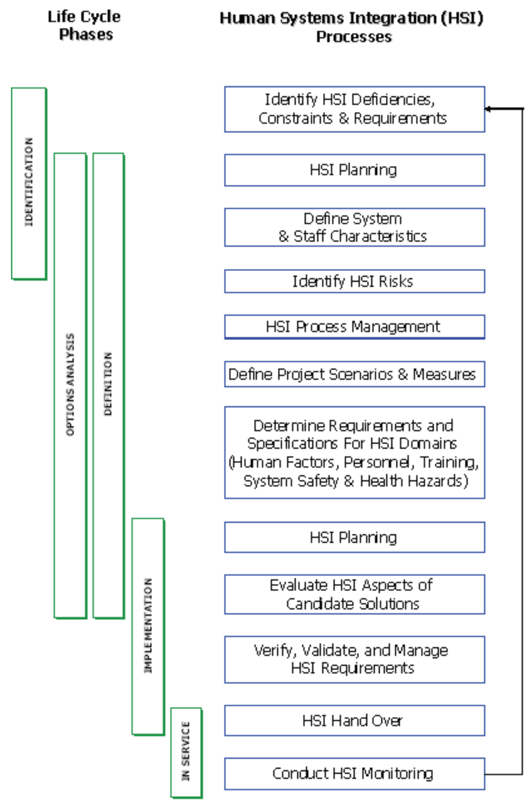

Figure 19: Version 3 HSI Process

Version 3 of the HSI process is the most accurate and complete version, and provides the most specific direction regarding the sub-activities underneath each process component, along with specific direction on where the outputs of the HSI process link with activities in the core MA&S process.

As part of the process of creating the HSI CONOPS for the ADM(Mat) community, and also as part of the on-going activities to focus on the generation of an "integrated" HSI Process, further efforts were applied to illustrate how a HSI approach can be generated from a linkage of the core analysis across the base processes in each HSI domain. The results of this development also reflected the "lessons learned" from HSI case studies in terms of how to best generate a HSI approach across the HSI domains.

High level process guidance for the integration of the HSI domains is illustrated in Figure 20. Note the following key features:

- For the foreseeable future, technical Subject Matter Experts and military design standards (or process standards) will exist within the separate HSI domains (HFE, SS, HHA, Training, Personnel). Achieving an "integrated" approach therefore requires an integration and synchronization of the most critical elements of the sub-domain processes.
    - During the execution of the case studies, this was demonstrated on several occasions. A time (and therefore cost) savings was achieved from this integration, as well as a "shared awareness" and synchronization of technical analysis across the personnel working in each domain was also achieved.
- The integrated approach allows one person to support HSI on a project, or allow teams of personnel working within each sub-domain, to be integrated through the process. This allows an integrated HSI approach to "scale" (i.e., the same approach and process is applied regardless of the number of HSI personnel).
- Within the high level view illustrated in Figure 20, there are a series of core activities that can be considered pure "HSI" activities that either feed specific analyses in each domain, or integrate the outputs of activities within each domain. These HSI activities include the creation of a HSI Plan, the definition of Project Scenarios, the linked HSI Concept of Operations and Concept of Support (CONSUP) for the System, the creation of the Target Audience Description (TAD), System Design Inputs (primarily integrated requirements), and System Evaluation variables (used in integrated HSI evaluations).
- On most case study projects, the Human Factors Engineering domain was the first detailed analysis of the system, and the first domain to integrate with engineering disciplines on concepts for a new design.
- The analysis of the role of the human, and the tasks and activities to be completed by the human, is the core analysis that is shared across all domains of HSI. In one case study, the HFE team led with this analysis, after which the Mission, Function, and Task decomposition served as the backbone for Training Analysis and Operational Hazards Analysis (System Safety).
- Workload Analysis and prediction studies, conducted by the HFE domain, fed into Personnel Analysis (the composition of the team) in terms of how many personnel were required.
- Once detailed Task Analysis was conducted and design concepts for human-machine interfaces or workspaces begun to be generated, the updated Task Analysis and design descriptions generated by the HFE domain provided additional inputs to Training Needs Assessments (TNA), HHA assessments, and SS assessments. HFE Task Analysis, combined with Knowledge Skill and Abilities (KSA) Analysis and Training Needs Assessment, were key inputs to Personnel Assessments (combined with HFE Workload Analysis) to determine: a) the numbers and types of people required to operate a system, and b) the career progression of those personnel based on an overall organizational structure in support of the concept or design being evaluated.

- The assessments in each domain lead to requirements in each domain, which form the overall HSI requirements when combined. This integrated requirements set creates the need for HSI trade offs to occur, which is a key component of an integrated process and one of the key advantages to managing the human role in any system. A trade off will occur when the requirements for one HSI domain drive the project in a direction that negatively impacts the requirements of another HSI domain. For example, an armoured vehicle with high levels of automation and highly integrated human-machine interface may dramatically decrease workload, and decrease procedural skill training requirements, but at the same time may decrease the number and types of personnel and increase the base skill requirements of the Operator thereby significantly altering the organizational composition of, and career progression through, a military unit. A key benefit of HSI is that an integrated approach can identify these trade offs, embrace them, resolve them, and effectively manage the system-wide impact of human issues in the overall system design management process. This benefit was realized on a number of projects observed and analyzed during the HSI Project.
- The integrated process applies to all phases of the defence life cycle. Much of the discussion in this report on HSI Process, and much of the HSI process work completed during the HSI project, focused on the DMS and MA&S portions of the acquisition process. However, case studies were completed at the Capability Planning phase, the CD&E phase, the R&D phase, and the life cycle management phase, with the same integrated process applied throughout (Figure 21). The difference between the application of the process at different phases is the breadth of the analysis, and the level of detail possible, with the most detail occurring when analyzing a specific solution in the Definition and Implementation phases of the acquisition cycle. The HSI project clearly demonstrated that HSI analyses conducted earlier in the life cycle can be rapidly re-used to accelerate the effort during the more detailed phases of analysis, especially when common methodologies were being employed.
- The integrated process applies to both government activities prior to a competitive bid process for a new system, and to the industrial team activities that are conducted during the Implementation phase of the DMS. The HSI project demonstrated that industrial team activity can be shaped by the Statement of Work, the performance requirements, and the requirements for HSI programs discussed during industry interaction.
- Further integration of these processes is possible, but not without integrated analyses and integrated analysis tools. This must become the focus of further R&D within the defence community. In addition, there is a range of additional human variables that can and should be considered (such as leadership and command variables when examining a C4ISR system, and the interplay between Competency, Authority, and Responsibility that results from the organizational structure, procedures, and level of automation introduced into command environments).

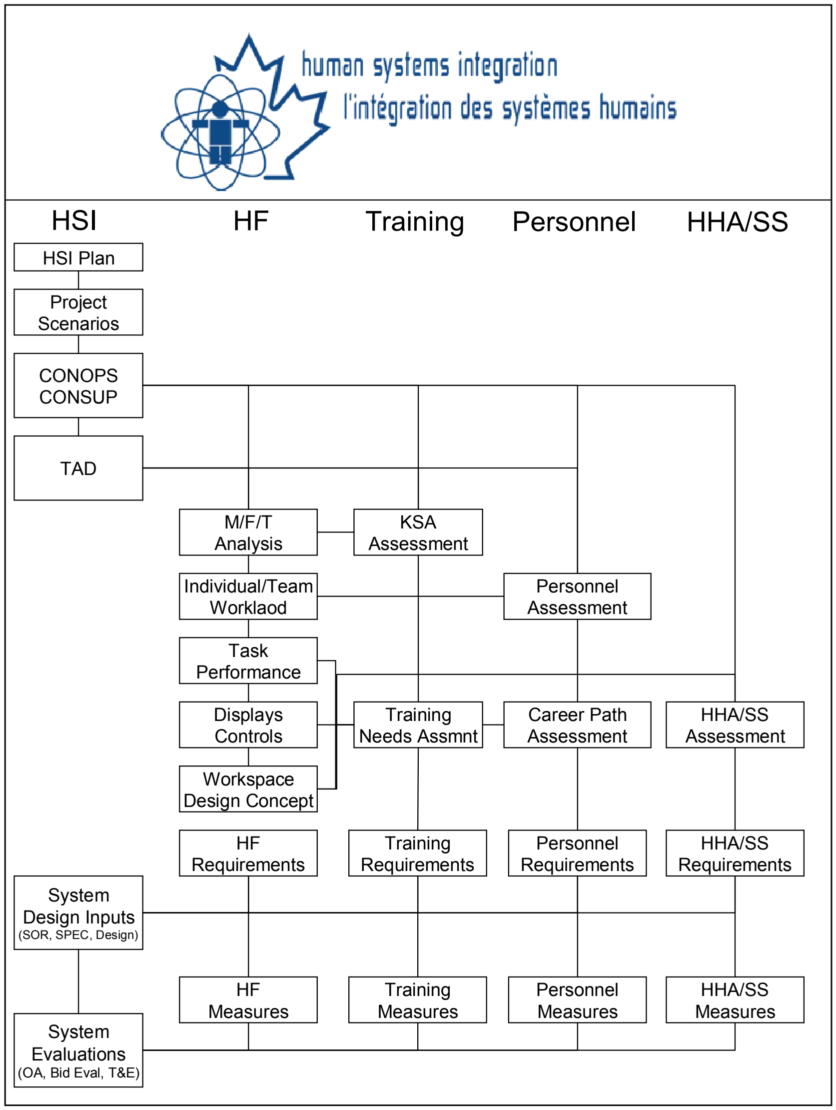

Figure 20: Linkage Across HSI Domains

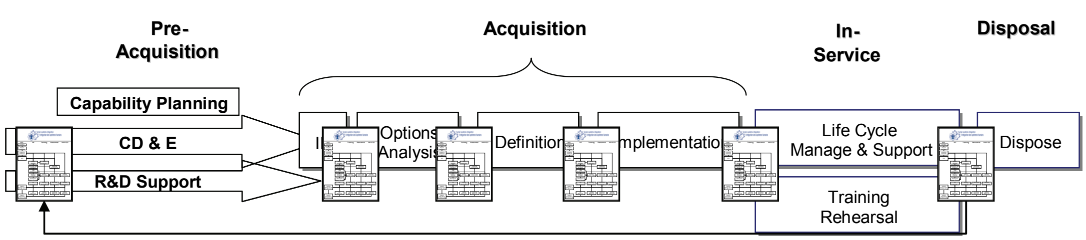

Figure 21: Integrated Analysis Applicable at all Phases of Life Cycle

7.4 HSI Guidance for COTS Acquisition

Throughout the HSI Project, there was considerable pressure from the defence acquisition community to clearly identify where HSI "fits" in COTS product acquisition.

Increasingly, defence acquisition teams are acquiring Commercial Off the Shelf or Government Off the Shelf (GOTS) products. The design of these products theoretically is complete; the product exists, and can simply "be acquired" and integrated into the Canadian Forces operational context by "wrapping" it with the appropriate doctrine, procedures, staffing and training to support effective operations.

The rationale behind the focus on COTS acquisition is to streamline the acquisition process, where extended projects with detailed technical requirements and extended design review cycles (i.e., a Development Project) can be replaced with faster acquisition cycles and existing products are evaluated against a mix of technical and performance-based specifications to identify which solution "fits best".

Since a focus on COTS acquisition was requested, it was generally felt that the acquisition community was looking for a scaled down emphasis on HSI. However, repeated project examples indicated that a COTS acquisition does not change the HSI activities required by Government acquisition teams.

Several key conclusions were drawn from the HSI Project regarding the role of HSI in COTS acquisition:

- The HSI process needs to be followed by both government and industrial participants in a COTS acquisition.
- The difference between a COTS procurement, and a Developmental procurement, is that the industrial team does not develop the design during the implementation phase as the product already exists. As a result, HSI does not "drive" the design during Implementation. Figure 22 illustrates this effect, where the "grayed out" bullets apply to Development programs but not to COTS programs.
- The remainder of the HSI analyses required to answer the core HSI question,

  "Can the specified operators and maintainers, within the future operational and support concepts, accomplish their roles safely and effectively using the proposed equipment, with the proposed training and manning levels?"

  apply equally to either a COTS or a Developmental acquisition project. The government acquisition team still needs to determine which COTS solution will fit best into the doctrinal, organizational, and procedural environment, and what the impact of the chosen COTS solution will be on doctrine, organizational structure, staffing, procedures, human performance and safety.
- An effective HSI Program is *even more important* on a COTS acquisition, since a COTS acquisition does not permit the Government to *influence the design* of the system (as it already exists), and therefore, the Government *can only influence the deployment concept* which includes the full consideration of the impact of the chosen solution on human performance, safety, skill levels, training requirements, organizational structure and roles, and the impact on the career progression of personnel. Properly managing these impacts becomes a focus for DND on a COTS acquisition, and therefore the role of HSI is elevated on these programs.

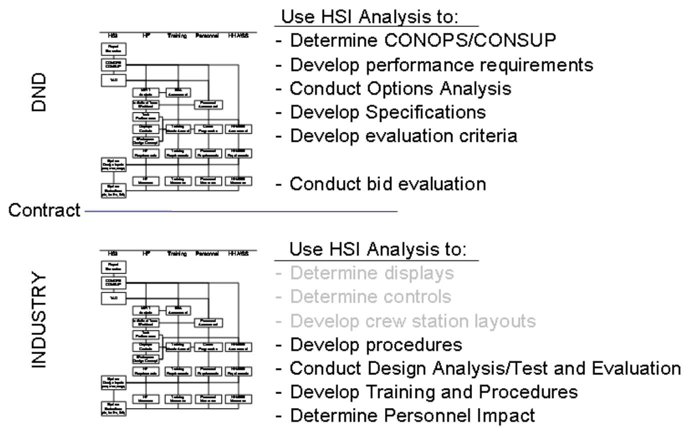

Figure 22: HSI Guidance for COTS Programs

7.5 HSI SOW and DID Templates

The traditional military acquisition process is dependent on specifications and standards, and structured data products that are specified through an acquisition project Statement of Work.

Several of the HSI domains utilize such specifications and standards, or handbooks that contain the same elements. Example of process standards include:

- MIL HBK 46855A for Human Factors Engineering;
- MIL STD 882D for System Safety; and
- The CFITES Standard in Canada for Training Development.

The integrated HSI approach utilized on the HSI Project included elements of these standards in terms of the types of analyses expected of the contractor teams supporting Government acquisition or analysis projects, and the format of the deliverables that contractor teams were required to submit for acceptance.

Within these standards, Data Item Descriptions exist that shape the format and content of the deliverables submitted to the Government.

In order to achieve an integrated approach to HSI, two modifications to the traditional approach were employed:

- The creation of a HSI Statement of Work: A statement of contractor tasks necessary to "integrate the HSI domains" was inserted into the contracting documents for a project.
- The creation of HSI DIDs: A set of DIDs were created to cause the necessary integrations (e.g., the HSI Plan DID) and/or to ensure that key domain specific analyses were generated in areas where historically no standard processes had existed (e.g., Personnel Impact Assessment DID).

Examples of HSI SOW and DID templates are contained in Annex I.

7.6 HSI Process Extension to Capability Engineering

During the latter half of the HSI Project, a significant R&D activity was initiated within DRDC entitled the “Collaborative Capability Definition, Engineering and Management (CapDEM)” project (Pagotto and Walker 2004, CapDEM Exploitation Plan 2004). The CapDEM project was tasked by the Joint Capability Review Board (JCRB) in January 2003 to define, demonstrate and validate the concept of Capability Engineering within the Department of National Defence.

Capability Engineering was a proposed concept to support Capability-Based Planning (CBP) by providing engineering rigour to the development of a capability in a system-of-systems construct. Capability Engineering, when fully developed, was intended to ensure a systematic link between the conceptualization of a capability and the definition of component systems and functions, while at the same time establishing an analytical environment to conduct trade-off analyses across systems to evaluate their impact on both each other and on the overall desired capability goal. With the departmental adoption of CBP, DND/CF initiated a migration away from platform-centric solutions to capability-based solutions which demanded a more holistic view of a system-of-systems.

Figure 23 graphically represents the domains of Capability Engineering, with the following key elements:

- Within the CBP construct, strategic defence guidance documents evolve overarching concepts and are used to map model-driven architectures to core capability areas (e.g., C4ISR) establishing clear, traceable links to high-level strategic and defence policies.
- Representations of defence capabilities are used to generate a comprehensive compilation of “architecture views” that detail the operational, system and technical perspectives of the capability at various layers of resolution. Evolving methodologies for these architecture views include the Department of Defense Architecture Framework (DoDAF) in the United States, and the Ministry of Defense Architecture Framework (MoDAF) in the United Kingdom.
- In Canada, the modelled capability is applied against the various Force Planning Scenarios and Canadian Joint Tasks to assess the “as-is” capability configuration compared to a clearly defined “to-be” end state. Using a suitable set of capability metrics, it is then possible to identify the capability gap that must be addressed to achieve transformation through a rigorously determined blend of existing and emerging systems and structures.
- Options for closing the capability gap can be iteratively analyzed, seeking an optimized blend of people, processes, and materiel within a Portfolio Program Management construct.
- The Capability Engineering approach identifies and considers cross-system interdependencies while supporting broad visibility within a spiral development process. Once the most appropriate program for addressing capability gaps has been determined, the resulting plan constitutes a Capability Roadmap and resource strategy that is both agile and responsive to evolving Strategic Defence directives.

It became evident to the CapDEM team that executing a Capability Roadmap and resource strategy would be difficult under the constraints of the current existing Canadian Defence acquisition process. A much more agile approach was needed to accommodate rapid technological and security environment changes within a resource-constrained environment. In addition to improved agility, Capability Engineering strives to provide the rigour of a "system-of-systems" engineering process to more effectively implement Capability-Based Planning.

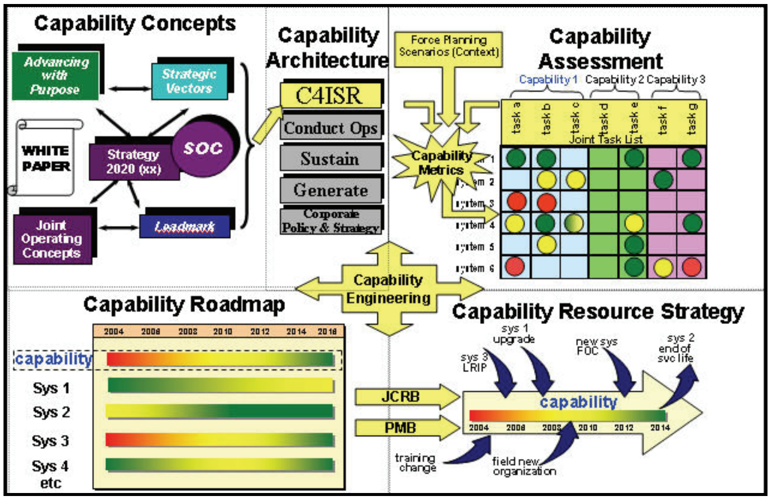

Figure 23: The Conceptual Domain for Capability Engineering

Immediately upon initiation of the CapDEM Technology Demonstration project a link was established to the HSI project community. The entire Capability Engineering process, and therefore the initial case study application areas, requires that the impact of any capability on human performance, the numbers and types of human resources, and their organizational structure must be systematically considered. HSI provides the processes and tools within the Capability Engineering approach that addresses these issues. As a result, HSI quickly became one of the key pillars of an effective CapDEM process.

The extension of the HSI approach into the context of Capability Engineering resulted in the following key impacts on the HSI Program Development team activities:

- HSI Tools, Techniques, and Processes were immediately exploited into the Capability Engineering development effort.
- Any Capability Concept examined in Canada must evaluate the PRICIE (spoken "pricey") variables, which include: **P**ersonnel, **R**esearch, Development/Ops Research, **I**nfrastructure & Organization, **C**oncepts, Doctrine & Collective Training, **I**nformation Technology Infrastructure, and **E**quipment, Supplies and Services. HSI provides the analytical foundation for addressing the "P" at a minimum and contributes significantly to the assessment of the organizational and human performance components of a number of the other variables. As a result, the Personnel domain within HSI, which had historically lacked attention within the HSI Program, was accelerated to the forefront and more completely integrated into the HSI process.
- The structured Architecture Level Analysis (e.g., DoDAF) conducted as part of capability assessment, required systematic consideration of the human role in the system/capability. HSI teams rapidly became involved in the execution of these analyses.

- It was quickly identified that to sufficiently address the "P in PRICIE" that a focused set of analyses within the DoDAF framework was required. As a result, the HSI community became tasked with the creation of "Human Views" (HVs) in addition to the existing architecture views for operations (Operational Views: OVs), systems (System Views: SVs), and technology (Technology Views (TVs)). Discussion of this effort with other nations quickly confirmed that all countries were in need of a more systematic analysis of the human component at a capability level of analysis.
- At HSI Project completion project was closing, the efforts on the integration of HSI into the Capability Engineering process were intensifying and additional efforts on the creation and validation of "Human Views" in the capability architecture analysis were being funded and initiated. In addition, the Canadian Forces was starting to establish pilot Capability Engineering Teams responsible for the provision of Capability Engineering support. HSI roles were a key component of the CETs.

7.7 Linkage of the HSI Process with Department of National Defence Policy

As a result of HSI process development efforts and of lessons learned from HSI case studies, it was evident that HSI must start to be integrated into core Defence policy to ensure systematic application and systematic integration with other business and engineering processes.

There were three levels that required the integration/link of HSI with official policy or processes:

- The Strategic Capability level;
- The Defence Management System level; and
- The Materiel Acquisition and Support level.

The required integration is discussed for each of these areas in Sections 7.7.1 to 7.7.3.

7.7.1 HSI at the Strategic Capability Level

The Strategic Capability Plan (SCP) outlines the highest level strategy for the acquisition of a new defence capability. The SCP was modified by the document managers at the Directorate of Force Planning and Project Coordination to include a reference identify the need for HSI analysis of capability alternatives, as well as a HSI Annex which focused on the need to investigate and consider the Personnel implications of new capabilities.

7.7.2 HSI at the Defence Management System Level

The Defence Management System is the process which guides the definition and acquisition of new systems within the Department of National Defence. The process has multiple phases; a capital acquisition project moves from the Identification Phase, to the Options Analysis Phase, Definition Phase, and then finally to the Implementation Phase. Senior Review Board (SRB) gates occur between each phase, in which a series of analyses, reports, and presentations are required to facilitate a project review to gain permission to proceed to the next phase.

Currently there is a SRB checklist that indicates that Human Factors, Training and Personnel should be considered in the Options Analysis and Definition Phases.

It was identified throughout the HSI Project that the "suggestion" of the need to consider HSI during these phases, must be tightened to become a requirement for HSI Analysis in the Options Analysis, and Definition phase activities.

It is critical that a single, key phrase, be added to the SRB lexicon when following the review procedures at the end of Options Analysis and Definition. Currently these review boards may ask (if they follow the checklist guidelines) "will there be a Training or Personnel impact as a result of this acquisition?" New terminology needs to be added, where the SRB then asks "How do you know?" This simple addition requires the acquisition team to explain how they determined whether an option or a solution had a measurable impact on future Training or Personnel requirements (the largest life cycle cost of many military platforms or systems). The HSI Program has demonstrated that it is possible to analyze and measure this impact, and that it is reasonable for the SRB to ask that a systematic analysis be conducted.

Follow on meetings with DFPPC are required to negotiate stricter requirements for HSI within the DMS process.

7.7.3 HSI in the Materiel Acquisition and Support Process

The Materiel Acquisition and Support Process is the process followed by ADM(Mat) personnel in their detailed management of acquisition (Definition and Implementation phases of the DMS), and life cycle support of defence systems.

Throughout the HSI project, an analysis was conducted to determine where HSI should be considered in the MA&S process. This was completed as part of the HSI CONOPS performed for ADM(Mat) (Annex F).

Further work is now required to author material for the MA&S Desktop to provide process descriptions, document templates, and case study examples to guide the MA&S community in the application of HSI as part of the overall Systems Engineering and Integrated Logistics Support processes.

Further work is also required by the community to use the outputs of the HSI Project to create this MA&S community guidance.

8 HSI Tools

8.1 Summary of HSI Tools

Throughout the HSI project, surveys were conducted to identify HSI tools. A listing of HSI tools was also obtained from a Technical Cooperation Program (TTCP) nation for reference by the HSI community.

In 1998, a HFE Tools workshop was conducted to review the state of Human Factors centric tools within an overall Human Factors process (Greenley 1999). Tool summaries (extract from Greenley 1999) are included in Annex E.

Furthermore, during the HSI project, a repository of modelling and simulation-based tools was created by the DND Synthetic Environment Coordination Office (DND SECO). The summary of each tool identified whether the tool had a HSI application; 200 of the 400 modeling and simulation tools were found to incorporate a HSI role.

Although there were many tools identified as available for use by the HSI community, only a few core tools were used repeatedly on the HSI case study projects. These tools included Mission, Function, and Task Analysis (MFTA) tools, Human Form Computer Aided Drafting and Design (CADD) tools, a range of prototyping and virtual simulation tools, and Task Network Modelling tools for Workload Analysis. The extensive use and re-use of these tools indicate that there is a core set of tools that can be extended to have a broader HSI utility in the future.

The project results identified a lack of tools available for Training Analysis and Personnel Analysis. Various paper and office tools were used in these areas, but specific analysis or simulation tools were not identified. However, such tools are known to exist, and known to be applied by the Human Resources (HR) community. Further work is to identify Training and Personnel tools and their possible integration with the HSI process and other HSI tools currently used. At project completion, it appeared that the CapDEM Technology Demonstration (TD) project might complete a portion of this work, as it continues to extend HSI R&D as part of the development of the Capability Engineering process.

8.2 Impact of "Integration" on HSI Tools

The "integration" of HSI domains made a key impact on the configuration and application of HSI Tools identified during the project. The primary artifact of integrating HSI Analysis, is the identification of "data repositories" within the Systems Engineering process that are "HSI Centric". These data repositories tend to be "owned" by the HSI community, and they are shared across the HSI domains (or at least shared by at least two HSI domains). Figure 24 illustrates the key shared repositories, including:

- Target Audience Description;
- Organization and Work Flow;
- Interface/Workspace Designs and Design Criteria; and
- Human Performance Measures and Criteria.

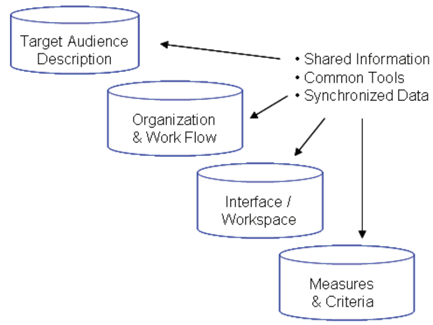

Figure 24: Shared HSI Datasets

These data repositories are created by HSI Analysis tools, which are often Modelling and Simulation-based. As a result, there is the opportunity to focus the future development or extension of HSI-based tools around these data repositories, and to integrate these data repositories with other Systems Engineering tools to better integrate HSI into the overall engineering process.

9 HSI Case Studies

This section summarizes the case studies that were conducted as part of the HSI Project, and are categorized according to a summary of their results. The HSI case studies are further described in Annex J.

9.1 Summary of Case Studies

Case studies were selected throughout the HSI project on an opportunity basis; different groups with funding typically approached the HSI Project team and asked for HSI support. The request was converted into an opportunity to apply a portion of the HSI process, attempt to capture cost-benefit data, and attempt to capture lessons learned.

While the vast majority of case studies analyzed were conducted as part of the HSI Project itself, some case studies were ongoing projects with significant HSI process application that were simply observed by the HSI Project team.

An analysis of each case study facilitated the categorization of each case study according to the type of HSI support and tasks that were conducted (note that each case study resulted in specific programmatic outputs and "lessons learned" that are documented in each case study summary contained in Annex J).

9.1.1 HSI Program Development Case Studies

These case studies focused on the definition and development of the programmatic elements of the HSI Program. These projects did not apply the HSI process, as they were focused on the definition of the HSI program and process.

1. <u>HSI Program - People, Process, Tools, & Communications:</u>
   Multiple tasks were conducted to define the personnel involved in HSI execution, the recommended HSI process, the relevant HSI tools, and HSI community communication mechanisms.

2. <u>Directorate of Technical Airworthiness (DTA) HSI Support:</u>
   Multiple tasks were conducted to provide HSI support to DND's Military Aircraft Certification Organization, the DTA, to develop the human centric aspects of the airworthiness certification process, and to monitor (and at times apply) HSI to aircraft design and upgrade programs. This focused on the evaluation of the impact of standard processes and techniques on the application of HSI by DND project teams and contract communities in the absence of policy.

3. <u>Modelling and Simulation Coordination Office Definition:</u>
   A survey of M&S tools conducted in DND identified over 200 tools that had a HSI application. This clearly indicated that modelling and simulation was a key "tool category" in support of HSI, but also that HSI was a key user/influencer in the evolving world of M&S management. As the M&S Coordination Office (later named the DND/CF Synthetic Environment Coordination Office) was being conceived, an opportunity presented itself to support the definition of the M&S office, to transition programmatic products from the HSI Program to the SECO program, and to investigate the role of HSI within the evolving M&S community.

4. <u>HSI Concept of Operations for ADM(Mat):</u>
   This project involved the development of a HSI Concept of Operations for the ADM(Mat) community, including the development of a clear and succinct

definition of a HSI concept, process, stakeholders, and links to other engineering disciplines.

5. TTCP HSI Workshop:
This project involved the conduct of an international workshop on application of HSI, hosted in Canada with attendees from Canada, USA, United Kingdom, and Australia. This provided an opportunity at the end of the project to compare and contrast Canada's efforts in HSI with those of other nations.

9.1.2 Case Studies Exercising Most of the HSI Process

These projects afforded the opportunity to exercise the majority of the HSI process, including the application of the HSI domains on a design, development, or acquisition challenge. These projects span the DND life cycle from capability planning through to R&D, a Major Capital Acquisition project following the DMS, and then finally with a mid life cycle upgrade project. Most of these projects were conducted within the HSI Project itself; however, some projects were conducted through separate mechanisms but still utilized the HSI process and incorporated a project team that still had detailed insight.

6. Joint Intelligence Information Fusion Capability (JIIFC):
A joint capability level project that focused on the Capability Engineering approach including capability requirements analysis and concept definition very early in the HSI process. The Capability Engineering approach included the application of a HSI approach with HSI tools to demonstrate and evaluate the disciplines that should be included in the JIIFC Capability Definition, and to provide a first test of integration of HSI within the Capability Engineering draft process.

7. Advanced Land Fire Control System (ALFCS):
A multiple year Technology Demonstration project focused on the development and evaluation of new armoured vehicle fire control system technologies within a medium fidelity armoured vehicle simulation test bed environment. This program involved a strong Human Factors Engineering program that was extended to include impacts on Training and Personnel of new force concepts. This R&D activity, and the HSI study results (in the areas of design requirements, Personnel, and Training requirements) fed directly into the Statement of Operational Requirements (SOR) for new armoured vehicle acquisition.

8. Future Armoured Vehicle System (FAVS):
A multi year Technology Demonstration project focused on the definition, development, and evaluation of advanced concepts for the fusion of sensor and map information into an immersive user display environment for future armoured vehicles. Requirements Analysis and evaluation include consideration of Human Factors, Health Hazards, Training, and Personnel in an integrated analysis approach. The application of constructive simulation (computer based models of enemy and other friendly vehicles and weapon systems) and virtual simulation environments, provided the opportunity to explore the role and validity of task network modelling as a predictive tool for individual and crew workload, as an aid in analyzing crew size, composition, and skill impacts of a future force concept.

9. Multi Mission Effects Vehicle (MMEV):
A multi year technology demonstration project established to evaluate a future

armoured vehicle concept that would integrate direct fire, indirect fire, and air defence on the same vehicle. This project was established to answer the following HSI questions raised by the Commander of the Army: a) Can a two person crew operate such a system?, b) If yes, what type of skill levels will be required in that crew? c) What type of skill fading will be expected based on the complexity of such a system, and what will the impact be on simulation-based training requirements?, and d) Based on the required skill levels, what is the impact of acquisition of such a system in 15 years going to be on organizational structure and career progression in the army? This entire R&D effort was focused on answering these HSI centric questions, using an integrated HSI approach, and extending the exploration of Task Network Modelling (TNM) (Integrated Performance Modeling Environment (IPME) tool) as a predictive analytical tool for workload and Personnel Impact Assessments.

10. Maritime Helicopter Project:
The MHP project involved the acquisition of a new fleet of maritime helicopters for the Canadian Forces. The project was a key case study for the application of HSI, and provided a multi-year opportunity required to officially integrate HSI concepts, HSI Requirements, HSI Statements of Work, HSI DIDs, the HSI Capability Maturity Model, and HSI Bid Evaluation Items into a formal Capital Acquisition project while monitoring cost and benefit. This project established the role of a HSI Manager and business approach that integrated Human Factors Engineering, System Safety, Health Hazard Assessment, Training, and Personnel on both the Government side and the contractor side of the acquisition process.

11. MHP Modelling:
This project was a portion of the MHP HSI initiative. It involved using 3D models of the aircraft supplied by each bidder to determine if the complete anthropometric range of personnel, with their required clothing and equipment, could perform their operational tasks in the rear of the aircraft, and whether maintenance could be performed by personnel within the ship's hangar. This case study focused on the role of "simulation-based acquisition" in the evaluation of HSI driven performance requirements within the helicopter bid evaluation process.

12. MHP Workload:
This project was a portion of the MHP HSI initiative. The focus of this project was to investigate the role of Task Network Modelling as a tool to predict crew workload, linking that analysis with Personnel Impact Assessments, so that the analysis could be used to determine, and later defend, the requirements in the procurement documents regarding the number of personnel the aircraft required. This analysis was re-used repeatedly to examine the distribution of roles amongst the defined crew, to balance workload and operational effectiveness, and to finalize operational and support concepts prior to the release of acquisition documents. This analysis was completed by a team of Human Factors Engineering and Training personnel, with the core analysis being re-used in support of HFE Workload Analysis and Personnel Impact Assessments. This was extended so that the core function and Task Analysis was used as the basis for Training Needs Assessment to determine the training and simulation requirements for the aircraft as inputs to the project requirements documents.

13. <u>Very Short Range Air Defence (VSHORAD): Grizzly 6x6 Light Armoured Vehicle (LAV):</u>
    This project involved the application of the HSI approach to a mid life upgrade for the Land Staff Air Defence community. A proposal had been made to upgrade the Grizzly LAV to permit a two person crew to operate a Very Short Range Air Defence system from within the vehicle, specifically "popping up" through a new hatch at the rear of the vehicle, and engaging an aircraft with VSHORAD weapons from this position. This concept introduced a number of concerns in the area of Human Factors, System Safety, and Health Hazards. A study was completed with a series of SMEs from each of the HSI domains, conducting analyses around a common Functional and Task Analysis of the crew roles, leading to an integrated HSI assessment being passed to the vehicle Life Cycle Manager and the Military Requirements Officer.

9.1.3 Case Studies Exercising a Sub-Set of the HSI Process

Several HSI application case studies provided the opportunity to apply an element of the HSI process and to achieve partial linkages across the HSI domains. These projects were executed at different phases of the project life and phases of the DMS.

14. <u>Visual Acuity for Divers:</u>
    The Navy identified the requirement to determine the minimum visual acuity required by both Army and Navy divers. This requirement provided the opportunity for a HSI project to demonstrate an integrated approach, including elements of Human Factors Engineering, System Safety, and Personnel Assessment (screening criteria).

15. <u>Grasshopper Uninhabited Aerial Vehicle (UAV):</u>
    UAVs were increasingly being considered for use by the Canadian Forces. UAV application opportunities included both the operational and tactical level. The Grasshopper UAV was a specific example of a tactical UAV that was proposed to DND. A field trial evaluation for this UAV was required. A HSI evaluation was conducted as part of the overall evaluation of the UAV; HSI evaluation variables in the areas of HFE, SS, HH, Training, and Personnel were incorporated into a HSI Trial Plan, which was a sub-component of the overall Project Trial Plan. Field exercises in Canada and the US generated a HSI evaluation dataset.

16. <u>Canadian Patrol Frigate (CPF) Accommodation:</u>
    A proposal had been made to alter the living arrangements on board the Canadian Patrol Frigate. The Navy required an evaluation of the impact of "extra accommodation" on human task performance and quality of life. A HSI study was conducted to evaluate the impact of the proposed changes including consideration of Human Factors Engineering, Safety, and Personnel issues. A review of the concept was completed, followed by a "test case" evaluation of the modifications on board a Canadian Patrol Frigate ship that was exercised through sea trials.

17. <u>Advanced Linked Extended Reconnaissance and Targeting (ALERT) Experimental Design Support:</u>
    The ALERT Technology Demonstration project was designed to investigate enhancements to the Coyote reconnaissance vehicle and its associated sensor suites and communication systems. The proposed changes included addition of

new sensors, significant integration of sensors, and a number of options for the fusion and transition of information through higher level commanders. This concept required systematic consideration and evaluation of crew roles, task flow alternations based on alternative crew roles, and the impact of design changes on task performance, Personnel, and Training requirements. As a result, a HSI study was conducted to develop the experimentation campaign for the ALERT Technology Demonstration project ensuring that the design of the R&D program, and the various levels of simulation-based experimentation (constructive, virtual, and live) would properly address the core HSI questions in the R&D activity.

9.1.4 Case Studies Focusing on HSI Tool Evaluation

To extend the HSI Tool Set, the following case studies explored the role of new tools in support of HSI Analysis, and focused on the role of Modeling and Simulation tools in support of HSI.

18. <u>Helmet Mounted Display (HMD) for the CF18:</u>
    The CF18 community was interested in exploring the role of Helmet Mounted Displays in the cockpit to support situational awareness and to support advanced engagement techniques such as head cued engagements. A HSI approach was desired to systematically consider the Human Factors, Personnel, and Training requirements associated with a HMD concept, within the context of formalized scenarios and mission profiles. The required analysis presented the opportunity to utilize the DND Decision Support System (DSS), a wireless network of 25 laptop computers with groupware installed that enables anonymous interaction among SMEs in a facilitated focus group to more efficiently and effectively collect data. This tool and the resulting environment were used as an 'integrating tool' in support of the rapid generation of linked sets of HSI requirements.

19. <u>Clothe the Mounted Soldier (CMS) Survey:</u>
    One of the challenges across the HSI community is the need to analyze requirements and design alternatives with the "user community" in a cost effective manner. Within the HSI tool set, a tool available to the HSI community was the Army Combat Clothing and Equipment System (ACCESS) survey methodology developed by DRDC Toronto. This is a multi-level survey system designed for systematic extraction and validation of requirements and/or design feedback. Within the HSI project, the concept of a "web-based" initial survey was further explored to ensure that the entry into a multi-level survey program could start from an even broader base of users from across the country. This On-Line Survey tool was created and employed both within the DND Wide Area Network (DWAN) and on the Internet (allowing soldiers to access the tool from home). This tool was used to survey the HSI requirements for Crew Suits for Land Staff mounted in armoured vehicles.

20. <u>Medium Logistics Vehicle Wheeled (MLVW) Survey:</u>
    The On-line Survey tool (presented in case study 19) was re-used with content modifications to elicit HSI requirements for the MLVW class of vehicles, as a first step towards a multi-level requirements investigation for acquisition.

21. <u>Surveillance, Target Acquisition, Night Observation (STANO) Survey:</u>
    The On-line Survey tool (presented in case study 19) was re-used with content modifications to elicit HSI requirements for STANO, as a first step towards a multi-level requirements investigation for acquisition.

22. Collaborative Displays:
Simulation-based design reviews are increasingly being used in support of HSI studies of requirements or design evaluations. However, there is very little scientific information to guide review teams on "how much simulation fidelity" is required to support design review activities. Two sets of pilot studies were conducted within this project, to begin to explore the answers to this question. Studies were conducted comparing four levels of visualization and immersion, and the associated impact on the ability of "users" to detect system design flaws and to conduct an effective design review from a HSI perspective.

9.1.5 Provision of HSI and Project Definition Support to Programs

These projects required the HSI team to support a project or program where there were clear opportunities to introduce HSI to a new application domain or a strategic parallel initiative. These projects involved "spreading the word" about HSI, as well as applying HSI principles in other fields. Support was provided to project managers, project directors, R&D planning managers and training program development managers. HSI was applied to test and "prove" the relevance of HSI, to build the base of support and "case" for HSI, and to evaluate how well a HSI approach would be accepted in the larger programmatic community.

23. CB^{plus} Program Definition:
The CB^{plus} project was focused on the development and evaluation of new protective clothing and equipment to counter chemical and biological warfare. The project concept included evaluations of new concepts in labs, in a chamber with an articulated mannequin, and in a chamber with live human subjects. The project required definition support that presented the opportunity for a HSI approach to the research, development, and experimentation process.

24. CB^{plus} Performance Protection Framework:
Within the CB^{plus} project, the Director of Nuclear Biological Chemical Defence (DNBCD) was required to produce the next generation of requirements for chemical and biological protection, which required a performance-based approach, including an effective balance between human performance and the required levels of protection to shape the next generation of protective clothing. This provided further opportunities to apply the HSI approach, integrating Human Factors, Safety, Health Hazard, and Training considerations in the analysis and documentation of this new requirements basis for protective clothing. The project also provided the opportunity to utilize constructive simulation to evaluate alternative concepts on individual and team performance.

25. Cipro Plus Requirements Definition:
The Cipro Plus project was focused on the research and development of liposome encapsulated ciprofloxacin, to provide an airborne delivered antibiotic that would counter airborne biological warfare agents. The definition of this project required establishing "user requirements" for a portable device to deliver the drug. This provided the opportunity for a HSI approach and associated support to project definition.

26. Collaborative Planning and Management Environment (CPME) HSI Support:
The CPME system was developed to support the planning and management of R&D projects throughout the Defence R&D Canada community. Challenges associated with the application and "use" of CPME had identified concerns with

the usability of the tool, as well as concerns in relation to the overall deployment concept (in terms of the roles and responsibilities of users, the training requirements, and the work flow in relation to corporate business practices). These challenges provided an opportunity for an integrated HSI approach to the conduct of requirements elicitation workshops, and user evaluation of the prototype technology.

27. Directorate of Training and Education Programs (DTEP) Defence Industrial Research (DIR) Project Definition:
    The DTEP established a DIR project to explore the role of a Learning Management System (LMS). This class of technology is central to effective management and delivery of modern training curricula, and provides the traceability opportunities to link Training with Human Factors requirements and Personnel management systems. As a result, the definition of the project provided an opportunity to provide HSI support, and ensures that advances in training tools and technology were integrated within the HSI Tools Repository.
28. HSI Evaluation of 3D Modelling for DMASP:
    Modelling and Simulation is increasingly being used as a tool in the analysis, design, and design evaluation of defence systems. DMASP wanted to explore the concept of stand alone and/or distributed 3D product models on individual and team task performance, workload, and skill set requirements of the life cycle management and aircraft operational communities.
29. Nuclear Biological Chemical Defence (NBCD) Respiratory Protection Program:
    The Directorate of NBCD needed to complete a comprehensive review of the CF NBCD respiratory protection program. This provided an opportunity to use the HSI approach to help define the operational requirements, identify the deficiencies, analyze the health hazards associated with Threat Scenarios resulting in potential exposure to CBR agents, and assess if the training that supports the respiratory protection program was adequate. This work provided the opportunity to incorporate HSI support in an existing program to determine if design or training changes were required.
30. Project Activity Reporting System (PARS) HSI Support:
    The PARS was developed to support the tracking of how personnel utilized their time and effort within DRDC. The PARS concept required both Requirements Analysis support, and user evaluations of storyboards and prototypes to ensure the resulting solution (technology, deployment concept, and business procedures) considered HSI concerns.
31. MMEV Project Definition:
    Refer to case study 9. The HSI community was provided with the opportunity to shape and define the project, and the project methodology to address HSI questions.

9.2 HSI Case Studies Lessons Learned

Each case study documented lessons learned, which are incorporated in each case study summary (Annex J). The following list represents a summary of the primary lessons learned:

- Program
  - There is a strong desire for HSI within the defence community, as human centric questions increasingly drive complex weapon system development and procurement.
  - HSI is as important in R&D and Concept Development & Experimentation projects as it is in Capital Acquisition projects.
  - Projects are willing to invest portions of their R&D, CD&E, or Acquisition Funds on HSI support.
  - A formal HSI program in the Department is sustainable as long as a few central resources are provided for coordination, and contract mechanisms are in place with competent HSI contractors. This core capability allows project teams to bring their funding and access the necessary HSI support using a range of HSI tools and techniques.
  - Canada is aligned with other nations in the definition and application of HSI, from a conceptual perspective.
  - The driving questions in military future weapons platforms, especially those that are part of a network centric operating concept, are HSI questions. These questions focus on what the impact of a new technology and concept will be on individual task performance and workload, team performance and workload, situational awareness, skill level requirements, organizational structure requirements, the numbers and types of personnel needed to staff the organization with the required skills, and the impact on recruitment and career progression. Structured HSI Analysis can cost effectively address these concerns, and HSI driven experimentation campaigns using simulation-based experimental environments provide the analytical backbone for data driven and defensible guidance to future weapon system teams.
  - In one case study (MHP), the HSI effort on the contractor team was estimated/observed (based on personnel in organisational charts) to represent approximately 60% of the COTS airframe delivery (Human Factors, System Safety, and Training) and 20% of the mission suite delivery (Human Factors, System Safety, and Training) efforts.
  - HSI Analysis can be a key contributor to the selection of the winning contender in acquisition bid evaluation processes.
- Policy
  - Canada lags other countries (specifically the UK and the US) in the definition of policy requiring HSI on acquisition programs.
  - The Airworthiness process, the defined requirements, and the need for a documented Basis of Certification are all strong procedural requirements for the application of elements of the HSI approach on aircraft projects. However, even with these “strong hooks” into the process, the absence of an official policy in ADM(Mat), requiring the systematic consideration of HSI resulted in projects either “skirting” the requirement for consideration of HSI (even in aircraft cockpit upgrades), or not

considering HSI early enough in the acquisition cycle to maximize impact.
  - The primary lesson from this effort, is that a policy is required to ensure that projects integrate HSI into their acquisition projects.

- <u>Process</u>
  - Documentation of the HSI process must point to application examples.
  - Documentation of the HSI tools must ensure that there is a link between processes and the tools that could or should be used in the execution of that process.
  - The HSI Process can be integrated into the Defence Management System and Materiel Acquisition and Support Process.
  - Integration of HSI Analysis into a Capability Engineering approach saves time and money in the capability architecture analysis process, and ensures that the human component is considered throughout.
  - Within the Architectural Analysis methods (DoDAF, MoDAF), in addition to Operational Views, System Views, Technical Views, etc., there is a need for Human Views that clearly isolate the human component of the capability analysis, and the impact of alternative capability configurations on the organization and the personnel within it.
  - Historical HSI Analysis can be re-used to effectively reduce the required effort in the conduct of HSI, especially when the same functions and high level tasks are being analyzed in the same class of vehicles.
  - Integration of the Systems Engineering based HSI domains (Human Factors, Health Hazards, and System Safety) with the Integrated Logistics Support HSI domains (Human Factors for maintenance, Health Hazard and Safety for maintenance, and Training) requires significant effort and a pre-planned focus. When this is not in place, the integration will not occur. This "operations" versus "support" integration requirement is significant, and offers additional benefits for HSI, but must be focused throughout the program.
  - The analytical "backbone" of HSI within the engineering process, provides opportunities for the systematic consideration of "soft" variables such as the impact of a design change on morale, and the subsequent impact on personnel quality of life.
  - HSI experimental design activities, when applied to simulation-based experimentation campaigns evaluating Interim or Future Force concepts, can clearly lead the overall experimental design, and can complete the first two steps of the Federation Development Process (FEDEP) which is used in distributed simulation experiments.
  - Focused efforts on the legal and procedural aspects of simulation-based analysis are required when used as the basis for bid evaluation.
  - Environment and HHA can contribute to the assessment of the impact of alternative design configurations on skill transfer from one operating concept to another.

- <u>Team and Communications</u>
    - A HSI cell can be effectively applied within a major capital acquisition project team.
    - To achieve the benefits of an integrated HSI approach, additional numbers of personnel are not required, but a strong HSI coordinator, who maintains a FOCUS on the integration of the domains, is required. Human Factors staff are well positioned to perform this function.
    - HSI is best integrated within a Capital Acquisition Project team when it occurs at the Systems Engineering Manager Level or equivalent. The HSI Manager must report at least to the Systems Engineering Manager (SEM).
    - A HSI cell in support of a Capital Acquisition Project requires access to the HSI Statement of Work and DID templates to facilitate the HSI process.
    - Links between the acquisition project and the personnel staff (ADM[HR]) should be maintained during the analysis phases to check the currency and validity of any Personnel requirements or assumptions the project is working with.
    - Human Factors Engineering personnel can adequately address Health Hazard Assessment issues on a capital acquisition team if they have access to HHA experts from the R&D labs to assist in requirements selection and bid evaluation criteria selection.
    - Lessons learned should be shared with all the stakeholders (i.e., operations, ADM[HR] and Training are the biggest HSI challenges in a Technology Demonstration projects). While all stakeholders are all interested in the lessons learned, they may not be in a position (timing wise) to exploit them. A central HSI repository that can be actively promoted to users and searched by users would substantially improve the usefulness and re-use of HSI data and analyses.
    - The HSI Project Web Site is a required communications resource.
- <u>Tools</u>
    - Over half of the M&S tools available to the DND M&S community (as documented in the DND SECO M&S Catalogue) have a role in HSI Analysis.
    - Simulation-based, iterative design and experimentation cycles, can effectively address a range of HSI variables. Military operators are able to effectively extrapolate their experiences in medium fidelity virtual simulation environments to provide structured feedback on task performance, workload, situational awareness, usability, Training, System Safety, Health Hazard, and Personnel impacts of future system designs. Objective measures used in virtual simulation-based experimentation can provide data sets on task performance, workload, usability, and learning time.

- Distributed virtual simulation provides an effective experimental environment for the investigation of team tactics and associated procedures, in support of HSI evaluations.
- Part task evaluations of new concepts can be replicated in Constructive Simulation (Task Network Modelling), Virtual Simulation, and Live Simulation in support of an integrated HSI Experimental Campaign.
- Distributed federations of military land and air vehicles can effectively be linked to create future force experimental environments to study HSI issues in a coalition force context.
- Task Network Modelling can predict crew task performance and support design evaluation of HSI issues.
- A HSI cell in support of a capital acquisition project requires access to Modelling and Simulation-based tools, such as human form mannequin software and task network modelling.
- Centralized Task Analysis for the primary missions of a capital acquisition project are required. These should be located in centralized Task Analysis databases accessible by Human Factors Engineering, System Safety, and Training personnel.
- Simulation-based analysis can enable performance-based HSI evaluations, which were historically not possible.
- Centralized Function and Task Analysis are the “integrating analyses” that “pulls together” and focuses Human Factors Engineering and Health Hazard Assessment investigations of weapon system and vehicle modifications. Human Factors leads with Task Analysis and workspace layout, followed by Health Hazard Assessments of hazard variables. HFE and HHA work together to iteratively create and evaluate design alternatives to minimize identified hazards.
- Combinations of simulation-based evaluations and field trial measurements work well together for a comprehensive HFE and HHA assessment of weapon system modifications.
- There is very little effort required to transition a Human Factors Engineering Trial Plan into a HSI Trial Plan. The additional effort requires the addition of measures related to Health Hazards, Safety, Training, and Personnel impact into the evaluation set. The result of incorporating these additions is a significantly more comprehensive analysis of the “human component” in the system.
- The DND Decision Support System (or any multi-user networked groupware facilitation tool) is a cost effective technology for the rapid assimilation of HSI requirements from a diverse multi-disciplinary user community, and for the rapid high level evaluation of alternative concepts.
- On-line surveys are a cost effective method of rapidly accessing an entire user community and obtaining initial high-level structured feedback on user requirements and concept alternatives.

10 HSI Cost-Benefit

This section discusses the cost-benefit of the application of HSI as it was analyzed throughout the case studies.

10.1 Cost-Benefit Framework

At HSI Project initiation, it was decided to attempt to track cost and benefit of the application of HSI, with a goal of attempting to establish a high level cost-benefit framework at the end of the HSI project based on the results of the case study projects.

10.1.1 Costs

The "cost" of applying HSI was calculated based on the cost of the engineering effort that was applied to the case study under analysis. As all case studies involved contractor work to apply part of the HSI process, the costs were derived from this effort.

10.1.2 Benefits

The benefits of applying HSI were identified in three different categories, including:

- Immediate Savings: the HSI approach saved resources (time or money) during the actual execution of the work. In this category a benefit was scored if the application of an integrated HSI approach saved time and/or money as compared to a traditional non-integrated approach (e.g., not linking HFE, HHA, SS, Training, or Personnel);
- Extrapolated Savings: the application of the HSI process clearly resulted in decisions that will save money over time. In this category a benefit was scored if the resulting design decision from a HSI Analysis resulted in a change that would clearly save money over the life cycle of the system (e.g., eliminate a feature that doesn't have to be built, or reducing operating costs); and
- Uncalculated Savings: the impact of HSI application resulted in decisions that will most likely save lives and improve operational effectiveness. As a result of the application of HSI, the system is improved or configured to optimize human task performance, to ensure effective recruiting or training, and to minimize the probability of hazards to the human or the probability of human error. Therefore, the application of HSI will increase the effectiveness of human (and therefore system) performance and reduce the opportunity of injury or death. However, because these savings are difficult to quantify, they were documented but not included in the cost-benefit analysis.

This is a conservative cost-benefit analysis, focusing only on calculable costs and savings. It was felt that if the utility of HSI was demonstrated using this form of analysis, that the Department would be more inclined to accept the introduction of HSI.

10.2 Case Study Cost-Benefit Data

The values used for cost-benefit calculations are detailed in the case studies contained within Annex J. The case study projects have been grouped into the following five categories for the purpose of cost-benefit analysis:

1. HSI Program Development;
2. Case Studies Exercising Most of the HSI Process*;
3. Case Studies Exercising a Sub-Set of the HSI Process*;
4. Case Studies Focused on HSI Tool Evaluations; and
5. Provision of HSI and Project Definition Support to Programs.

*Only case study groups 2 and 3 have been used in cost-benefit calculations, as these are the groups of projects that applied the HSI process with clear opportunities for immediate and extrapolated savings. Case study groups 1, 4 and 5 involved development of the HSI program, evaluation of HSI tools and HSI and Project Definition Support with little to no opportunity for immediate savings or for the measurement of any savings within the time and scope of the overall HSI project.

A summary of all the data is provided in Table 2. These data indicate that not all case studies contributed to overall cost-benefit calculations as discussed. However, all data is provided for completeness. Following Table 2 is a summary discussion of the cost-benefit analysis.

Table 2: Cost Benefit Data Associated with Case Studies. Note only Case Studies 6-17 are used for Cost-Benefit calculations.

#	Case Study	Cost	Immediate Savings	Extrapolated Savings
HSI Program Development				
1	HSI Program - People, Process, Tools, & Communications	$273,000		
2	DTA HSI Support	$1,155,000		
3	Modelling and Simulation Coordination Office Definition	$91,000		
4	HSI CONOPS for ADM(Mat)	$18,000		
5	TTCP HSI Workshop	$36,000		
	Sub-totals	*$1,573,000*	*$0*	*$0*

Case Studies Exercising Most of HSI Process				
6	Joint Intelligent Information Fusion Capability (JIIFC)	$223,000	$125,000	
7	Advanced Land Fire Control System (ALFCS)	$460,000		$131,000,000
8	Future Armoured Vehicle System (FAVS)	$300,000	$75,000	
9	Multi Mission Effects Vehicle (MMEV)	$600,000	$175,000	
10	Maritime Helicopter Project (MHP)	$1,200,000	$2,000,000	$2,000,000
11	MHP Modelling	$200,000		
12	MHP Workload	$85,000	$1,120,000	
13	Very Short Range Air Defence (VSHORAD):	$80,000		
	Sub-totals	*$3,148,000*	*$3,495,000*	*$133,000,000*
Case Studies Exercising a Sub-Set of the HSI Process				
14	Visual Acuity for Divers	$85,000		
15	Grasshopper UAV	$25,000	$20,000	
16	Patrol Frigate Accommodation	$20,000		
17	Advanced Linked Extended Reconnaissance and Targeting (ALERT) Experimental Design Support	$53,000		
	Sub-totals	*$183,000*	*$20,000*	*$0*

Totals for Case Studies 6-17	***$3,331,000***	***$3,515,000***	***$133,000,000***

Case Studies Focused on HSI Tool Evaluations				
18	Helmet Mounted Display for the CF18	$17,000		
19	Clothe the Mounted Soldier Survey	$10,000	$60,000	
20	MLVW Survey	$14,000	$60,000	
21	Surveillance, Target Acquisition, Night Observation (STANO) Survey	$10,000	$60,000	
22	Collaborative Displays	$66,000		
	Sub-total	*$117,000*	*$180,000*	*$0*

Table 2 (continued): Cost Benefit Data Associated with Case Studies. Note only Case Studies 6-17 are used for Cost-Benefit calculations.

#	Case Study	Cost	Immediate Savings	Extrapolated Savings
Provision of HSI and Project Definition Support to Programs				
23	CBplus Program Definition	$191,000		
24	CBplus Performance Protection Framework	$135,000		
25	Cipro Plus Requirements Definition	$49,000		
26	Collaborative Planning and Management Environment (CPME) HSI Support	$26,000		
27	DTEP Defence Industrial Research (DIR) Project Definition	$7,900		
28	HSI Evaluation of 3D Modelling for DMASP	$18,700		
29	NBCD Respiratory Protection Program	$130,000		
30	Project Activity Reporting System (PARS) HSI Support	$8,000		
31	MMEV Project Definition	$42,000		
	Sub-total	*$607,600*	*$0*	*$0*
	Grand Total for All Case Studies (1-31)	***$5,628,600***	***$3,695,000***	***$133,000,000***

10.3 Overall Cost-Benefit Analysis and the Investment in HSI

The case studies involving the application of HSI (case studies 6 through 17) spent $3,331,000 and saved $3,515,000, resulting in a 106% payback. In addition, there were several extrapolated savings, where it was evident that the HSI analysis influenced decisions that will save money over time, including:

- Approximately $131,000,000 in total extrapolated savings in an armoured vehicle project (case study 7) as follows:
  - The validation of the removal of one person from a four person armoured vehicle crew, with an extrapolated life cycle savings of over $126,000,000.
  - The "early" HSI effort (user involvement) identified initial system functionality concepts that would not benefit the armoured vehicle community. The removal of these functionality concepts from the system's design resulted in over $5,000,000 in savings, if the functionality had remained through to final system production.
- The elimination of an unnecessary display on a shipboard system (case study 10), saving approximately $2,000,000 in engineering, equipment, installation, and maintenance costs.

The cost of HSI application from case studies 6 through 17 ($3,331,000) compared to the combined immediate ($3,515,000) and extrapolated ($133,000,000) savings due to the application of HSI resulted in a 4000% payback; this suggests that HSI is a worthwhile investment.

In addition, several uncalculated benefits were observed. On a number of programs, the decisions impacted by the HSI Analysis resulted in design changes or selection decisions that will result in safer and more effective operations. These uncalculated savings are based on actuarial science, the "value" of human life, and the magnitude of the impact of a "successful military operation". This includes the impact on military and civilian lives saved as a result of being able to complete military operations in a shorter or more effective manner. These cost-benefit arguments quickly become circular, multi-variate, and easy to discount, so they are not included in the overall cost-benefit calculations. However, recognition of making systems safer and more effective is warranted.

It is estimated that there is the possibility of hundreds of millions of dollars in downstream uncalculated savings based on lives saved or re-engineering costs avoided as a result of the application of HSI.

10.4 HSI Investment Calculation

Project teams continually inquire as to "How much does HSI cost?", with the typical answer being "It Depends". To provide a more specific answer to this question, four of the case studies, where data was available, were analyzed based on the level of effort expended on HSI application in relation to the engineering effort applied on the project.

These data indicate that:

- On multidisciplinary engineering development or acquisition projects, HSI was allocated 4% to 20% of the engineering budget. This range was found to be true on industrial development teams, or on Government acquisition teams.
- The successful investment in HSI was found at similar levels across projects regardless of project size.
- The level of effort spent on HSI to realize these savings was also consistent across projects regardless of overall project size.

A comparison of similar projects found that the level of HSI investment varied based on the extent to which the focus of the project addressed HSI concerns as its primary purpose. For example, case study projects 7, 8, and 9 illustrate that:

- <u>Case Study #7:</u> The focus was on the development of an advanced fire control system that included high ease of use. Approximately 10% of the engineering budget was spent on HSI.
- <u>Case Study #8:</u> On a "next generation" interface to a fire control system where new concepts for immersive displays with augmented reality and information fusion were being evaluated, the HSI portion of the engineering budget was increased by the project team to 16% to account for increased complexity of the human interface.
- <u>Case Study #9:</u> On a "future system" project involving an entirely new armoured vehicle concept, where the primary questions of the development and experimentation program focused on crew size, skill sets, organizational structure, and impact of the new concepts on career progression, the HSI portion of the engineering budget was increased by the project team to 20% to account for increased complexity of the human interface as well as overall human system interaction.

From an industrial team perspective, the relative effort of HSI increases on COTS programs that are being delivered since the technology is "off the shelf", and the only requirement is to package and train the technology for a customer's operational and support environment. Therefore the <u>HSI issues are the primary issues to be resolved</u> for the customer. For example, a military "off the shelf" airframe resulted in HSI comprising 60% of the engineering effort by the industrial team to deliver the aircraft (comprised of HFE, SS, and

Training), while a COTS mission suite project dedicated 20% of the engineering effort on HSI (comprised of HFE, SS, and Training), as additional engineering integration work was also required (all data reported verbally by engineering teams).

The need for HSI is even further elevated based on the nature of future military capability development and acquisition projects in the context of NEOps. On these future programs, the core capability development and acquisition project questions focus on issues such as Concept of Operations definition, development of organizational structures and work flow, development of information routing and fusion algorithms in support of multi-level decision making, re-definition of military roles, changes to military skill levels, creation of new personnel categories, changes to recruiting and promotion strategies, Safety Analysis relating to “sensor-shooter” links and the need (or not) for human intervention. These NEOps programs have a solid requirement to consider technical feasibility, but this is a lesser concern; the major impact on military operations and the resulting through life cost of these systems are HSI centric. The results of this project indicate that these NEOps programs should have 20% (as a minimum) of their work force and engineering effort focused on HSI both on government teams and corporate teams.

10.5 The Overall Cost-Benefit Equation

Based on the data captured in the HSI project, the following cost-benefit statements are evident:

- An investment in HSI should range from 4% to 20% of the engineering effort on a military project, regardless of the phase of the defence life cycle (R&D phase, definition phase, development phase).
- In general, this investment will pay for itself in time and effort saved (cost savings will equal the investment made) if an integrated HSI approach is taken (i.e., Human Factors, Training, Personnel, Health Hazard, and Safety issues are considered through an integrated analysis, design, and evaluation effort).
- Across multiple programs, a HSI investment will pay for itself through a) avoided unnecessary development, b) avoided re-engineering, and c) possible reductions to Personnel requirements on future systems.
- In general, the application of HSI will result in more effective and safe systems and capabilities, which will result in significant savings over the life of any system.

11 Conclusions and Next Steps

With minimal resources, a Canadianized HSI Program was developed. In concert with HSI program development, a series of HSI case study projects were executed leveraging the investment of many programs across DND. This resulted in a solid foundation for the establishment and continuation of a formal HSI Program within the Canadian Defence community.

At the time of project completion, a number of additional tasks were required to complete the HSI Program formalization process. These next steps included:

1. Establish HSI Policy:
   There are four levels of opportunity for the effective creation of a HSI Policy:
   a. R&D Policy: Technology Demonstration projects are increasingly investigating next generation technology and solutions for the interim force. Many of these technologies will incorporate HSI. Including HSI in the R&D process, and ensuring that the CF understands the HSI impact of the technology proposed is an essential first step in the Defence Life Cycle. Ongoing liaison is required with the DRDC TD oversight leaders to determine where HSI policy or guidance could be defined for the TD program.
   b. Concept Development & Experimentation: The CD&E work within DND is conducted at Joint (Canadian Forces Experimentation Centre) and environment specific (Army Experimentation Centre, Maritime Warfare Centre, Air Warfare Centre) CD&E centers. Each center has their own local procedures for the conduct of CD&E. As the study of future concepts often has a HSI impact, it is important that continued liaison be conducted with the leaders of these centers to introduce HSI processes within their local CD&E processes.
   c. Defence Management System: Continued liaison with DFPPC is required to improve the application of HSI requirements in the DMS process, and to ensure that a more stringent HSI review process is incorporated to guide the conduct of SRBs.
   d. MA&S Process and Desktop: Continued liaison with ADM(Mat) functional authorities in Systems Engineering and ILS is required to author more content for the MA&S Desktop, including the placement of HSI templates on the Desktop, and the creation of a formal Defence Administrative Orders and Directives (DAOD) policy for HSI within the MA&S community.
2. Establish a HSI Team:
   Continued staffing of a HSI Team is required, based on the recommended HSI Team locations and structure presented in this report.
3. Establish HSI Support Supply Arrangement or Standing Offers:
   A minimum of $5M per year of regular, ongoing, contracting mechanisms are required with the HSI industrial base. This should allow for the contracting of multiple firms or teams, each with a "HSI" capability and not a series of discrete teams with capability in one or two domains of HSI (e.g., Human Factors or Training), as this defeats an "*integrated*" approach to taskings.

4. Continue to Formalize HSI Process:
   Continued authoring of the MA&S Desktop material, and the placement of the HSI SOW and DID templates within the MA&S Desktop in the ADM(Mat) community, are the minimum key activities that are required.
5. Increased Integration of HFE, Training, and Personnel Analysis:
   This requirement is critical in the area of Architecture Analysis (e.g., DoDAF) at the Capability Level to fully integrate HSI analyses, and to better integrate this within the fields of Systems and Capability Engineering. It is understood that the CapDEM TD will continue this work through their development of Human Views.
6. Extend HSI Tools:
   The R&D community needs to continue to look for opportunities to develop integrated HSI tools that support integrated processes. A repository of these tools should be established.
7. Initiate and Maintain the HSI Newsletter:
   The "first" HSI Newsletter needs to be developed and distributed. The introduction of the HSI Newsletter must be advertised across the HSI Community.
8. Continue to Maintain the HSI Web Site:
   The HSI Web Site must eventually leave the DRDC servers and be maintained by the HSI Team wherever it resides.

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13 List of Acronyms

ACCESS	Army Combat Clothing and Equipment System
AEC	Army Experimentation Centre
AEC	Air Experimentation Centre
ALERT	Advanced Linked Extended Reconnaissance And Targeting
ALFCS	Advanced Land Fire Control System
CADD	Computer Aided Drafting And Design
CapDEM	Collaborative Capability Definition, Engineering and Management
CBA	Cost-Benefit Analysis
CBP	Capability-Based Planning
CD&E	Concept Development and Experimentation
CE	Capability Engineering
CET	Capability Engineering Teams
CF	Canadian Forces
CFAWC	Canadian Forces Air Warfare Centre
CFEC	Canadian Forces Experimentation Centre
CFITES	Canadian Forces Individual Training And Education System
CMM	Capability Maturity Model
CMS	Clothe the Mounted Soldier
CONOPS	Concept of Operations
CONSUP	Concept of Support
COTS	Commercial Off the Shelf
CPF	Canadian Patrol Frigate
CPME	Collaborative Planning and Management Environment
DAOD	Defence Administrative Orders and Directives
DAR	Director Aerospace Requirements
DCDS	Deputy Chief of Defence Staff
DFPPC	Directorate of Force Planning and Project Coordination
DGAEPM	Director General Aerospace Equipment Program
DGLEPM	Director General Land Equipment Program
DGMEPM	Director General Maritime Equipment Program
DGSP	Director General Strategic Planning

DID	Data Item Description
DIR	Defence Industrial Research
DLR	Director Land Requirements
DMASP	Director of Materiel Acquisition and Support Programs
DMR	Director Maritime Requirements
DMS	Defence Management System
DNBCD	Director of Nuclear Biological Chemical Defence
DND	Department of National Defence
DoDAF	Department of Defense Architecture Framework
DRDC	Defence Research and Development Canada
DRG	Defence Research Group
DSS	Decision Support System
DSTHP	Directorate of Science And Technology Human Performance
DTA	Directorate of Technical Airworthiness
DTEP	Directorate of Training and Education Programs
DWAN	DND Wide Area Network
FAVS	Future Armoured Vehicle System
FEDEP	Federation Development Process
GOTS	Government Off The Shelf
HF	Human Factors
HFE	Human Factors Engineering
HH	Health Hazards
HHA	Health Hazard Assessment
HMD	Helmet Mounted Display
HR	Human Resources
HSI	Human Systems Integration
HV	Human Views
ILS	Integrated Logistics Support
IPME	Integrated Performance Modelling Environment
JCRB	Joint Capability Review Board
JIIFC	Joint Intelligence Information Fusion Capability
KSA	Knowledge Skills And Abilities
LAV	Light Armoured Vehicle

LCMS	Life Cycle Management System
LMS	Learning Management System
M&S	Modeling and Simulation
MA&S	Materiel Acquisition and Support
MANPRINT	Manpower and Personnel Integration
MFTA	Mission, Function and Task Analysis
MHP	Maritime Helicopter Project
MLVW	Medium Logistics Vehicle Wheeled
MMEV	Multi Mission Effects Vehicle
MoDAF	Ministry of Defense Architecture Framework
MWC	Maritime Warfare Center
NATO	North Atlantic Treaty Organization
NBCD	Nuclear, Biological, and Chemical Defence
OV	Operational Views
PARS	Project Activity Reporting System
POC	Points of Contact
R&D	Research and Development
SCP	Strategic Capability Plan
SECO	Synthetic Environment Coordination Office
SEM	System Engineering Manager
SMEs	Subject Matter Experts
SOR	Statement of Operational Requirements
SOW	Statement Of Work
SRB	Senior Review Board
SS	System Safety
STANO	Surveillance Target Acquisition Night Observation
SV	System Views
TAD	Target Audience Description
TD	Technology Demonstration
TNA	Training Needs Assessment
TNM	Task Network Modelling
TTCP	Technical Cooperation Program
TV	Technical Views

UAV	Uninhabited Air Vehicle
VCDS	Vice Chief of Defence Staff
VSHORAD	Very Short Range Air Defence

Annex A: HSI Capability: Concept Description Report

This document is a description of the concept for a Human Systems Integration (HSI) capability to be developed within the Department of National Defence and the Canadian Defence community in general.

This document outlines the original concept for the resulting HSI capability, including the name, mission, logo, capability components, and HSI development project outputs.

CANADIAN DEPARTMENT OF NATIONAL DEFENCE HUMAN SYSTEMS INTEGRATION CAPABILITY: CONCEPT DESCRIPTION

by

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On behalf of
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March 2000

Executive Summary

This document is a description of the concept for a Human Systems Integration (HSI) capability to be developed within the Department of National Defence (DND) and the Canadian defence community in general.

There is increasing interest in the application of Human Systems Integration in the material acquisition and support cycle for military systems. This support comes from within the Canadian defence community as well as through evidence from the successful introduction of HSI programs in allied nations (eg; United States and United Kingdom).

For the reasons outlined in this document, Canada has decided to formalize an HSI capability in DND supported by the HSI capability in Canadian industry. This development will occur a series of projects. This is not one project that is noted on a particular managers budget but is a project that will leverage the activities of a number of smaller efforts towards a common goal.

This document outlines the concept for the resulting HSI capability, including the name, mission, logo, capability components, and HSI development project outputs.

An important issue that must be determined throughout this effort will be the selection of a "home" for the HSI capability coordinators. This in turn will be dependent on the need for HSI capability co-ordination. Several options may be relevant for further analysis in the future:

1. Maintain co-ordination through a minimal funding stream in DRD Canada to ensure a department neutral co-ordination approach and links to the joint R&D community.
2. Establish co-ordination inside ADM(Mat), such as in DBCM, in conjunction with other functional authorities. This could be accomplished by assigning co-ordination responsibility to the functional authority for Systems Engineering or ILS, or by establishing a new functional authority for HSI.
3. Establish co-ordination inside VCDS somewhere, such as in DFPPC. As HSI involvement is required at the immediate initiation of a project (as suggested in the Defence Management System manual) many of the analyses must be co-ordinated by Project Directors and therefore it would be appropriate to co-ordinate HSI activities from the operation side of the project leadership team.
4. Eliminate the co-ordination requirement, and have DBCM staff take over maintenance of the HSI process in conjunction with the other MA&S processes, transferring the HSI Web Site content to their Acquisition Desktop for on-going maintenance.

All of these options are feasible, alone or in combination, and any variation will result in the successful continuation of the HSI Project into regular material acquisition and support operations.

Table of Contents

Annexes

1 Introduction

This document is a description of the concept for a Human Systems Integration (HSI) capability to be developed within the Department of National Defence (DND) and the Canadian defence community in general.

This concept provides the framework and background rationale for a project to establish an HSI capability within DND.

1.1 Background

The military community, like most other business environments, experienced considerable downsizing and reorganization through the 1990's. Now, the acquisition and operation environments are re-inventing themselves through the Revolution in Military Affairs and related initiatives aimed that the development of efficient operational and administrative forces.

As a result the material acquisition and support process continues to be reformed to permit smaller groups of DND managers and engineers to define and procure more complex military systems faster than they ever have before, with an emphasis on life cycle cost reduction.

At the heart of these changing times are the operators and maintainers of future military systems. There is increasing pressure on material acquisition and support teams to acquire systems that will allow smaller crews to operate in more dynamic operational environments, with more sophisticated to increasingly higher levels of performance, safely.

As a result, there is increasing interest in the application of Human Systems Integration in the material acquisition and support cycle for military systems. This support comes from within the Canadian defence community as well as through evidence from the successful introduction of HSI programs in allied nations (eg; United States and United Kingdom).

Human Systems Integration (HSI) is the technical process of integrating the areas of human factors engineering, manpower, personnel, training, systems safety, and health hazards with a materiel system to ensure safe, effective operability and supportability.

For the reasons outlined in this document, Canada has decided to formalize an HSI capability in DND supported by the HSI capability in Canadian industry.

This document outlines the concept for the resulting HSI capability.

1.2 Scope

This planning activity has been conducted to develop an HSI program to integrate the domains of Human Factors Engineering, Training, Personnel, Manpower, Safety, and Health Hazards into the core of the MA&S process.

The goal is to conduct this integration in such a fashion that domain expertise remains in the current areas throughout the department, while facilitating a better integration and re-use of data, analysis tools, and R&D.

This planning activity, and the future HSI capability development project, is essentially a non funded initiative, with effort being applied to planning and development tasks as opportunity permits and through the leveraging of resources with other interested groups.

1.3 Feedback and Contact Information

Feedback on this concept and the HSI project are always welcome. Please forward your comments to:

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   (613) 992-7662

2. Dr. D. Beevis
   DCIEM
   (416) 635-2138

2 Human Systems Integration Defined

Human Systems Integration (HSI) is the technical process of integrating the areas of:

- human factors engineering,
- manpower,
- personnel,
- training,
- systems safety, and
- health hazards

with a materiel system to ensure safe, effective operability and supportability.

This definition has been developed through NATO working groups and is generally used throughout the HSI program in allied nations, as well as several projects in Canada.

The basis of HSI is the ***technical integration*** of the six domains listed. These domains have been included in the material acquisition and support process for a number of years as distinct specialty engineering or support disciplines, however, this recent effort by many nations attempts to more formally integrate the analysis and output of each area.

This integration is ***not an attempt to rationalize human resources***, but is an attempt to link existing personnel and analytical capability to:

- **Share** analysis
- **Re-use** analysis
- **Synchronize** linked analysis, performance requirements, performance measures, and evaluation techniques
- **Share R&D** efforts
- **Introduce** the presence of **all domains earlier** in the material acquisition and support cycle.
- **Realize a cost savings** to the material acquisition and support process through all of the above, while adding value through more effective consideration of human centred requirements and project success drivers.

3 Rationale for the Human Systems Integration Project

The development of an HSI capability within DND is being pursued for a number of reasons, including:

- Lessons Learned From Previous Projects
- Lessons Learned from the Commercial Community
- Technological Requirement
- Technological Opportunity
- International Co-operation and Interoperability
- Pressure and Support from DND Project Personnel

3.1 Missed Lessons Learned From Previous Projects

The 1998 proposal entitled "Way Ahead and Investment Strategy for Human Factors (HF) and Modeling & Simulation (M&S) R&D in DND"[1] identified a series of project where the Auditor General or Project Close Out Reports had identified lessons learned that could have been avoided through the system application of Human Systems Integration. Examples included:

- Missed opportunities to predict the impact of system design on human capabilities (or lack thereof).
- Maintenance costs 2.5 times greater than the system being replaced, which came as a surprise as no predictive analysis was conducted and no constraints were established regarding the systems impact on crew skill or training requirements.
- New technology that required higher skill levels than anticipated, which required the development of a new training system post-deployment.
- Lack of consideration of human performance or impact of human error in operational analysis of future systems.
- Increased pressure to understand health hazard impacts on future system operators and maintainers and to introduce design based mitigation's of potential risk areas.
- Injury patterns due to extended exposure to vehicle based platforms, or physical demands that exceed human capabilities.

[1] The HF/M&S Working Group, 1998. Way Ahead & Investment Strategy for Human Factors (HF) and Modeling and Simulation (M&S) R&D in DND. Defence Research and Development Canada Proposal.

3.2 Lessons Learned from the Commercial Community

The Standish Group[2] conducts regular surveys of hundreds of technology based projects to determine the factors that contribute to success or failure. As recently as 1995, this group has indicated the primary drivers of project success and project failures. These factors are summarized in Table 1 in order. Areas where systematic application of HSI principles could improve project performance are in indicated in bold text.

Table 1: Reasons Project Succeed and Fail

Reasons Project Succeed	Reasons Projects are Impaired or Ultimately Cancelled
1. User Involvement	**1. Incomplete Requirements**
2. Executive Management Support	**2. Lack of User Involvement**
3. Clear Statement of Requirements	3. Lack of Resources
4. Proper Planning	4. Unrealistic Expectations
5. Realistic Expectations	5. Lack of Executive Support
6. Smaller Project Milestones	**6. Changing Requirements & Specifications**
7. Competent Staff	7. Lack of Planning
8. Ownership	8. Didn't Need it Any Longer
	9. Lack of IT Management
	10. Technology Illiteracy

3.3 Technological Requirement

A series of recently released strategy documents, and a suite of studies from the Defence Management Committee (DMC) work regarding the Revolution in Military Affairs (RMA), together have started to describe the future of military operations. These documents indicate a continually integrated battlefield, increased use of information based technology, information presentation at higher levels of abstraction, multi disciplinary and multi cultural (different nations and different business cultures) operational teams assembled quickly and changed on-the-fly as the situation demands, and an increased use of distributed simulation to bring all these facets together in a rehearsed and organized fashion.

Many of these forward looking documents have emphasized that issued addressed by Human Systems Integration must be considered early and systematically, specifically authors have noted that:

- Projects must adequately and systematically address the increasing re-allocation of functions from human to machine.
- Considerable analysis on the impacts of future systems on team work and decision making is required, especially on projects that focus on information technology and distributed communications systems.
- The future members of the Canadian Forces will need to be highly trained, and will be drawn from the regular work force personnel pools for shorter periods of service than in the past. This will increase the need to understand selection criteria and

[2] The Standish Group, 1995. CHAOS Report. From the World Wide Web, http://standishgroup.com/visitor/chaos.htm.

training requirements for all future systems, and be prepared to efficiently ask "what if" as technology and the recruiting base fluctuates.

- Research and develop activities must be more closely linked to the needs and method of operation/maintenance of the ever changing Forces.

3.4 Technological Opportunity

While advances in information based technology create challenges that require a more systematic approach to HSI, these same advances provide technology that actually facilitates the integrative nature of an HSI approach.

The primary technological developments that create the opportunity for HSI include distributed databases, modeling, and simulation.

As database technology continues to evolve, and access can be more effectively distributed with increased interfaces through web browsers, the ability to link the domains of HSI and share data increase.

As **modeling technology**, especially system level human performance modeling, continues to advance the ability to HSI analysts to quickly and efficiently analyze alternate system concepts, or alternate system configurations in enhanced. This allows HSI analysts to:

- **Provide more accurate analysis** and predictions of human centred cost-benefit analysis to DND acquisition and support teams.
- **Share common analysis models** across HSI domains, which in turn increases the accuracy and efficiency of the analysis process related to consideration of the human role in future systems.

As simulation technology, especially constructive simulation and live simulation that utilizes humans in the loop, continues to become common place and Canada establishes re-configurable simulations of many of the major vehicle platforms and command centres, the ability for HSI analysts to conduct analysis is enhanced. **Simulations permit more concise evaluations of the impact of system alternatives on task performance, workload, training demands, alternate team structures, and the probability of hazards.**

3.5 International Co-operation and Interoperability

It is important for Canada to co-operate with allied nations, to share R&D, and to have acquisition processes and operational techniques that are as interoperable as possible. The requirement for this integration is increasing as coalition based operations become standard procedure, and as the global defence industrial base consolidates.

Some of Canada's most significant allies, particularly the United States and the United Kingdom have included new Human Systems Integration processes and support resources as part of their acquisition reform processes. As a result there is the opportunity for Canada to include the formalization of an HSI capability as part of acquisition reform activities here, leveraging lessons learned and established practices in allied nations. This will then permit more effective communication among the global HSI community and consistent communication between DND and the industrial base.

3.6 Pressure and Support from DND Project Personnel

Members of the DND acquisition and support community are very aware of the points raised in the previous five sub-sections. This has become apparent through continual feedback from Project Directors, Project Managers, DND engineering and procurement staff, and senior managers.

The 1998 document, Way Ahead and Investment Strategy for Human Factors (HF) and Modeling & Simulation (M&S) R&D in DND, was the first attempt at suggesting a Human System Integration capability be established in Canada. This document was distributed to 95 personnel throughout the department for review by their staff. Approximately 20 formal written responses were received to this distribution, all of which were in favour of such an initiative and many of which noted the requirement for more formalized HSI programs. A summary of this feedback is provided in Annex A to this report.

In 1999 a workshop was held to review the various human factors engineering tools that have been developed in DND throughout the last decade. The results of this workshop[3] provided some direction on how HFE and HSI tools should be further developed and integrated. However, **the overwhelming and surprising result of this workshop was the unanimous call for formalized HSI processes to direct teams where to use tools, and a centralized HSI resource pool for non-specialists to consult.**

[3] Greenley, M. 1999. The Way Ahead for Human Factors Engineering Tools. DCIEM Report #1999 CR 048.

4 Constraints on the Development of an HSI Capability

For the reasons outlined in Section 3, it has been decided to develop an HSI capability within the Canadian defence community, and specifically within DND. The development of this capability must consider and be conducted within the bounds of a number of limitations and constraints. These constraints include:

- Minimal Resources. As DND continues to downsize and streamline personnel and process costs, there are little to no resources available to implement a formal HSI program and assign full time personnel to it at the start. As a program gains acceptance and demonstrates its utility and role in the acquisition and support process this may change, but initiation of the activity will have to be performed with minimal resources.
- Life Cycle Cost Impact. The introduction of a HSI analysis and measurement cannot add cost to the life cycle of defence systems, and must demonstrate that it can significantly reduce such costs.
- Current Business Culture. The current management culture is focused on streamlining and integrating processes, and the reduction of layers of bureaucracy and paperwork. Any HSI activity must be conducted within this culture and share these goals.
- Linked Efforts. The Directorate of Business Change Management (DBCM) is currently actively involved in the execution of the Acquisition Reform Initiative. This activity is documenting refined processes, work products, tools and techniques for DND Project Management (PM), Engineering and Support Management (ESM), and procurement. The engineering and support efforts are reviewing and documenting the processes for systems engineering and Integrated Logistics and Support (ILS). Systems engineering has historically been responsible for human factors engineering and system safety in the acquisition process, while ILS has been responsible for manpower, personnel, and training considerations. HSI processes and capability must therefore be developed within the framework being established within DBCM and with the approval and guidance of the DBCM functional authorities and their committees.
- Depth of HSI Skill Base. There is some skill base for some domains of HSI within DND, although it has diminished with downsizing and could diminish further with the volume of retirements expected in the next six years. There is a skill base in industry in many HSI domains but not all. There is little to no skill base in HSI as an integrated discipline in Canada. This relative resource levels must be considered in any development efforts, with the likely best approach being to combine and integrate any available capabilities into the overall Canadian defence HSI capability.

5 The Human Systems Integration Project: Overview

In order to develop an HSI capability within DND a project or series of projects will be conducted. This is not one project that is noted on a particular manager's budget but is a project that will leverage the activities of a number of smaller efforts towards a common goal.

Much of the work that will be conducted in this development effort will be coordinated and minimally funded through Defence Research and Development Canada (DRD Canada) project (16KE "HSI-Process Models"). This group has taken the lead in conceptualization, planning, and direction of this development as it has received the bulk of feedback and pressure to develop this capability and has historical capability in the HSI area. This group is also a "purple" resource which is required to help facilitate the integration required in HSI capability development.

5.1 Names

The name of the current initiative is the Human Systems Integration Project.

One of the capabilities established will be the Human Systems Integration Support Team, which may also be known as the Virtual HSI Support Team (see below).

5.2 Mission and Objectives

5.2.1 Mission

The mission of the HIS Project is:

> **"The pursuit of optimal health, safety, human factors engineering, and human performance through the application of HSI principles in military systems involving the human element."**

5.2.2 Objectives

To establish a HSI capability, the HSI Support Team ought to have the following objectives:

1. Provide HIS support to MA&S projects in the early planning stages as well as during Ops.
2. Integrate existing HSI capability within the Canadian defence community, both within DND and within Canadian industry.
3. Provide points of contact (POCs) available to advise DND material acquisition and support project directors and managers, specifically on the personnel, training, Human Engineering, Health Hazard Assessment and System Safety related issues.
4. Document and maintain an HSI process, and HSI policies if ever required.
5. Document, demonstrate, and continually enhance a set of HSI analysis tools and techniques as well as Models, simulations and related databases mainly derived from the R&D domain.
6. Provide regular communication between and about all the above items using web based and e-mail technology.

7. Promote HSI through the Manpower, Personnel, Training, Health Hazard Assessment, System Safety, and Human Factors Engineering communities.

5.3 Logo

The proposed logo for the HSI Project, and future HSI Support Team, is illustrated in Figure 1. This logo is a modification to similar logos from the United States and the United Kingdom and has roots in the US Army MANPRINT program which provided the foundation for many HSI initiatives. The overlapping spheres show the integration of the HSI domains.

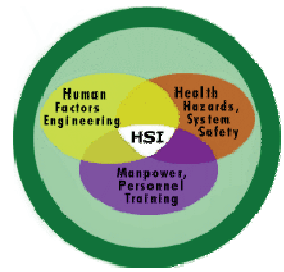

Figure 1: HSI Logo

5.4 HSI Capability Components

The HSI project will endeavor to establish (I) People, (ii) Process, and (iii) Tools in order to meet the mission of the HSI Project and resulting HSI Support Team. In combination these components will form the foundation for a formalized HSI capability that can be continually enhanced and maintained.

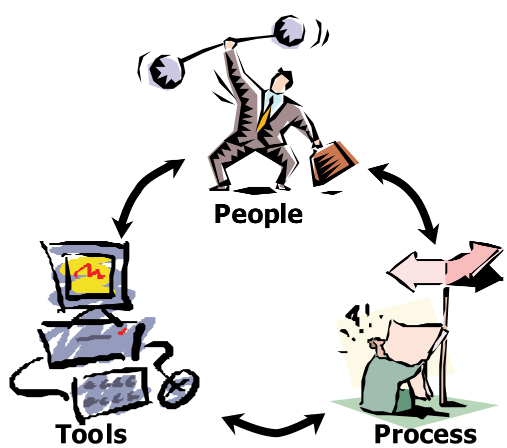

Figure 2: HSI Capability Components

5.4.1 People

The human resources necessary to co-ordinate the HSI capability, and the resources required to provide the technical HSI analysis required by DND project offices will constantly be under review and will largely adjust and respond as demand requires.

Regardless of resource levels, it is anticipated that three groups of personnel will be required to develop and maintain an HSI capability:

1. <u>HSI Coordinators</u>. As HSI is an integration of a number of different organizations and groups, existing in multiple departments within DND, it will be important to have some form of small co-ordination. During the period of the initial HSI Project to develop this capability (nominally from 2000 to 2003) this co-ordination will be provided by the DRD Canada Thrust Leader and Project Leader of 16KE, however,

in time this role may switch to any number of potential groups and must be one of the decisions made during the developmental project.

2. DND HSI Steering Committee. In order to address the lack of human resources in DND and the inability to significantly hire additional resources, it is expected that the HSI capability will be most effectively established as “virtual team". This virtual support team will integrate existing personnel that have interests or capabilities in the various HSI domains, and will identify these personnel as POCs accordingly. These **DND personnel will be invited to sit on a DND HSI Steering Committee that will meet one or two times a year to influence HSI policy, process, R&D, and to share case studies from their areas**. In time HSI related personnel from other Government Departments may be asked to join this steering board to further leverage shared interests and resources. In addition, it is expected that some form of representation from the defence industrial base might sit on this board as Members-at Large as well to link HSI interests in DND with the capability of industry.
3. HSI Industrial Base. Much of the technical HSI work is currently provided and will continue to be done by industry personnel. This personnel support defence projects as scientists, consultants, or staff inside the large defence system design and manufacturing firms. It will be very important to link DND interests with these industry based resources in order to provide a capable, consistent, and flexible HSI capability for DND material acquisition and support projects.

In time, it is expected that an HSI Capability Maturity Model will be developed, in collaboration or at least in consultation with allied nations to help shape and manage the configuration of the analytical capability available to DND material acquisition and support projects. In other words, this model or tool will be used to quantify a company’s ability to deliver on HSI.

This human resources capability will provide HSI support to a DND project in a number of ways. The three primary methods of a project obtaining HSI support are expected to be:

1. Project Conducts Own HSI Analysis. In this scenario, the project directors or managers would access existing HSI capabilities available through the human resource matrix in DND who will then manage the HSI process and conduct the necessary analysis.
2. Project ID's and Obtains Own HSI Support from Industry. In this scenario the project is aware of the capabilities required, uses the HSI contact directory and government bidding process to contract HSI support. This may be conducted in combination with R&D support from DND Canada depending on the nature of the project.
3. Project Requests HSI Support Guidance. In this scenario the HSI contact directory is used to identify a local HSI representative (eg: in own environment, such as Land) or the HSI coordinators who are then contacted for advice in determining the scope of HSI required on the project and guidance on how to obtain the required HSI support.

In reality, various combinations of these three scenarios are likely to be applied across the different HSI domains depending on the requirements, size, and duration of a given project.

5.4.2 Process

Currently each of the HSI domains (HFE, Training, Manpower, Personnel, System Safety, Health Hazard Assessment) have a series of analyses that they conduct at various stages during the conceptualization, definition, development, and evaluation of a military system. These same techniques are used slightly different ways to determine requirements, develop performance measures, and conduct the selection of existing military systems (commercial off the shelf or COTS) products.

These analyses represented the processes used by each domain. Some processes are guided by military or commercial standards, while others are simply standard practice. In Canada few processes in HSI domains are formalized or mandated, however most are reflected as guidance in procurement process related documents.

All of these processes must in turn be executed within the Material Acquisition and Support (MA&S) process, which is in turn completed within the defence project life cycle as directed by the Defence Management System (DMS).

Currently many of these processes (eg: MA&S, Training) and under review with new versions being documented concurrent to the establishment of this HSI initiative.

In the end, an HSI Process must be established that effectively links the HSI domains, within the MA&S process and in accordance with the DMS. This process must clearly communicate the integration of the various HSI domains and provide direction on the potential use of HSI related analysis tools, and potential re-use of the resulting HSI related analysis.

5.4.3 Tools

Several types of tools will be required to ensure that a mature HSI capability is established within DND, including:

- Communication Tools. The primary communication tool is expected to be the HSI Web Site. This site will be located on the Defence Information Network (DIN) which is the DND intranet, on Descartes which is the DRD Canada intranet, and on the World Wide Web (some material may not be placed here depending on security issues). This web site shall contain a description of HSI, the HSI Process, descriptions of HSI tools, access to any available on line HSI tools, and guidance on the various HSI POCs in DND. It is also anticipated that HSI capability in industry will be registered on the site so that all interested parties within DND and industry can effectively locate each other. The secondary communication tools is expected to be a regular (eg: monthly or quarter), simple, e-mail newsletter that is distributed to interested parties. This newsletter will provide very brief news items provided by the HSI community, and will provide links to any updated material on the HSI Web Site so that interested parties can stay current.

- Analysis Tools. The "Way Ahead for HFE Tools" project identified a series of HSI related tools currently available for use in DND. These tools will be further integrated through the R&D process based on DND project demands, with "integration" of these tools being a core focus within the spirit of HSI. Additional tools are likely to be identified as the community grows and experiences are shared, and future tools are expected to be "invented" through shared requirements and support from the DRD Canada community. In some cases tools will consists of computer based tools that can be purchased commercially or obtained through DND, while others might be web based software tools access through the HSI Web Site. Further tools may consist of simple document templates for items such as HSI Plans, or various forms of analyses.

- Demonstrations. Demonstrations are a tool in themselves, and provide a necessary source of guidance and information to allow DND project teams to understand the application of HSI, and to demonstrate the impact of HSI on the MA&S process. HSI related demonstrations are expected to include case studies provided by members of the HSI community, and may also include particular projects established to demonstrate the application of the HSI process or HSI analysis tools and techniques. There may also be the opportunity to establish DRD Canada technology demonstration projects centred on potential future HSI capabilities.

- Libraries. It will be important for libraries of HSI references to be maintained, but more important for libraries of HSI analysis tools, analysis results, databases, models, and simulations to be maintained. These libraries will be the key to consistent and persistent application of HSI principles and are essential to realize the cost savings and technical efficiencies that will come through analysis re-use.

5.5 HSI Project Output

As a result of the HSI Project to develop this HSI capability the following minimum outputs are expected by 2004:

- An Virtual HSI Support Team, with:
  - Coordinators.
  - POCs within each Domain and through all Environments.
  - A defined industry capability base.
- A directory of HSI contacts in DND and industry
- An HSI policy in the MA&S community, with associated direction in the Defence Management System Manual
- An HSI Process, integrated with the MA&S process
- A description of available HSI Tools mapped against the HSI process
- HSI document templates to be used in the process
- HSI case studies, demonstrating the process
- An HSI Web Site that integrates all the above
- A regular, e-mail based HSI newsletter that links and informs the community.

An important issue that must be determined throughout this project will be the selection of a "home" for the HSI Coordinators. This in turn will be dependent on the need for HSI capability co-ordination. Several options may be relevant for further analysis:

1. Maintain co-ordination through a minimal funding stream in DRD Canada to ensure a department neutral co-ordination approach and links to the joint R&D community.
2. Establish co-ordination inside ADM(Mat), such as in DBCM, in conjunction with other functional authorities. This could be accomplished by assigning co-ordination responsibility to the functional authority for Systems Engineering or ILS, or by establishing a new functional authority for HSI.
3. Establish co-ordination inside VCDS somewhere, such as in DFPPC. As HSI involvement is required at the immediate initiation of a project many of the analyses

must be co-ordinate by Project Directors and therefore it would be appropriate to co-ordination from the operation side of the project leadership team.

4. Eliminate the co-ordination requirement, and have DBCM staff take over maintenance of the HSI process in conjunction with the other MA&S processes, transferring the Web Site content to their Acquisition Desktop for on-going maintenance.

All of these options are feasible, alone or in combination, and any would result in the successful continuation of the HSI Project into regular MA&S operations.

Annex A:

Feedback on the 1998 Document

“Way Ahead and Investment Strategy for Human Factors (HF) and Modeling & Simulation (M&S) R&D in DND"

The document "Way Ahead and Investment Strategy for Human Factors (HF) and Modeling and Simulation (M&S) R&D in DND (29 October 1998)" contained the original concept for an HSI/M&S Support Team. This document was sent to 95 individuals for distribution and review with approximately 20 written responses. Key feedback from this review is contained in Table A1. A wide and impressive range of personnel responded, with encouraging support for an enhanced HSI capability throughout.

Table A1: Summary of Written Feedback to October 1998 HF/M&S Way Ahead

Source of Feedback (Directorate or Project)	Feedback on the Concept of a Modeling and Simulation Based HSI Support Team
A/DQA	The vision presented should cover the immediate needs to DND with respect to the fields of HF/M&S. …as a weapon systems speed, capability, and lethality continue to increase, for safety and operational effectiveness, a detailed understanding of HSI factors is required, well before the system is in fact produced. HSI plays a major role in determining support and sustainment of a proposed system and establishing personnel requirements to maintain and field the capability. HSI development will cost resources, but it is an investment that can feed and spill into the commercial world….far more resources should be shifted to HSI development… … a fundamental change in thinking, with respect to Material Acquisition and Support (MA&S) process must be promoted and achieved…the change is the acceptance that in many cases a virtual product must be procured before the final physical product is procured…
ACOS Ops	The CFMG sincerely supports the concept of applying HF/M&S principles to acquisition projects…ensuring the interface between man and machine should improve the human condition in the workplace and benefit the health of the soldier. Support should be provided to "purple" or joint projects, and not just support to "all three environments".
DASOR	…enthusiastic at the idea of creating an HSI/M&S Support Team…
DAVPM	..proposal to create an HSI/M&S Support Team is very interesting, and likely will be an important step in efficient planning for these activities…currently a lack of sharing between projects…in many cases HSI is not adequately addressed due to a lack of awareness and knowledge…
DGIIP	DGIIP supports the proposal to examine HSI in order to ensure that Human Systems Integration is taken into account during the acquisition process. An objective of the scoping study and mandate should be to look at HSI responsibilities and resources currently divided between ADM(HR-Mil), ADM(Mat) and the ECS to determine if they might be more efficiently and effectively applied, or perhaps brought together into one focal point.
DGOR	Setting up a HSI support team is an effective way to ensure "reusability" of M&S tools through the whole equipment life cycle. …the idea of a part-time function of such a team is in line with the prevailing concept of exploitation of M&S, the trend to "virtualize" M&S in infrastructures as much as possible…
DGSP	In sum, from a DGSP perspective the proposal in the paper is sound and should be pursued. …any departmental direction concerning HSI and the use of M&D in DND acquisition process should be promulgated through ADM(Mat) documentation…however, given the high level guidance contained in the DMS Manual, it would be appropriate to include direction concerning HSI related M&S tools in the next version of the document.

Source of Feedback (Directorate or Project)	**Feedback on the Concept of a Modeling and Simulation Based HSI Support Team**
DHRRE	…the psychological aspect should not be ignored…as our systems become more sophisticated it is imperative that the personnel recruited are capable of learning how to operate the equipment…selection criteria should be established before the equipment comes on line Determine what training is required is a function of job analysis…job analysis should also drive selection criteria and performance/training appraisal.
DLR	..the thrust of the paper, that greater use must be made of human systems integration (HSI) and M&S within the CF and DND, is logical and correct… …the fact that the majority of CF and DND procurement is modified commercial off the shelf rather than development…*must be considered*
DMPPD DGMDO	Clearly, more effective use of modeling and simulation and a better appreciation of the Human Factors issues in project development is essential to making our capability acquisition process more efficient, accountable, and cost effective. … cost effective project and life cycle management of any capability demands a full accounting of all of the human factors issues involved in meeting the requirement…including safety, training, performance, and recruiting issues… …the establish of an HSI/M&S cell…does promise clear benefits…validation of requirements, validation of chosen solution, better forecast problems and issues… …need to screen which projects would benefit from HSI/M&S *as opposed to blanket application across all projects*
DNSSA	The Directorate of General Safety (DGS) safety plan is not broad enough to cover all elements of safety - a broader safety statement is required. The nuclear safety program is the responsibility of the Director General Nuclear Safety (DGNS).
DRET	…reviewed with a great deal of interest… …DRET 3…has the potential of forming an integral part of the proposed team concept…
DSSPM	…no doubt in my mind that the practical help and the synergistic effects derived through a Human Systems Integration (HSI) infrastructure within DND (and possible Government wide) will lead to a positive benefit/cost ratio. We believe that the earlier this project can be set up the better. …this project will have to be handed over with funding to an agency that will implement the tools and maintain them on a continuing basis…
DSTM	…recognize the important role that human modeling must play in any model of complete system performance…
DTA	…effort to quantify the life cycle value of HFE and M&S is essential… …subsequent to demonstrating the financial and operational benefits of an integrated HSI solution, I believe it is essential to incorporate the requirement to utilize HSI processes …as mandatory in the Defence Management System or the Project Management Process…failing that making mandatory the action of employing the HSI processes… …the requirement of a central office to operate and maintain HSI/HFE/M&S tools is essential…
PM AAP	…we could have used this type of support to improve, correct or redefine a number of elements… It is important that we (ARMY) support the activity with a constant and firm money base

Source of Feedback (Directorate or Project)	Feedback on the Concept of a Modeling and Simulation Based HSI Support Team
	to see an eventual result.
PM CSH	PMO CSH is in overall agreement with continued emphasis of Human Factors modeling in Major Crown Project procurements…a significant elements of CSH SOR and Performance Specification was developed through cabin performance modeling
PMO MHP	…document accurately outlines the many advantages of effectively applying HF/M&S to the procurement and life cycle management of a new weapon system … the best place to begin addressing these issues is in the initial procurement… …can HF/M&S assist in the procurement where the only options are OFF-THE-SHELF products…?

Annex B: HSI Virtual Support Team Development Plan

This document outlines the rationale and proposed method to establish a Virtual Human Systems Integration (HSI) Support Team within the Department of National Defence. This is one of a series of analysis and planning documents developed to guide the development of an enhanced HSI Capability in DND.

HUMAN SYSTEMS INTEGRATION (HSI) PROJECT: VIRTUAL SUPPORT TEAM DEVELOPMENT PLAN

by

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On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by

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DRD Canada Scientific Authority
Dr. André Vallerand

March 2000

Executive Summary

This document outlines the rationale and proposed method to establish a Virtual Human Systems Integration (HSI) Support Team within the Department of National Defence (DND). This is one of a series of analysis and planning documents developed to guide the development of an enhanced HSI Capability in DND.

In 1998 an original process for an HSI support team was proposed and distributed throughout DND. Feedback on this document came from a wide and impressive cross section of the DND community, and included representatives from research, operations, operational research, project management, engineering, strategic planning, medicine, safety, and human resources, among others. All of the feedback was supportive of the HSI Project, and the concept of establishing a Virtual HSI Support Team. Some individuals volunteered their participation in such an initiative if the proposal was ever executed as a project.

In November 1999 a Letter of Invitation was sent to approximately 25 different groups within DND, inviting further discussion about the establishment of an HSI Support Team, which was followed up by interviews with the addressees. The results of the interviews concluded with re-enforced support to the concept of an HSI Support Team, especially the establishment of a Virtual HSI Support team. It is clear that while the Canadian HSI community is small compared to other nations, that there is still a solid cross section of individuals who are candidates to participate in regular HSI activities.

This document proposes that the HSI Support Team be established with HSI co-ordinators, an HSI Steering Board, and participation in the HSI community by other interested parties in DND and Canadian industry.

The HSI Co-ordinators will be responsible for calling annual or bi-annual meetings, developing minutes for those meetings, developing the HSI e-mail based newsletter, and acting as a general point of contact for HSI related inquiries. The co-ordination role is primarily one of facilitation.

The HSI Steering Board will meet on an annual or bi-annual basis for one or two days to review the need for HSI policy (if any), amendments to the HSI Process, the requirements for future HSI Tools, opportunities to collaborate on HSI related initiatives, and to present HSI related case studies.

The HSI Steering Board will not have any ability to establish policy or approve processes. In ADM(Mat) the DBCM staff are responsible for the establishment of material acquisition and support policy, and responsible for HSI related processes (DBCM 2-8 for human factors engineering, system safety, and health hazards; and DBCM 2-4 for manpower, personnel, and training) and it is recommended that DBCM 2-8 eventually inherit responsibility for the overall HSI process as well. In VCDS the DFPPC organization is responsible for the development and management of the Defence Management System Manual which is the other document that influences the policies and processes related to HSI. It is assumed that these DBCM and DFPPC personnel will participate in the HSI Steering Board, however, any policy or process change requests will be made through these personnel back to their host organizations for staffing and approval.

Interested DND Personnel and the HSI Industrial Base will receive regular updates from the HSI Steering Board on changes to the HSI Web Site. Members of industry will also receive communications and the opportunity to influence through their CDIA representative.

The HSI Web Site will be the official repository of HSI related information on contact information, process, tools and techniques, and case studies. This Web site will be used to foster communication among the HSI community.

In addition, an e-mail based newsletter will be established and distributed to all registered HSI Contacts on a regular basis (monthly or quarterly depending on demand). A concept for this newsletter is attached in Annex B to this report. This newsletter will be designed to be able to be reviewed quickly, resulting in rapid assimilation and low maintenance.

An HSI Contact Database will be established to register all parties interested in HSI within DND and within Canadian industry. The database will be split into two repositories, one for DND personnel and one for industry personnel. Each repository will be provided on-line through the HSI web site. Users will be able to search the database, and will also be able to view or print the entire listing as a formatted PDF file.

This report contains the prototypes of the displays necessary to conduct the registration process and to operate the contact database. The software will be delivered under separate cover.

This analysis, planning, and development activity has concluded that the technical competence and interest exists to establish the HSI Virtual Support Team within DND. At the encouragement of potential team members electronic communications tools have been proposed and prototyped for use in establishing and maintaining the HSI Team.

It is recommended that the HSI Project proceed with registration of DND and Industry contacts, and start to use the electronic newsletter as soon as possible.

Table of Contents

Annexes

1 Introduction

This document outlines the rationale and proposed method to establish a Virtual Human Systems Integration (HSI) Support Team within the Department of National Defence (DND). This is one of a series of analysis and planning documents developed to guide the developed of an enhanced HSI Capability in DND.

1.1 Background

An initiative has recently been established to formalize an enhanced HSI capability within DND. A summary of this activity can be found in HSI Capability Concept Description document developed in March of 2000.

The HSI Project that is being conducted to establish this HSI capability requires the identification and integration of people, process, and tools that in combination will create enhanced HSI support to DND material acquisition and support projects. Most of this activity will involve the integration of existing resources in DND and in Canadian industry.

The "people" portion of this effort involves the establishment of a Virtual HSI Support Team. This document outlines the method and analysis tools to establish the team.

1.2 Objective

This document has been developed to guide the activities of the HSI Project in developing the Virtual HSI Support Team. The objective in creating this plan was to document a process that can be followed to successfully establish the team, and to provide the products necessary to enable the plan to be executed.

2 Method

This section outlines the activities conducted over the past several months to study the feasibility and potential composition of the Virtual HSI Support Team, and the activities conducted to develop the method to establish the team within DND.

2.1 Review Historical Feedback on HSI Support Team Concept

In 1998 a document was distributed throughout DND entitled "Way Ahead and Investment Strategy for Human Factors (HF) and Modeling and Simulation (M&S) R&D in DND". This proposal was the first to document a structured approach to the establishment of an HSI related support team using existing resources. There was considerable feedback on this document and the establishment of such a team, so this feedback was reviewed again as an input to this planning process.

2.2 Develop List of Potential Interested Groups

This effort began by developing a list of potential individuals or groups that would be interested in participating on an HSI Support Team. These individuals were identified as those who were already known to be responsible for HSI related domains, and/or those who had indicated an interest through their written response to the 1998 HF/MS&S Way Ahead document (see 2.1 above).

2.3 Develop Letter of Invitation

A letter of invitation was developed and distributed to these individuals, outlining the objectives of the HSI project and the concept of the HSI support team. In that letter it was indicated that a member of the HSI Project team would contact the invitee for further discussion of the concept.

2.4 Conduct Interviews and Review Written Responses

Interviews were held as they could be arranged with the invited personnel. In addition, some individuals and groups chose to provide their feedback in writing, and these were subsequently reviewed and integrated into the feedback repository.

2.5 Develop Virtual Team Concept

Using the inputs from the HSI Capability Concept Description document, and the results of the interviews a concept for the establishment and maintenance of a Virtual HSI Support Team was documented.

2.6 Review Industry Contact Options

The HSI Team concept included participation by members of Canadian industry. Therefore, an assessment was conducted of the different ways that the HSI Project could make contact with Canadian industry and have them register their HSI related capability in some way. This investigation included discussions with business development officers in DRD Canada, Public Works and Government Services Canada staff, and administrators of the Canadian Defence Industrial Association.

2.7 Develop HSI Team Contact Database Concept

A concept was developed for a database to house the contact information for DND and industry personnel interested and capable in the various HSI domains. This concept was then prototyped and developed as an operational prototype with a web browser based search and review capability.

2.8 Develop HSI Team Registration Tools

Forms and registration instructions were then developed to permit both DND and industry personnel to register their HSI related interests and capabilities into the database. These forms were then integrated into a prototype version of the HSI web site, to allow DND and industry to register their capability electronically.

2.9 Develop Plan for HSI Team Registration

A plan was then developed to guide the final implementation of the HSI Contact Database registration process and the installation of the contact database on the HSI Web Site.

2.10 Develop Plan for Formalization of Virtual HSI Support Team

Finally, a brief sequence of activities was developed to guide the use of the contact database in the establishment of the final Virtual HSI Support Team.

3 Results

This section outlines the results of the team development planning process.

3.1 Historical Feedback on HSI Support Concept

From original document "Way Ahead and Investment Strategy for Human Factors (HF) and Modeling and Simulation (M&S) R&D in DND (29 October 1998)" which contained the original concept for an HSI/M&S Support Team. This document was distributed to 95 addressees, from which approximately 20 written responses were received by the working group that authored the proposal.

Table A1 in Appendix A summarizes key points from this written feedback, which was used as background rationale and design direction for the establishment of the HF Virtual Support Team concept.

This feedback came from a wide and impressive cross section of the DND community, and included representatives from research, operations, operational research, project management, engineering, strategic planning, medicine, safety, and human resources, among others.

All of the feedback was support of the HSI Project, and the concept of establishing a Virtual HSI Support Team. Some individuals volunteered their participation in such an initiative if the proposal was ever executed as a project.

3.2 Results of Letter of Invitation to DND Groups

The late November 1999 Letter of Invitation was sent to approximately 25 different groups within DND, as summarized in the far left column of Table 1. This same table indicates that some form of contact and discussion was held with 15/25 or 60% of this list, which while better than the 20% response rate on the 1998 proposal should have been much higher as this group was targeted as being more likely candidates for participation on the HSI team.

The primary reason for the lack of a 100% response was peoples schedules throughout the winter of 2000, as many personnel were quite busy combined with leave requirements prior to March 31 end of year. This pace of work, combined with the limited dates each week for the Waterloo based interviewer to conduct interviews made scheduling quite a challenge. Regardless, a solid volume of feedback was received and the encouragement to continue with the HSI project remains.

Table 1: Summary of Response to Letter of Invitation Fall 1999/Winter 2000

Individual or Group	Contact Made?		Current Status or Further Action
	Y	N	
DMSS 2-6	✓		
DLR DLR Prog	✓	✗	Spoke with DLR 3 personnel who responded on behalf of DLR Prog. DLR will have a new M.Sc. trained Human Factors resource in September 2000 who will the DLR point of contact for HSI.
DAR DAR Prog 3		✗	Air staff would like a written meeting request with summary of aim sent to DAR, DAR Prog, DSAA, SGAFD, MPD, DAR Prog 3 and DAR Prog 2 so that they can respond as a group.
DTA 3-6	✓		DTA may require letter asking permission for DTA 3-6 to participate in any formal meetings.
DSSPM DSSPM 2	✓		

Individual or Group	Contact Made? Y	N	Current Status or Further Action
DSTHP DSTHP 2	✓		
DNPR		✗	
DLP	✓		
D Air PG&T		✗	
DRET	✓		Spoke with DRET staff on the phone, reviewed capability descriptions and mandate of DRET 3.
DHRRE	✓		
DMHRRE	✓	✗	Some phone discussions, but must still meet with human resource modeling analysts to discuss their techniques. Clearly DMHRRE asked by DRET community to perform manpower and personnel assessments as required.
DMPPD DMPPD 2-3		✗	
DGNS		✗	
DMH Svcs	✓		Suggests that HSI project also talk with DMED Pol (Occupational Medicine and Preventative Medicine)
CLS Med Adv.		✗	
D Air PM&S 4		✗	
COS J3/Doc & Trg	✓		
CFMGHQ/ACOS Ops CFMGHQ/ACOS Hlth Services		✗	Major D. Van Loon appointed as contact. Some phone discussion, still must meet.
D Safe G		✗	
DFS		✗	
DFPPC 2 DFPPC 7-2	✓	✗	Spoke with DFPPC 2, still must get a meeting with DFPPC 7-2.
DBCM 2-8	✓		Systems Engineering - must have continual meetings.
DBCM 2-4	✓		ILS and LCC - must have continual meetings.
DCIEM OHE	✓		

Key challenges in conducting these interviews included:

- Availability, as indicated above.
- Lack of concrete materials to comment on. Clearly, while personnel are interested in the concept of an HSI team and project, solid products such as proposed document templates, or HSI processes, were required to fully engage their participation. These products should be made available prior to any further face to face discussions with potential HSI team members to secure their attention and focus their participation.

These meetings raised a number of points about the HSI Project, the process that should be developed, policy that should be developed, and HSI related guidance that project teams required. Some time was spent in each meeting discussing the concept of the HSI Team. The main points raised during these interactions, regarding the actual team component included:

- A multi-disciplinary Steering Board concept is a good idea to assist with HSI domain integration.
- With industrial involvement from the start by HSI support contractors, a Virtual Team (i.e. like a project management team) is the preferred approach to take into account the personnel number restrictions and the inability for NDHQ personnel to spend money on travel.

- Communication amongst interested parties must be relatively frequent and consistent (this was emphasized several times) and cannot rely on interested individuals remembering to find the time to check a web site for the latest information.
- A documented process is key to linking and integrating the work of different personnel, as their ability to compare processes helps structure the team's interactions.
- There is a general increase in awareness of HSI among project management and engineering staff. Project direction staff require further education which is occurring as a result of the new Statement of Operational Requirements (SOR) template and guidance.
- Key areas of HSI expertise should be clearly identified and promoted to all personnel in DND. Project staff should have available support to prevent technical variability as project management or direction staff become loosely familiar with concepts and methods d decide to "try it themselves".
- A Capability Maturity Model or similar tool is required to help judge the relative capability of different HSI resources in industry, and also within DND to help chart the development of internal technical and management staff.
- It would be nice to see full time co-ordination resources assigned to this effort at some point.
- Training staff can be assigned through the DRET development office to a major acquisition project on a full time basis.
- DRET 3, through DRET 3-3 provides Training support to minor (<$100 million) acquisition and development teams and would be the "purple" training resource for the HSI team.
- The safety and health hazard community is evolving new groups, boundaries, and processes at the moment but it appears that there are at least 2 or 3 organizations that should result as candidates for HSI team participation, which may include a health hazard assessment team through DRD Canada.
- There are now Surgeon General staff within the naval fleet who submit report copies into the DMSS community regarding safety and hazards.
- There are a number of "purple" and environment specific personnel analysis resources (eg: DMHRR as a purple capability) however, they are not frequently asked to participate early in the acquisition process (as they should). Much of this effort is linked into the development of training requirements once a system is fully defined, as opposed to assisting with the analysis of the manning and personnel impacts of options for the project (which is done, but rarely).
- If research is required to determine future recruitment criteria for a job category it may be passed to DHRRE (but they mainly do empirical research).
- HSI is dealt with in the maritime engineering community by DMSS 2-6. There used to be a co-ordinator on the requirements side (DMPPD) but there is not longer.
- HSI was dealt with in the air engineering community by DTA but little is being done at the moment. Participation of DTA personnel may require asking special permission to DTA by the HSI coordination group.

- Modeling and simulation is growing in use in the air environment as an HSI related analysis aid.
- Modelling, Simulation, and Simulation Based Acquisition are growing in importance and visibility in all environments in DND as exemplified in the recent DND-wide Modelling and Simulation Symposium focusing on "M&S Integration and Concept Development and Experimentation for 2020" attended by the MND, CDS, VCDS, DCDS and organized/steered by DGSP and ADM(S&T).
- There is a Officer (Major) completing a M.Sc. in Human Factors at Loughborough University in the UK who will be the Land HSI POC after September 2000. This person will be posted into the DLR organization (requirements).
- The Operational Human Engineering (OHE) group at DCIEM conducts much of the human factors support to the land environment, especially in the area of requirements development and product evaluation for land requirements staff.
- HSI coordination should always remain a "purple" function, as should the entire program.

3.3 Virtual Team Concept

The results of the interviews concluded with re-enforced support to the concept of an HSI Support Team, especially the establishment of a Virtual HSI Support team. It is clear that while the Canadian HSI community is small compared to other nations, that there is still a solid cross section of individuals who are candidates to participate in regular HSI activities, particularly early industry participation or involvement.

A key result of the interview process was the lack of ability for personnel to provide structured input to the "concept" of an HSI team. Future interactions require a proposed team structure, and draft HSI process, and a proposed team communication process in order that team interactions have a solid framework to focus group participation.

Towards this end, a description of the Virtual HSI Support Team has been developed. This description uses future tense "…the team will..." and an affirmative tone. It is hoped that this does not suggest that the design and operation of this team is decided, and fixed. This is simply a proposal to be used in future team invitation and interactions so that there is a baseline from which to evolve.

3.3.1 Virtual Team Membership

The HSI Virtual Support Team requires the integration of four groups of personnel. The four groups of personnel will include:

1. HSI Coordinators. As HSI is an integration of a number of different organizations and groups, existing in multiple departments within DND, it will be important to have some form of team co-ordination. During the period of the initial HSI Project to develop the team (nominally from 2000 to 2003) this co-ordination will be provided by the DRDC leader of 16KE. Meetings of interested parties will be held over this three year period to determine how to best continue this co-ordination in 2004.
2. DND HSI Steering Board. In order to address the lack of human resources in DND and the inability to significantly hire additional resources, the HSI Support Team will established as a "virtual team". This virtual support team will integrate existing personnel that have interests or capabilities in the various HSI domains, and will identify these personnel as POCs accordingly. These active team members will be

awarded a seat on a DND HSI Steering Board that will meet one or two times a year. Based on interviews and feedback to date it is estimated that the regular distribution for HSI Steering Board communication will consist of approximately 18 personnel as follows:

- 2 DRD Canada Co-ordinators
- 2 DBCM representatives
- 1 DFPPC representative
- 1 Requirements rep from the Land environment (at least, but preferably reps from each environment and Joint)
- 3 Engineering or Management reps (one from each environment)
- 1 Training rep from DRET
- 1 Human Resources rep form DMHRR
- 2 or 3 different safety and/or hazard analysis reps
- 3 HSI related DRD Canada Thrust Co-ordinators or Defence Scientists
- 1 Industry representative invited through the Canadian Defence Industrial Association (CDIA).

3. Interested DND Personnel. Based on the interviews there will be a number of additional personnel who will be simply interested in staying current on HSI issues. These personnel will be registered in a HSI DND Contact Database and will be included on all public HSI related communications. The DND Steering Board will be established through invitations to registered HSI DND Contacts.

4. HSI Industrial Base. Much of the technical HSI work is currently, and will continue to be done by industry personnel. These personnel support defence projects as scientists, consultants, or staff inside the large defence system design and manufacturing firms. These personnel will be registered in a HSI Industry Contact database and will be included on all public HSI related communications. The invitation to act as the CDIA HSI rep on the HSI Steering Board will be distributed through registered HSI Industry Contacts.

3.3.2 Roles and Responsibilities

The HSI Co-ordinators will be responsible for calling annual or bi-annual meetings, developing minutes for those meetings, and acting as a general point of contact for HSI related inquiries. The co-ordination role is primarily one of facilitation.

The HSI Steering Board will meet on an annual or bi-annual basis for one or two days to review the need for HSI policy (if any), amendments to the HSI Process, the requirements for future HSI Tools, opportunities to collaborate on HSI related initiatives, and to present HSI related case studies.

The HSI Steering Board will not have any ability to establish policy or approve processes. In ADM(Mat) the DBCM staff are responsible for the establishment of material acquisition and support policy, and responsible for HSI related processes (DBCM 2-8 for human factors engineering, system safety, and health hazards; and DBCM 2-4 for manpower, personnel, and training) and it is recommended that DBCM 2-8 eventually inherit responsibility for the overall HSI process as well. In VCDS the DFPPC organization is responsible for the development and management of the Defence Management System Manual which is the other document that influences the policies and processes related to HSI. It is assumed that these DBCM and DFPPC personnel will participate in the HSI Steering Board, however, any policy or process change requests will be made through these personnel back to their host organizations for staffing and approval.

Interested DND Personnel and the HSI Industrial Base will receive regular updates from the HSI Steering Board on changes to the HSI Web Site. Members of industry will also receive communications and the opportunity to influence through their CDIA representative.

3.3.3 Operation

The HSI Support Team will generally operate as illustrated in Figure 1.

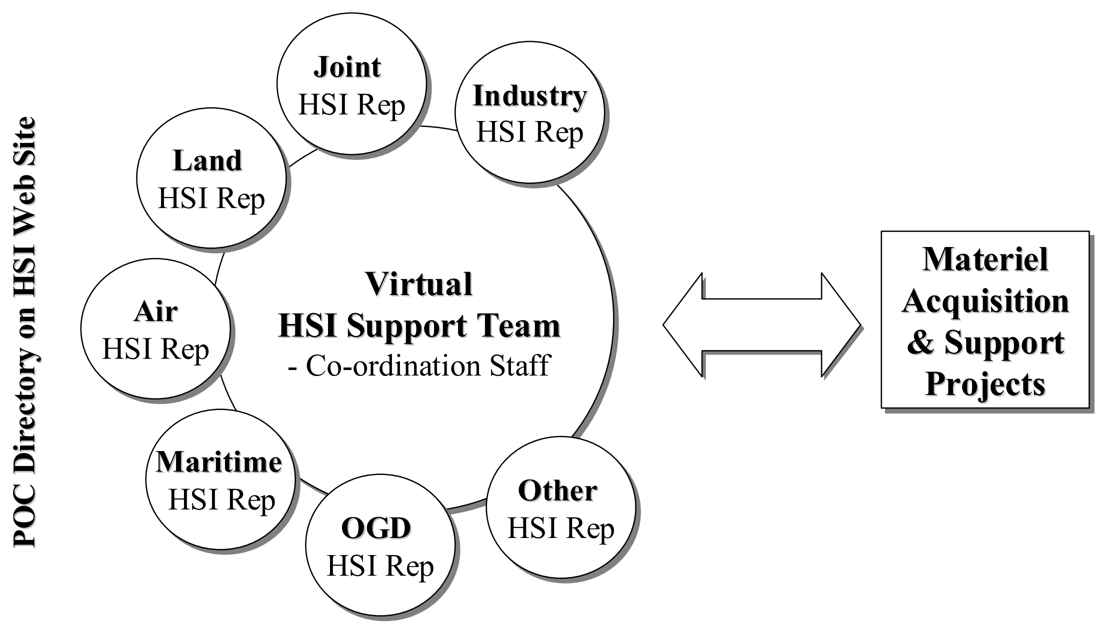


Figure 1: HSI Support Team Operation

It is expected that three types of DND project support scenarios will result:

1. Project Conducts Own HSI Analysis. In this scenario, the project directors or managers would access existing HSI capabilities available through the human resource matrix in DND who will then manage the HSI process and conduct the necessary analysis.
2. Project ID's and Obtains Own HSI Support from Industry. In this scenario the project is aware of the capabilities required, uses the HSI contact directory and government bidding process to contract HSI support. This may be conducted in combination with R&D support from DRD Canada depending on the nature of the project.

3. <u>Project Requests HSI Support Guidance</u>. In this scenario the HSI contact directory is used to identify a local HSI representative (eg: in own environment, such as Land) or the HSI co-ordinators who are then contacted for advice in determining the scope of HSI required on the project and guidance on how to obtain the required HSI support.

In reality, various combinations of these three scenarios are likely to be applied across the different HSI domains depending on the requirements, size, and duration of a given project.

3.3.4 Team Communication

The HSI Web Site will be the official repository of HSI related information on contact information, process, tools and techniques, and case studies.

In addition an e-mail based newsletter will be established and distributed to all registered HSI Contacts on a regular basis (monthly or quarterly depending on demand). A concept for this newsletter is attached in Annex B to this report. This newsletter will be designed to be able to be reviewed quickly, resulting in rapid assimilation and low maintenance.

Technical investigations have concluded that it would be possible to manage the HSI Electronic Newsletter automatically, with interested parties receiving an e-mail reminder for submissions, then clicking on a link to a web page where they would enter any news updates in a maximum three line article by filling in form fields and submitting it, all of which are consolidated in the order they are received and re-distributed as the newsletter after the "due date" for submissions has passed.

3.3.5 Team Development Process

At a high level the development of the Virtual HSI Support Team will be through the following steps:

1. Register HSI Contacts within DND, and register HSI Contacts in Industry.
2. Establish the electronic newsletter based on the result of the registration process, and continue on a regular basis.
3. Use the newsletter distribution to invite DND personnel to review and comment on the draft HSI process and prototype HSI web site. This invitation and the resulting feedback will be conducted electronically.
4. Invite DND personnel to attend 1st HSI Steering Board Meeting to discuss the reduction of feedback on the HSI Process and Web Site and to chart the "way ahead".
5. Edit the HSI Process and release it on the operational HSI Web site.
6. Use the electronic newsletter to notify all DND and industry personnel of the recently released HSI process and web site.
7. Continue to use the electronic newsletter to notify personnel of developments.
8. Invite the HSI Steering Board to attend a meeting at least once per year, with the minimum goal of exchanging recent work product examples.

The remainder of this document outlines the details associated with implementation of Step 1 above, register HSI Contacts.

3.4 HSI Contact Database

The HSI Contact Database will be established to register all parties interested in HSI within DND and within Canadian industry. The database will be split into two repositories, one for DND personnel and one for industry personnel.

Each repository will be provided on-line through the HSI web site. Users will be able to search the database, and will also be able to view or print the entire listing as a formatted PDF file.

3.4.1 HSI DND Contact Information

The database will contain the following information for each DND contact:

- Contact Information, including a contact name, work department and location, and contact phone number.
- The number of HSI related professionals at the work location, or within the group
- Level of Interest in HSI, by selecting one of; **(1) <u>Interested in HSI</u>** - the individual or group does not conduct HSI analysis, arrange for HSI analysis, or manage an HSI related function but is interested in the topic and would like to be kept informed of any initiatives in DND in this area; **(2) <u>Responsible for HSI Function</u>** - the individual or group is responsible for an HSI Function (eg: human factor engineering, training, manpower/personnel analysis, system safety, or health hazard assessment), and are therefore responsible for requirements definition and evaluation in the HSI area; **(3) <u>HSI Related R&D</u>** - the individual or group conducts R&D related to HSI; or **(4) <u>HSI Analysis Capability</u>** - the individual or group has a technical HSI analytical capability which is used to conduct analysis, develop or execute models, conduct audits, etc.. related to the development, verification, validation, and test and evaluation of HSI related requirements.
- A short description (50 words maximum) of the support available through this registered HSI capability (if relevant).
- An indication of which DND Environments the individual or group is are able to provide HSI related support, with a selection of "All" if it is a "purple" capability.

Example screens for the contact database search screens, search results, and contact registration information is provided in Annex C to this report.

3.4.2 HSI Industry Contact Information

The database will contain the following information for each industry contact:

- General company information including the name, address, phone number, web site, and number of HSI professionals at the location.
- HSI contacts including name, number, and e-mail for a primary and secondary contact.
- HSI services including an indication if the HSI capability supports internal development projects, or if they contract out HSI services.
- An indication of which Model, Simulation, database or other related new tool or technique they can bring to bear, that could be used, shared, or acquired to the benefit of the HSI community.

- HSI capability areas, including an indication of whether the capability is (1) an Integrated HSI Capability - HSI personnel who are experienced conducting or managing an integrated HSI analysis process on complex development or acquisition projects. Integration refers to a combined HFE, Training, Manpower/Personnel, System Safety, and Health Hazard analysis preferably in accordance with a recognized HSI analysis common process, and/or (2) Human Factors Engineering - HSI personnel who are experienced conducting or managing a Human Factors analysis, design and evaluation program on complex development or acquisition projects. This HFE experience should include regular application similar to Mil Hdbk 46855., or (3) Training - HSI Personnel who are experience conducting or managing training development or analysis on complex projects. This training experience should include that similar to the CFITS process in the Canadian DND, or (4) Manpower/Personnel - HSI personnel who are experienced determining the staffing requirements for military or similar complex systems. This experience should include systematic scenario based analysis of staffing requirements, similar to that outlined in the US Army Manpower, Personnel and Training guidance, or (5) System Safety - HSI personnel who are experienced conducting or managing safety system programs on complex acquisition or development project, including categorization, prioritization and assessment of hazards. This experience should be similar to that outlined in Mil Std 882, or (6) Health Hazard Assessment - HSI personnel who are experienced in conducting or managing health hazard assessment analyses in complex system acquisition or development projects, or in the operational environment for complex systems. This experience should be similar to the United States Army Health Hazard Assessment processes and include experience in assessment of acoustical energy, biological substances chemical substances, oxygen deficiency, radiation energy, shock, temperature extremes, trauma, and vibration.
- Capability description, including an up to 50 word description of the capability and any unique characteristics or facilities that exist.
- An indication of whether the firm has a standard (documented and trained) process for HSI that is followed on all projects.
- An indication of whether the firm has Defence project experience.
- An indication of whether the firm has related project experience. "Related" means complex acquisition or development projects with multidisciplinary engineering teams in mission critical applications. Examples of related areas might be nuclear power, air traffic control, civil aerospace or shipbuilding, telecommunications, etc..
- A listing of sample projects, with up to five projects (and the contracting agency) entered under each domain, or the same project listed many times if applied to multiple HSI domains.

Example screens for the contact database search screens, search results, and contact registration information is provided in Annex C to this report.

3.5 HSI DND Contacts Registration Tools

DND personnel will register into the HSI contact database on-line. They will receive a broadcast e-mail inviting them to register within one month using the forms proposed in Annex D.

3.6 HSI Industry Contacts Registration Tools

Industry personnel will register into the HSI contact database on-line. They will receive a notification through the MERX notification system, and will register through interaction with the internet version of the HSI Web Site, using the forms proposed in Annex D.

4 Conclusions and Recommendations

This analysis, planning, and development activity has concluded that the technical competence and interest exists to establish the HSI Virtual Support Team within DND. At the encouragement of potential team members electronic communications tools have been proposed and prototyped for use in establishing and maintaining this HSI Team.

It is recommended that the HSI Project proceed with registration of DND and Industry contacts, and start to use the electronic newsletter as soon as possible.

Annex A:

Feedback on the 1998 Document

"Way Ahead and Investment Strategy for Human Factors (HF) and Modeling & Simulation (M&S) R&D in DND"

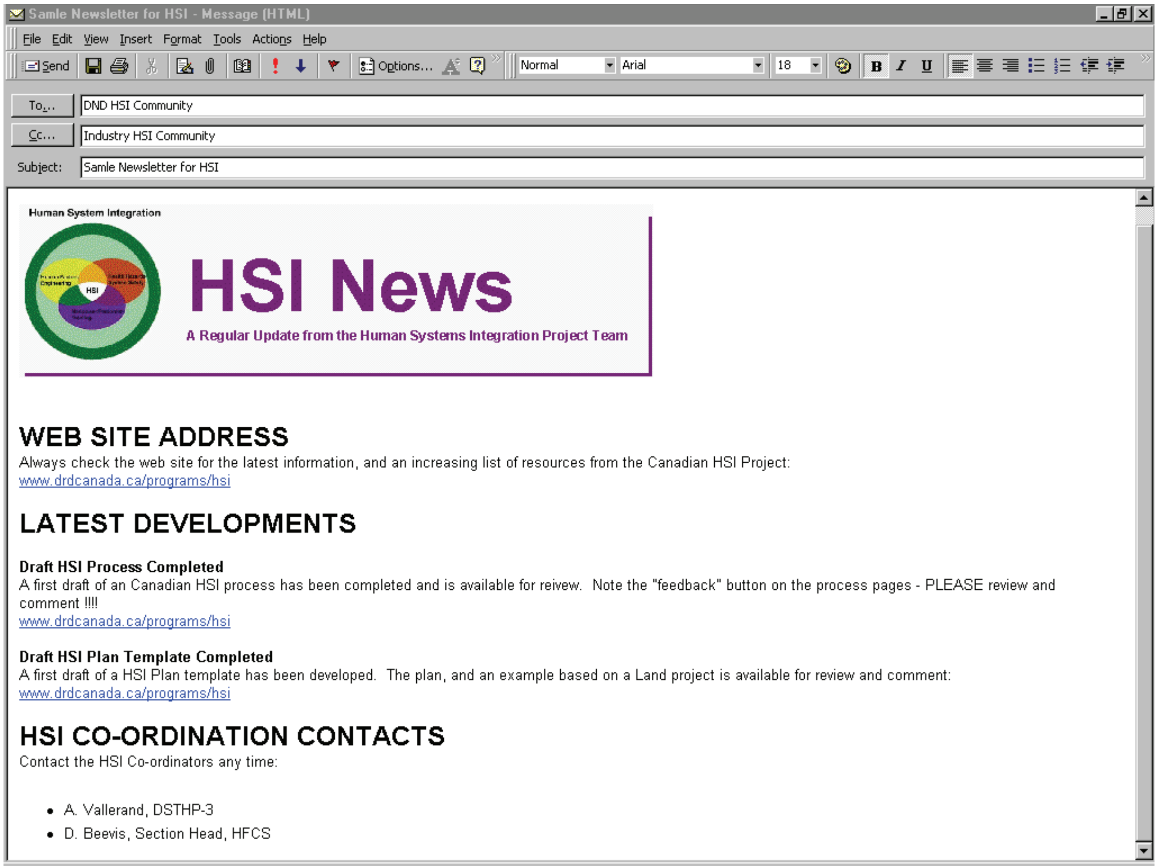
Table A1: Summary of Written Feedback to October 1998 HF/M&S Way Ahead

Source of Feedback (Directorate or Project)	Feedback on the Concept of a Modeling and Simulation Based HSI Support Team
A/DQA	The vision presented should cover the immediate needs to DND with respect to the fields of HF/M&S. …as a weapon systems speed, capability, and lethality continue to increase, for safety and operational effectiveness, a detailed understanding of HSI factors is required, well before the system is in fact produced. HSI plays a major role in determining support and sustainment of a proposed system and establishing personnel requirements to maintain and field the capability. HSI development will cost resources, but it is an investment that can feed and spill into the commercial world….far more resources should be shifted to HSI development… … a fundamental change in thinking, with respect to Material Acquisition and Support (MA&S) process must be promoted and achieved…the change is the acceptance that in many cases a virtual product must be procured before the final physical product is procured…
ACOS Ops	The CFMG sincerely supports the concept of applying HF/M&S principles to acquisition projects…ensuring the interface between man and machine should improve the human condition in the workplace and benefit the health of the soldier. Support should be provided to "purple" or joint projects, and not just support to "all three environments".
DASOR	…enthusiastic at the idea of creating an HSI/M&S Support Team…
DAVPM	..proposal to create an HSI/M&S Support Team is very interesting, and likely will be an important step in efficient planning for these activities…currently a lack of sharing between projects…in many cases HSI is not adequately addressed due to a lack of awareness and knowledge…
DGIIP	DGIIP supports the proposal to examine HSI in order to ensure that Human Systems Integration is taken into account during the acquisition process. An objective of the scoping study and mandate should be to look at HSI responsibilities and resources currently divided between ADM(HR-Mil), ADM(Mat) and the ECS to determine if they might be more efficiently and effectively applied, or perhaps brought together into one focal point.
DGOR	Setting up a HSI support team is an effective way to ensure "reusability" of M&S tools through the whole equipment life cycle. …the idea of a part-time function of such a team is in line with the prevailing concept of exploitation of M&S, the trend to "virtualize" M&S in infrastructures as much as possible…
DGSP	In sum, from a DGSP perspective the proposal in the paper is sound and should be pursued. …any departmental direction concerning HSI and the use of M&D in DND acquisition process should be promulgated through ADM(Mat) documentation…however, given the high level guidance contained in the DMS Manual, it would be appropriate to include direction concerning HSI related M&S tools in the next version of the document.
DHRRE	…the psychological aspect should not be ignored…as our systems become more sophisticated it is imperative that the personnel recruited are capable of learning how to operate the equipment…selection criteria should be established before the equipment comes on line Determine what training is required is a function of job analysis…job analysis should

Source of Feedback (Directorate or Project)	Feedback on the Concept of a Modeling and Simulation Based HSI Support Team
	also drive selection criteria and performance/training appraisal.
DLR	..the thrust of the paper, that greater use must be made of human systems integration (HSI) and M&S within the CF and DND, is logical and correct… …the fact that the majority of CF and DND procurement is modified commercial off the shelf rather than development…*must be considered*
DMPPD DGMDO	Clearly, more effective use of modeling and simulation and a better appreciation of the Human Factors issues in project development is essential to making our capability acquisition process more efficient, accountable, and cost effective. … cost effective project and life cycle management of any capability demands a full accounting of all of the human factors issues involved in meeting the requirement…including safety, training, performance, and recruiting issues… …the establish of an HSI/M&S cell…does promise clear benefits…validation of requirements, validation of chosen solution, better forecast problems and issues… …need to screen which projects would benefit from HSI/M&S *as opposed to blanket application across all projects*
DNSSA	The Directorate of General Safety (DGS) safety plan is not broad enough to cover all elements of safety - a broader safety statement is required. The nuclear safety program is the responsibility of the Director General Nuclear Safety (DGNS).
DRET	…reviewed with a great deal of interest… …DRET 3…has the potential of forming an integral part of the proposed team concept…
DSSPM	…no doubt in my mind that the practical help and the synergistic effects derived through a Human Systems Integration (HSI) infrastructure within DND (and possible Government wide) will lead to a positive benefit/cost ratio. We believe that the earlier this project can be set up the better. …this project will have to be handed over with funding to an agency that will implement the tools and maintain them on a continuing basis…
DSTM	…recognize the important role that human modeling must play in any model of complete system performance…
DTA	…effort to quantify the life cycle value of HFE and M&S is essential… …subsequent to demonstrating the financial and operational benefits of an integrated HSI solution, I believe it is essential to incorporate the requirement to utilize HSI processes …as mandatory in the Defence Management System or the Project Management Process…failing that making mandatory the action of employing the HSI processes… …the requirement of a central office to operate and maintain HSI/HFE/M&S tools is essential…
PM AAP	…we could have used this type of support to improve, correct or redefine a number of elements… It is important that we (ARMY) support the activity with a constant and firm money base to see an eventual result.
PM CSH	PMO CSH is in overall agreement with continued emphasis of Human Factors modeling in Major Crown Project procurements…a significant elements of CSH SOR and Performance Specification was developed through cabin performance modeling

Source of Feedback (Directorate or Project)	Feedback on the Concept of a Modeling and Simulation Based HSI Support Team
PMO MHP	…document accurately outlines the many advantages of effectively applying HF/M&S to the procurement and life cycle management of a new weapon system … the best place to begin addressing these issues is in the initial procurement… …can HF/M&S assist in the procurement where the only options are OFF-THE-SHELF products…?

Annex B:
Concept for Electronic Newsletter



Samle Newsletter for HSI - Message (HTML)

File Edit View Insert Format Tools Actions Help

To... DND HSI Community

Cc... Industry HSI Community

Subject: Samle Newsletter for HSI

Human System Integration

HSI News

A Regular Update from the Human Systems Integration Project Team

WEB SITE ADDRESS

Always check the web site for the latest information, and an increasing list of resources from the Canadian HSI Project:
www.drdcanada.ca/programs/hsi

LATEST DEVELOPMENTS

Draft HSI Process Completed
A first draft of an Canadian HSI process has been completed and is available for reivew. Note the "feedback" button on the process pages - PLEASE review and comment !!!!
www.drdcanada.ca/programs/hsi

Draft HSI Plan Template Completed
A first draft of a HSI Plan template has been developed. The plan, and an example based on a Land project is available for review and comment:
www.drdcanada.ca/programs/hsi

HSI CO-ORDINATION CONTACTS

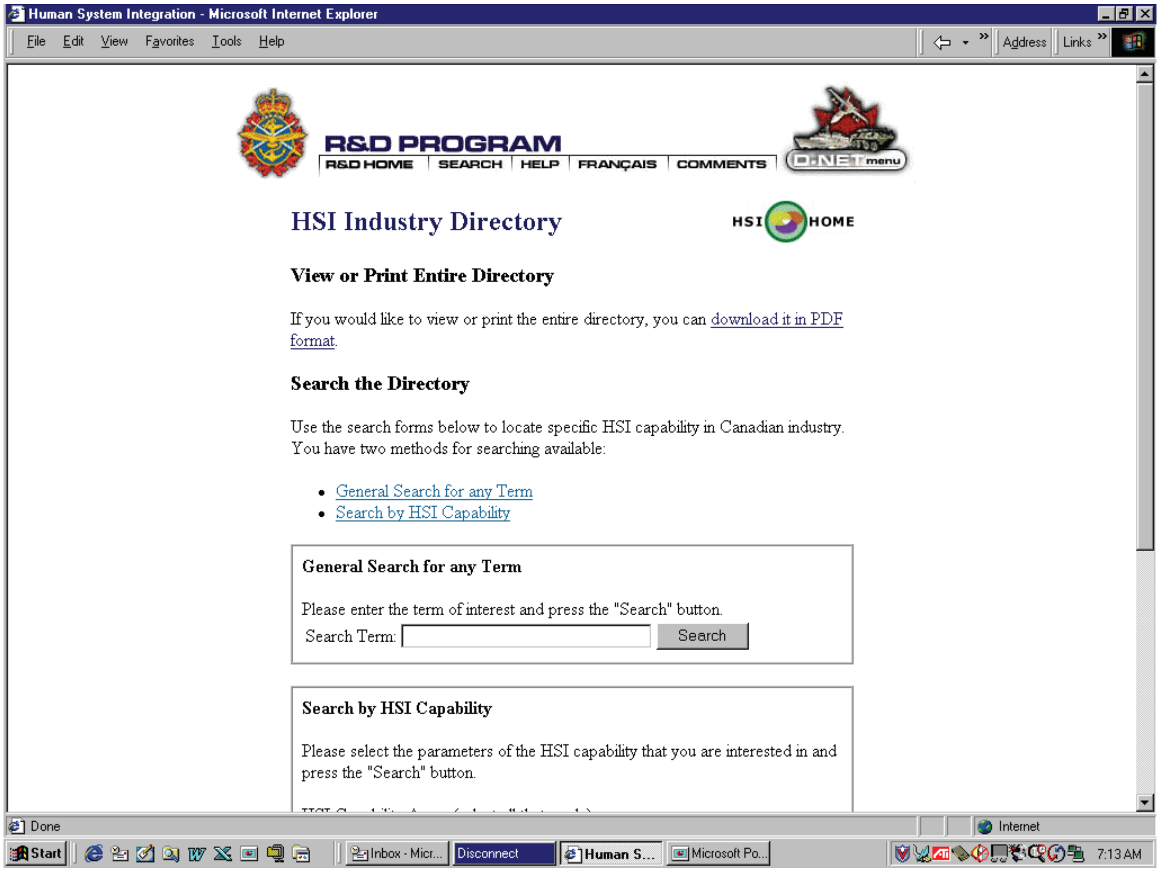
Contact the HSI Co-ordinators any time:

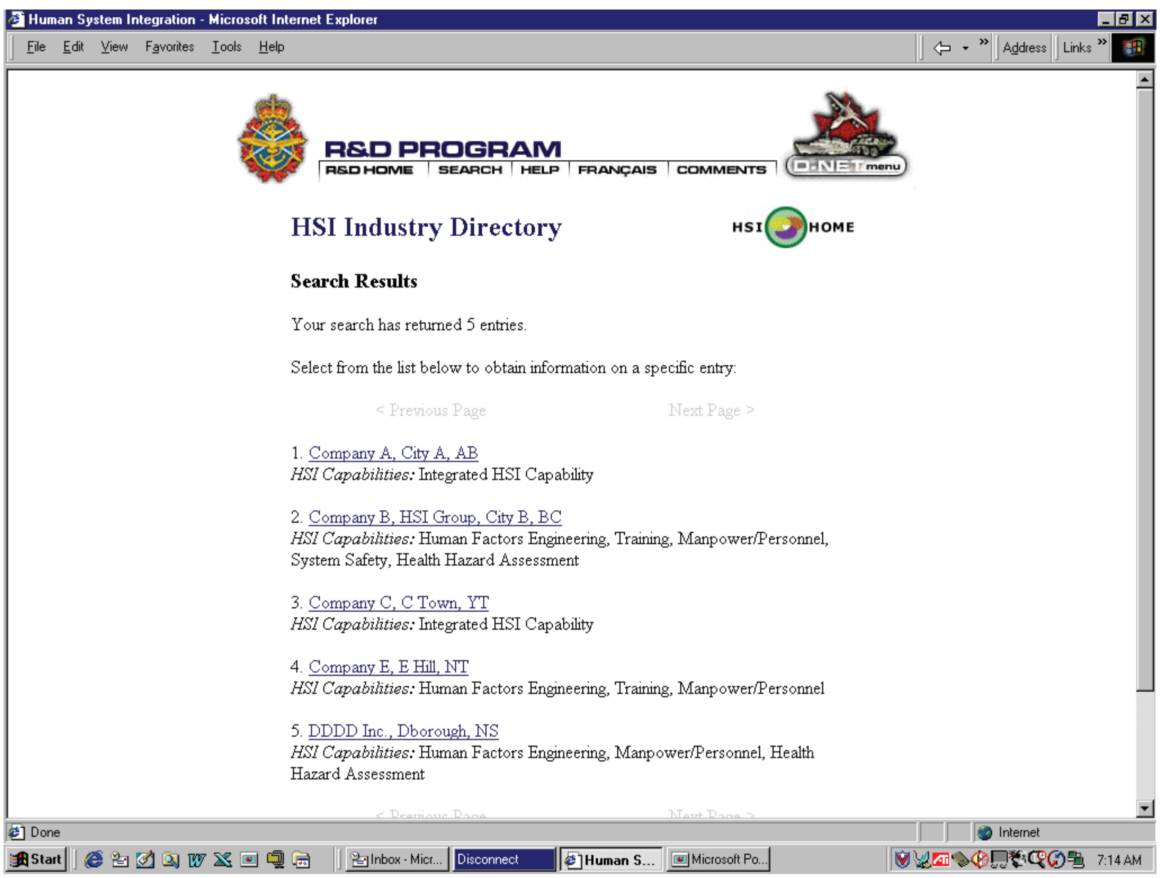
- A. Vallerand, DSTHP-3
- D. Beevis, Section Head, HFCS

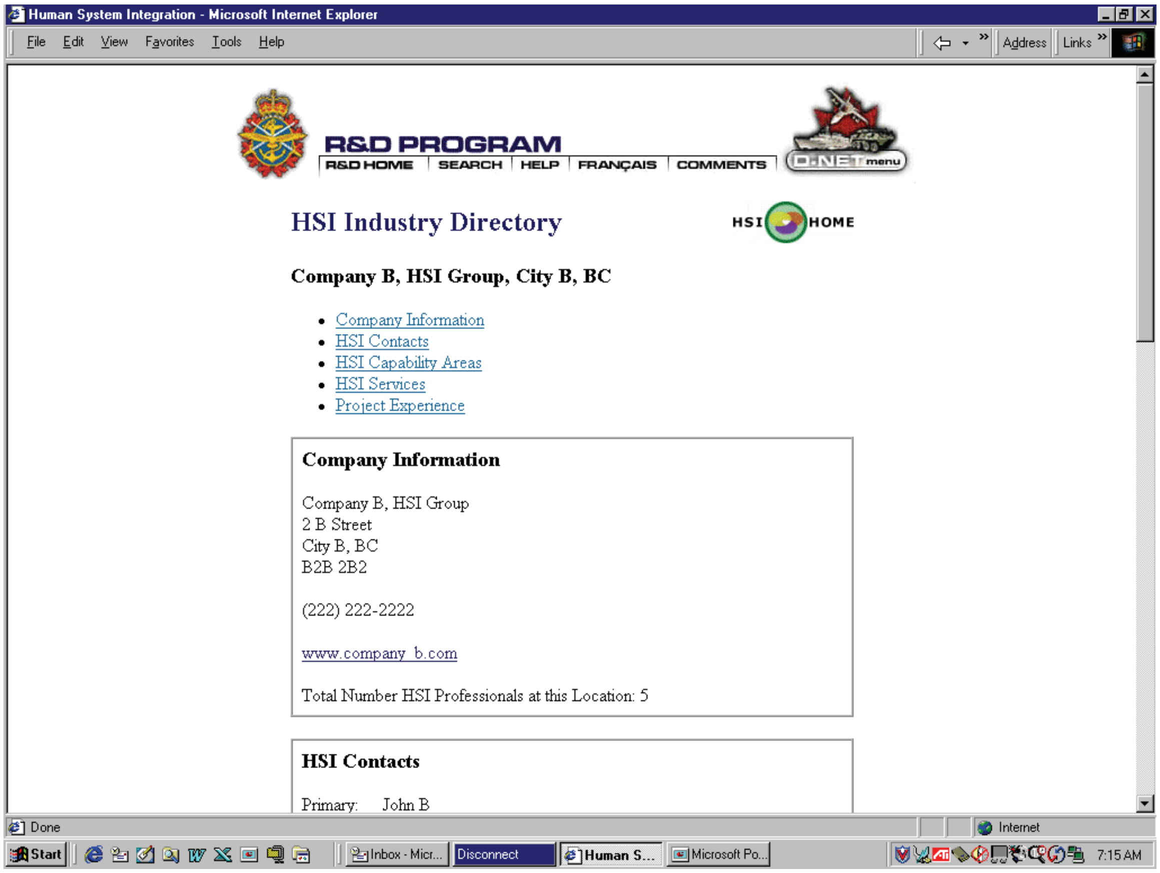
Annex C: HSI Contact Database Prototype

The following pages illustrate an example of a:

- Search Page
- Search Results
- Contact Information Page


Human System Integration - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address Links
R&D PROGRAM
R&D HOME SEARCH HELP FRANÇAIS COMMENTS
D-NET menu
HSI Industry Directory
HSI HOME
View or Print Entire Directory
If you would like to view or print the entire directory, you can download it in PDF format.
Search the Directory
Use the search forms below to locate specific HSI capability in Canadian industry. You have two methods for searching available:
General Search for any Term
Search by HSI Capability
General Search for any Term
Please enter the term of interest and press the "Search" button.
Search Term:
Search
Search by HSI Capability
Please select the parameters of the HSI capability that you are interested in and press the "Search" button.
Done
Internet
Start
Inbox - Micr...
Disconnect
Human S...
Microsoft Po...
7:13 AM

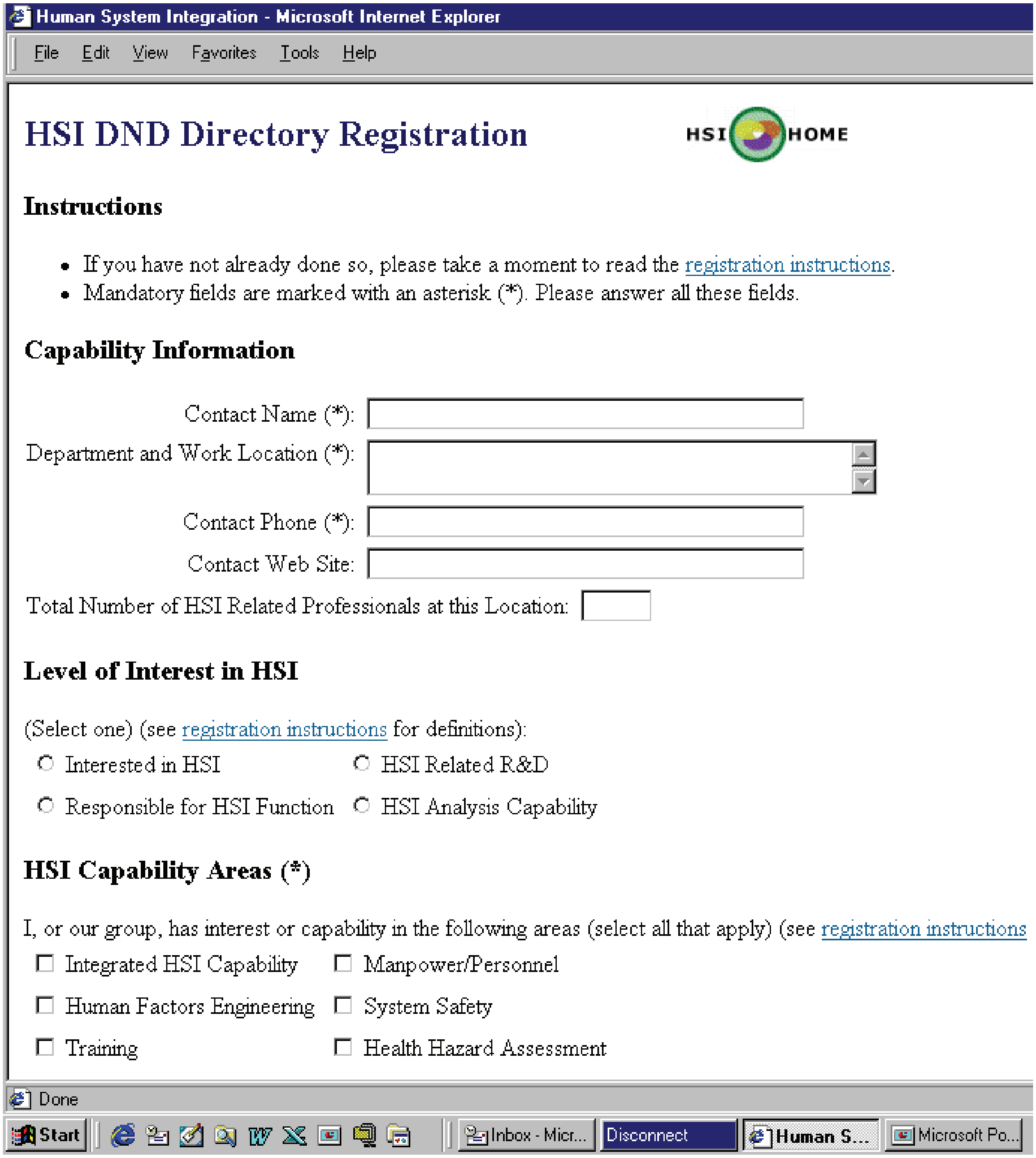

Human System Integration - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address Links
R&D PROGRAM
R&D HOME SEARCH HELP FRANÇAIS COMMENTS
D-NET menu
HSI Industry Directory
HSI HOME
Search Results
Your search has returned 5 entries.
Select from the list below to obtain information on a specific entry:
< Previous Page
Next Page >
1. Company A, City A, AB
HSI Capabilities: Integrated HSI Capability
2. Company B, HSI Group, City B, BC
HSI Capabilities: Human Factors Engineering, Training, Manpower/Personnel, System Safety, Health Hazard Assessment
3. Company C, C Town, YT
HSI Capabilities: Integrated HSI Capability
4. Company E, E Hill, NT
HSI Capabilities: Human Factors Engineering, Training, Manpower/Personnel
5. DDDD Inc., Dborough, NS
HSI Capabilities: Human Factors Engineering, Manpower/Personnel, Health Hazard Assessment
Done
Internet
Start
Inbox - Micr...
Disconnect
Human S...
Microsoft Po...
7:14 AM


Human System Integration - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Address Links
R&D PROGRAM
R&D HOME SEARCH HELP FRANÇAIS COMMENTS
D-NET menu
HSI Industry Directory
HSI HOME
Company B, HSI Group, City B, BC
Company Information
HSI Contacts
HSI Capability Areas
HSI Services
Project Experience
Company Information
Company B, HSI Group
2 B Street
City B, BC
B2B 2B2
(222) 222-2222
www.company_b.com
Total Number HSI Professionals at this Location: 5
HSI Contacts
Primary: John B
Done
Internet
Start
Inbox - Micr...
Disconnect
Human S...
Microsoft Po...
7:15 AM

Annex D: HSI Contact Database Registration Form Prototypes

The following pages illustrate an example of a:

- DND Registration Form
- Industry Registration Form



Human System Integration - Microsoft Internet Explorer

File Edit View Favorites Tools Help

HSI DND Directory Registration

HSI HOME

Instructions

- If you have not already done so, please take a moment to read the registration instructions.
- Mandatory fields are marked with an asterisk (*). Please answer all these fields.

Capability Information

Contact Name (*):

Department and Work Location (*):

Contact Phone (*):

Contact Web Site:

Total Number of HSI Related Professionals at this Location:

Level of Interest in HSI

(Select one) (see registration instructions for definitions):

- Interested in HSI
- HSI Related R&D
- Responsible for HSI Function
- HSI Analysis Capability

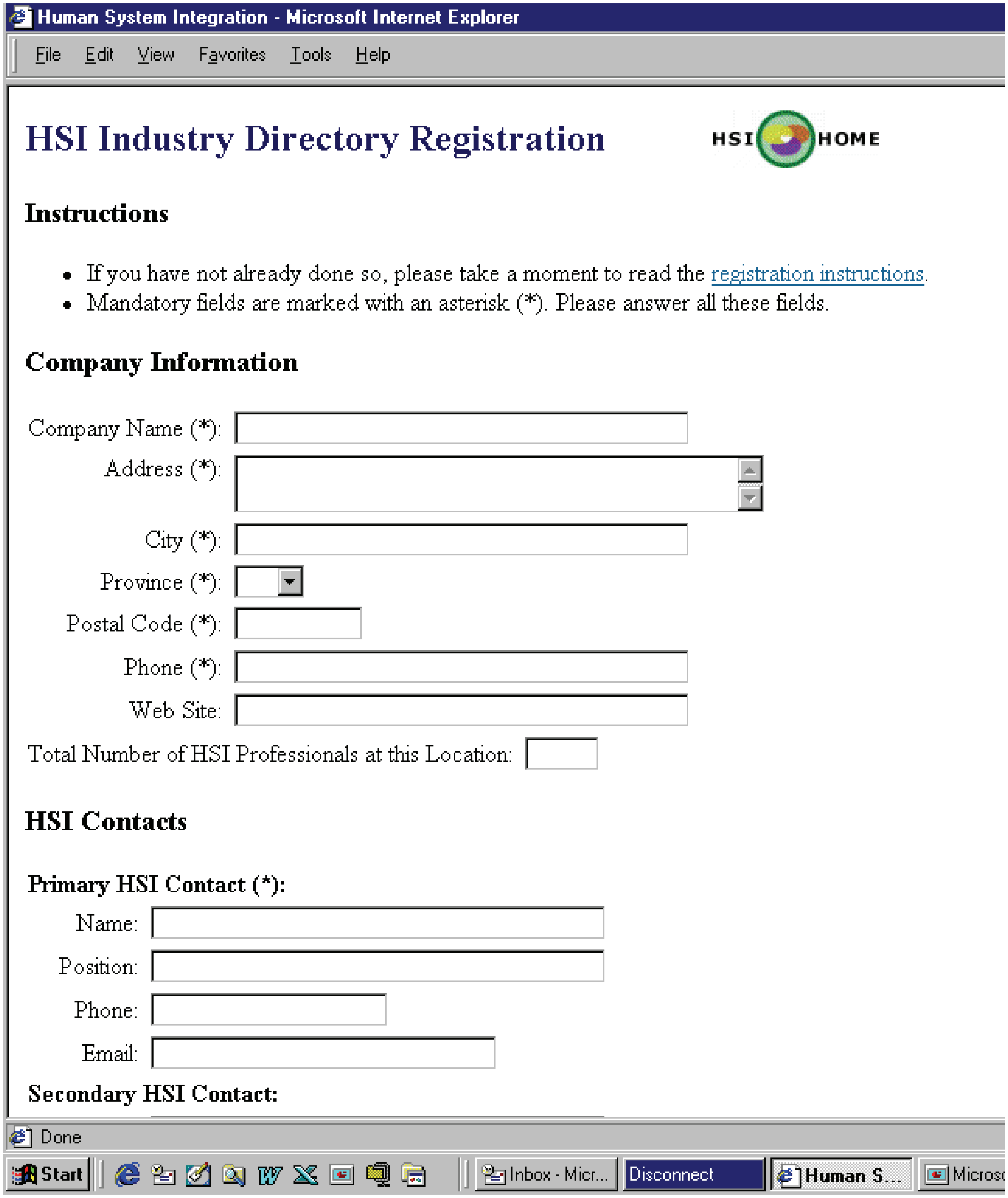
HSI Capability Areas (*)

I, or our group, has interest or capability in the following areas (select all that apply) (see registration instructions

- Integrated HSI Capability
- Manpower/Personnel
- Human Factors Engineering
- System Safety
- Training
- Health Hazard Assessment

Done

Start | Inbox - Micr... | Disconnect | Human S... | Microsoft Po...



Human System Integration - Microsoft Internet Explorer

File Edit View Favorites Tools Help

HSI Industry Directory Registration

HSI HOME

Instructions

- If you have not already done so, please take a moment to read the registration instructions.
- Mandatory fields are marked with an asterisk (*). Please answer all these fields.

Company Information

Company Name (*):

Address (*):

City (*):

Province (*):

Postal Code (*):

Phone (*):

Web Site:

Total Number of HSI Professionals at this Location:

HSI Contacts

Primary HSI Contact (*):

Name:

Position:

Phone:

Email:

Secondary HSI Contact:

Done

Start Inbox - Micr... Disconnect Human S... Microso

Annex C: HSI Process Development – Version 1

This document provides the original proposed Human Systems Integration (HSI) process, which was developed to provide guidance for the application of HSI within the Materiel Acquisition and Support process in DND.

HUMAN SYSTEMS INTEGRATION (HSI) PROJECT: HSI PROCESS DEVELOPMENT

by

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PWGSC Contract No. W7714-9-0260/001

On behalf of
DEPARTMENT OF NATIONAL DEFENCE

as represented by

Defence and Civil Institute of Environmental Medicine
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North York, Ontario, Canada
M3M 3B9

DCIEM Scientific Authority
David Beevis

March 2000

Executive Summary

This document is the final report of a project to develop a Human Systems Integration (HSI) Process for the Canadian Department of National Defence (DND) HSI Project. The process is to be used as guidance for the application of HSI within the material acquisition and support process in DND.

Early start up meetings indicated that the resulting HSI process should be simple, be sequenced, illustrate interrelations and interdependencies, map the HSI process to the process from each of the HSI domains, map the HSI process against the DMS process, and show variables based on development vs COTS buy projects.

The HSI process developed has been described at two levels of decomposition. The highest level process is composed of five processes each of which has a series of sub-processes. The high level processes include (1) Conduct HSI As-Is Analysis, (2) Conduct HSI Options Assessment, (3) Conduct HSI To-Be Analysis, (4) HSI Evaluation, Verification, Validation, and Assurance, and (5) Conduct HSI Monitoring.

These five high level processes suggest a sequential, step-by-step series of activities, however, the sub-process are actually a series of analysis that iterate and update a number of times throughout the life cycle of a materiel system.

It is the integrative nature of HSI, and the analysis re-use through iteration that provides the value of this analysis. The high level sequential process allows the HSI tasks in the defence acquisition and support process to be described in a fashion consisted with the acquisition project life cycle model described in the Canadian Defence Management System (DMS).

As a result of the focus on HSI domain integration during process development, a series of core or common data repositories are evident within this process. Examples of these include:

- Organization and Work Flow
- Target Audience Description
- Workspace & Interfaces
- HSI Risks, Requirements, Measures, and Criteria

These data repositories are developed gradually throughout the project, through iterative analysis that gradually focuses in on the detailed performance specifications for the primary option. They are shared data sets across all of the HSI domains are unique within the Systems Engineering and ILS community in terms of their development and use by the HSI community.

In summary, this project has developed an HSI process that has been integrated within the Canadian DMS process. The HSI process is consistent with international practice, but at the same time introduces a slightly more integrated approach than many have taken which is necessary to make use of limited resources within the DND community and to encourage analysis sharing and re-use.

It is recommended that this process be further reviewed with subject matter experts in each HSI domain and the functional authorities for systems engineering and ILS in DBCM. The next edited version should then be released on the HSI Web Site for wider circulation, review, and use.

Table of Contents

Annexes

1 Introduction

This document is the final report of a project to develop a Human Systems Integration (HSI) Process for the Canadian Department of National Defence (DND) HSI Project. The process is to be used as guidance for the application of HSI within the material acquisition and support process in DND.

1.1 Background

An initiative has recently been established to formalize an enhanced HSI capability within DND. A summary of this activity can be found in HSI Capability Concept Description document developed in March of 2000.

The HSI Project that is being conducted to establish this HSI capability requires the identification and integration of people, a process, and analysis tools that in combination will create enhanced HSI support to DND material acquisition and support projects. Most of this activity will involve the integration of existing resources in DND and in Canadian industry.

The "process" portion of this effort involves the documentation on an HSI Process that provides direction on the management and analysis required to effectively consider HSI issues during material acquisition and support. This document outlines the method and results of an initial effort at developing the required process.

1.2 Objective

The objectives of this project were to develop a base HSI process model, integrated into the Canadian material acquisition and support context, suitable for review through the HSI web site.

1.3 Deliverables

The deliverables from this project included:

- A base HSI Process model descriptions in MS Word. These process models were to include a process diagram, brief descriptions of each step in the process, and descriptions of process inputs and outputs.

2 Method

This section outlines the method followed in this project. The primary tasks completed by the project team are reviewed in the following sub-sections.

2.1 Project Leader Start Up Meetings

Start up meetings were held with David Beevis at DCIEM, into addition to start up discussions with Dave Madelely at the Directorate of Business Change Management (DBCM 2-8) who is the functional authority for Systems Engineering in the ADM(Mat) community. These meetings were used to review the scope of the process development effort and to obtain inputs which primarily consisted of other process and process examples.

2.2 Project Team Start Up Meetings

Project work began with a meeting to plan an information search and document review strategy. The internet was identified as the primary search tool within initial targets including US Defence Acquisition (US Acquisition Deskbook), MANPRINT, Manprint Domains, and any Human Systems Integration sites. Other search areas and techniques included: DND Intranet (Deskbook), Defence Management Information and Training Materials, and project contacts (DCIEM, DRDB, and DBCM).

2.3 Document Search

Searches for information to support the development of the Canadian HSI process were conducted throughout the project. Based on the initial targets and tools (above) a number of other information sources were identified. The most current version of documents were obtained when costs were nominal. Documents with significant costs were reviewed to the extent possible but were not obtained unless absolutely necessary.

2.4 Document Review

All obtained documents were briefly reviewed to determine their applicability to the project goals. More detailed reviews were conducted for the higher priority documents.

The search and review process was intensive in the initial phase of the project but continued at a lower level into the closing stage of the project.

The documents obtained and reviewed were grouped into the following categories:

1. Defence Acquisition
2. Health Hazard Assessment
3. Human Factors Engineering
4. Human Systems Integration
5. Manpower and Personnel
6. System Safety
7. Training

The obtained and reviewed documents are outlined in Table 1.

Table 1: Documents Obtained and Reviewed During Process Development

Category	Reference
Defence Acquisition	1. 5000.2- R Change Three 1999 Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs
	2. Defence Management System Course (1999)
	3. Defence Management System Manual (1999)
	4. web.deskbook.osd.mil/ - US Defence Acquisition Desktop. Extensive descriptions, links, documentation and search capability.
Health Hazard Assessment	5. Leibrecht, B. (1990) Health Hazard Assessment Primer, US Army Aeromedical Research Laboratory, Fort Rucker, Alabama 36362-5292.
	6. US Army Center for Health Promotion and Preventive Medicine (USACHPPM), Aberdeen Proving Ground
	7. Web site documents: The Army Health Hazard Assessment Program Story Materiel Developer's Guide to Systems Health Hazards
Human Factors Engineering	8. Army Regulation 602-1 Human Factors Engineering Program, Department of the Army, 8 February 1991.
	9. ASTM F 166-95a (1996) Standard Practice of Human Engineering Design for marine Systems, Equipment and Facilities.
	10. ASTM F 1337-91 (1996 - reproved) Standard Practice fo Human Program Requirements for Ships and marine Systems, Equipment and Facilitates.
	11. Critical Process Assessment Tool (CPAT) (1998) *Human Factors Engineering*, Military Specifications and Standards Reform Program (MSSRP)Air Force Space and Missile Centre, El Segundo, California.
	12. Greenley, M. (1999) The "Way Ahead" for Human Factors Engineering Tools, Report to Defence and Civil Institute of Environmental Medicine, Toronto, Canada.
	13. Human Engineering Process (1998) DD 21/ONR, SC-21 S&T Manning Affordability Initiative.
	14. IEEE Std 1023-200 (Rev .1 Draft) (1999) Recommended Practice for the Application of Human Factors Engineering to Systems and Equipment of Nuclear Power Generating Stations and Other Nuclear Facilities.
	15. McKay, D., Kobierski, R. (1996) Naval Human Factors Engineering Task Specification, Directorate of Ship Engineering Report, DMSS-2-6-4.
	16. MIL-HBDK-1908B Definitions Of Human Factors Terms, 16 August 1999□MIL-STD-1472F Department Of Defense Design Criteria Standard - Human Engineering, 23 August 1999
	17. MIL-HBDK-759C Handbook For Human Engineering Design Guidelines, 31 July 1995
	18. MIL-HDBK-46855A Human Engineering Program Process And Procedures, 17 May 1999

Category	Reference
	19. NUREG-0711 (1994) Human Factors Engineering Program Review Model, US Nuclear Regulatory Commission, Washington, DC 20555-0001.
	20. Webb, R., Matthews, M., Brooks, J., (1998) Tactical Battlefield Command System: Human Factors Tasks and Risks During the Procurement Cycle, Report to Defence and Civil Institute of Environmental Medicine, Toronto, Canada.
Human Systems Integration	21. 268 Human Systems integration (HSI) (1999) Wright-Patterson Air Force Base, Ohio, Air Force Materiel Command
	22. Critical Process Assessment Tool (CPAT), Integrated Logistics Support, 14 August, 1998, SMC/AXL
	23. Critical Process Assessment Tool (CPAT) (1998) *Overview*, Military Specifications and Standards Reform Program (MSSRP)Air Force Space and Missile Centre, El Segundo, California.
	24. HF R&D Planning Team, Human Factors R&D for 2010-2020, Department of National Defense, Canada.
	25. Human Factors Integration (HFI) Management (Draft Document), DERA Centre for Human Science, UK.
	26. Human System Integration (HSI) Procedures manual, NAVSEA Technical Note No. 077-55W5-TN 0001. Naval Sea
	27. MANpower and PeRsonnel INTegration (MANPRINT) Web site
	28. MANPRINT Bulletin Vol. VI No.7, 1992 HQDA DAPE-MR, The Pentagon, Washington, DC.
	29. MANPRINT Quarterly Summer/Fall 1999, 300 Army Pentagon, Washington, DC
	30. MANPRINT Quarterly Winter 1997, 300 Army Pentagon, Washington, DC.
	31. MANPRINT Quarterly Winter 1998, 300 Army Pentagon, Washington, DC
	32. MANPRINT Quarterly Winter 2000, 300 Army Pentagon, Washington, DC
	33. Program Description, Domain Descriptions, Integrated Product Teams Systems Command, Washington, EC 20362-5101.
	34. www.acq-ref.navy.mil/turbo/arp15.htm Integrated Logistic Support site for US Navy Acquisition Reform. Descriptions and tools.
	35. www.epgc4i.com/epg/ - Electronic Proving Ground, For Huachuca, Arizona – Reliability, Availability, Maintainability, Manpower, Personnel, Training, Human Factors Engineering Support Services.
	36. www.eurocontrol.be/projects/eatchip/hfi/home.htm – HFI in European Air Traffic Management System.
	37. www.manningaffordability.com Naval based Manning Affordability site with strong HSI information source.
	38. www.nickleby.com – Early Human Factors Analysis and HFI developed by Nickleby HFE Ltd.

Category	Reference
Manpower & Personnel	39. Army Regulation 70-8 Soldier-Oriented Research and Development in Personnel and Training, Department of the Army, 31 July 1990.
	40. Friedman, F., et al. (1981) Integration of Manpower, Personnel, and Training Issues from the Materiel System Acquisition Process in the planning Programming and Budgeting System, US Army Research Institute for the Behavioral and Social Sciences, Alexandria, Virginia 22333.
	41. Manpower, Personnel and Training Decision Support System (Marketing Literature) Dynamics Research Corporation.
	42. Rhode, A., et al. (1980) Manpower, Personnel, and Training Requirements For Materiel System Acquisition, US Army Research Institute for the Behavioral and Social Sciences, Alexandria, Virginia 22333.
	43. www-perscom.army.mil/dcsops/manpower.htm - Manpower, Personnel and Training Domain Branch of PERSCOM
System Safety	44. Greenley, M., Angel, H., Brooks, J., Kumagai, J., 1999, Human Factors Integration Requirements for Armoured Fighting Vehicles: Part II: A Review of The Human System Integration Material Available for Armour Systems SORs and a Plan for Future HSI R&D, Defence and Civil Institute of Environmental Medicine.
	45. Greenley, M., Brooks ,J., MacAulay, K., 2000, Human Systems Integration Requirements Management for Naval Systems, Defence and Civil Institute of Environmental Medicine.
	46. http://ax.laafb.af.mil/axm/axmp/CPAT/cpat.html
	47. http://www.system-safety.org/ - System Safety Society home page.
	48. MIL-STD-882D Standard Practice For System Safety, 10 February 2000
	49. Space and Missile Systems Center – Acquisition Health and Safety
	50. System Safety Analysis Handbook (1997) 2nd Edition (Preface, Forward, Abstract and Introduction and Tool Matrix only) System Safety Society, Tullahoma, Tennessee.
	51. Web site supporting Control of Large and Complex Technical Systems by Ken Rigby. Complete "system" site with details on System Safety. http://www.airtime.co.uk/users/wysywig/wysywig.htmand
Training	52. Manual of Individual Training and Education Vol.10 Managing Individual Training and Education in Projects (1999) A-P9050-000/PT-010, This is a series of 12 volumes that contains guidance on the Canadian Forces Individual Training and Education System (CFITES)

2.5 Interviews

In parallel to this document review of related processes and procedures, interviews were being conducted with members of the HSI community to discuss potential participation in the HSI Support Team. These interviews were used to review linked processes, particularly training and the higher level Engineering and Support Management processes.

2.6 Process Development

The project team first developed a high level process for each HSI Domain within each phase of the Defence Management System. These processes were then analyzed for areas of overlap or sharing between domains. The areas of overlap and key linkages where then extracted as the HSI Process.

2.7 Process Validation

The base HSI Process was then compared to a series of existing international HSI processes, and a draft was reviewed with DBCM 2-8 in relation to the draft Engineering and Support Management process.

2.8 Process Completion

The base HSI Process was then finalized with process descriptions, a process diagram and an outline of process tools and outputs. This material was then used as the basis for a design for the HSI Web Site through another project.

2.9 Report Development

The final step in the project involved the preparation of this report and a presentation of the results to the HSI Project Team.

3 Results

This section outlines the results of the HSI Process development activity and provides the base HSI process material necessary for the HSI Web Site.

3.1 Assumptions & Constraints

The results of this activity are impacted by a number of assumptions and constraints.

Early start up meetings indicated that the resulting HSI process should:

- be simple
- be sequenced
- illustrate interrelations and interdependencies,
- map the HSI process to the process from each of the HSI domains
- map the HSI process against the DMS process
- show variables based on development vs COTS buy projects

This list of objectives resulted in an ambitious undertaking within a relatively small effort in terms of process development. The resulting impact of this constraints was a high level "process" in terms of flow, linkages and outputs but one that could still benefit from review an integration in terms of the establishment of a contiguous flow in inputs and outputs between processes as would be developed if using modeling software to record these interrelationships.

3.2 LCMS/DMS Process

One of the objectives of the process development activity was to develop a process mapped against the Defence Management System (DMS) process. This is the process managed by the Directorate of Force Planning and Project Coordination (DFPPC) that guides the phases of an acquisition project within the overall Life Cycle Management System (LCMS) in DND. This process is illustrated in Figure 1.

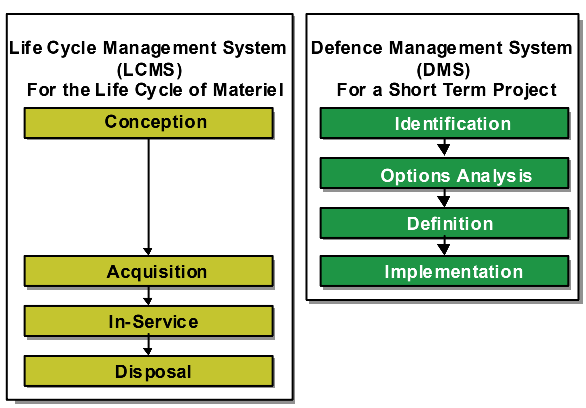

Figure 1: the LCMS and DMS Phases

The DMS consists of four main project phases, called Identification, Options Analysis, Definition, and Implementation.

3.2.1 DMS Identification

During definition the Project Director will create the project, and describe the rationale, framework, rough costs, and plan for the project through the creation of a series of documents that culminate with the Synopsis Sheet (Identification) which is presented for approval to move on to the next phase.

Documents produced during this phase include the SS(ID), the Project Charter ,the Project Profile and Risk Assessment (PPRA), the Statement of Operational Requirements (SOR), the Project Management Plan (Development), and perhaps an early version of an Engineering and Support Management Plan (ESMP).

3.2.2 Options Analysis

With the project rationale defined and approved the project will move into the Options Analysis phases where a number of different options or concepts are analyzed to determine which one is best for DND to proceed with. This involves cost benefit comparison of different options to achieve the goal.

For example if land forces were deficient in their ability to observe forward a number of options might be to purchase better sights for their vehicles, add sights on masts to vehicles, acquire unmanned aerial vehicles to fly above the vehicles, develop a class of vehicles that is always placed out front to observe and transmit information back, or acquire links to high resolution satellites. Some of these ideas are a stretch, however, the main point is that the purpose of this phase to compare entirely different concepts to determine which will be the basis of the final procurement activity.

The phase ends with the update to all the previous project documents, and the development of the SS(Preliminary Project Approval) or SS(PPA) which provides permission to proceed to the next phase.

3.2.3 Definition

Once the preferred option for the project has been selected the project team will analyze it in more detail to determine the final performance requirements and specifications for the project. These specifications and their evaluation criteria are documented in procurement documents that are used as the basis of contracting with a winning vendor at the start of the implementation phase.

The phase ends with the update to all the primary project documents, the creation of bid documents, and the creation of the SS (Effective Project Approval) or SS(EPA), which provides final approval to spend and acquire the system in question.

3.2.4 Implementation

During the implementation phase a bidding process will be completed, a winning vendor selected, and the system will be delivered to DND. During this phase the project team will monitor contractor activity and manage their budgets and requirements.

The primary documentation in this phase is the contract, and the various design reviews, tests, and evaluations that occur to ensure that the system meets it goals.

3.3 DBCM ESM Process

Within the material acquisition and support community, ADM(Mat) personnel provide the project management and engineering support to acquisition projects. DBCM is responsible for developing MA&S policy, processes, and work product templates. DBCM 2-8 is the functional authority responsible for Systems Engineering, and together with DBCM 2-4 who responsible for Integrated Logistics and Support (ILS) manage the higher levels processes under which the HSI process falls in the hierarchy of processes.

DBCM is currently completing the Acquisition Reform project which includes the development of new processes as guidance to DND projects. This activity includes the Engineering and Support Management (ESM) process being developed by DBCM 2-8 and managed through the ESM Plan or ESMP which is currently being drafted and integrated with the overall Project Management Plan (PMP) developed by DBCM 2-9. All of these processes and plans are being located on the intranet based Acquisition Desktop.

During the period that this project was being completed, the ESM process was in a preliminary draft state. However, discussions with DBCM 2-8 confirmed the following:

- The overall process will be called "Manage Engineering and Support"
- It will be decomposed into three sub-processes called "Specify Engineering and Support", "Execute Engineering and Support" and "Execute Deployment"
- Specify Engineering and Support will have sub-sub-processes related to options analysis, the development of engineering requirements, and the management of requirements through the acquisition process.
- Execute Engineering and Support will have sub-sub-processes related to the implementation of the engineering and ILS plans and the continued management of requirements.
- Within these processes are place holders for "Manage Human Systems Integration", with the opportunity to conduct further integration once this base HSI Process is reviewed further with DBCM staff, and once the ESM process is more formalized.
- The HSI Process outlined in this report will be the sole process for human factors engineering, system safety, and health hazard assessment and the DBCM processes on the Acquisition Desktop will be linked to the web version of the HSI processes.

3.4 HSI Process Descriptions

This section outlines the HSI process descriptions that were developed.

3.4.1 Unique Aspect of the Process

The HSI Process developed has one unique feature compared to others that resulted from the objectives given to the process development team - it really focuses on INTEGRATION.

The process labels and descriptions were developed to force shared consideration of each HSI domain, which is in contrast to other processes that have simply retained current domain processes.

For example an HSI process might list processes such as Conduct Function Allocation, Conduct Training Needs Assessment, Conduct Personnel Gap Analysis, which is a list of the select processes from human factors engineering, training, and personnel respectively. In contrast the process outlined in this report might have a process called Conduct Organization and Work Flow Analysis that would then be used as the basis for function analysis, training analysis, and personnel assessments.

This integration is necessary in Canada in order to make the most effective user possible of low numbers of personnel, and it provides an opportunity to shape integration of analysis, promote analysis re-use, and to develop tools used by multiple domains.

3.4.2 Proposed High Level Process

The HSI process has been described at two levels of decomposition. The highest level process is composed of five processes (Figure 2) , each of which has a series of sub-processes.

Figure 2: High Level HSI Process

These five high level processes suggest a sequential, step-by-step series of activities (as required in the project goals), however, the sub-process within are actually a series of analysis that iterate and update a number of times throughout the life cycle of a materiel system.

It is the integrative nature of HSI, and the analysis re-use through iteration that provides the value of this analysis. The high level sequential process allows the HSI tasks in the defence acquisition and support process to be described in a fashion consisted with the acquisition project life cycle model described in the Canadian Defence Management System (DMS).

These processes are described further in the following sections.

3.4.2.1 Conduct HSI As-Is Analysis

The purpose of the HSI As-Is Analysis is to develop an understanding of the current status of the "system" from an HSI perspective. This analysis requires the team to describe the current system, describe the characteristics of the operator and maintainer community, identify deficiencies with the current system in each HSI domain, describe the project, document any high level HSI related risks and requirements for the project, and develop an HSI Plan to manage HSI risk and requirements throughout the project cycle.

During this process the following questions should be answered:

- Who might have information of use to this project, or be capable of conducting requirements analysis, in the areas of human factors engineering, training, staffing, system safety, and health hazards?
- How is the current system operated and maintained?
- Who operates and maintains the current system, and what are their characteristics?
- What are the HSI related deficiencies with the current systems in areas such as human task performance, workload, human error, training, staff numbers, staff characteristics, safety hazards, or health hazards?
- What HSI constraints will be placed on this project?
- Based on the concept for the project what are the HSI Risks?

- Based on the current system, and any analysis available, what are the known high level HSI requirements?
- How will HSI risks and requirements be addressed on this project?

During this process the following key HSI outputs will be generated:

- Target Audience Description
- List of HSI Deficiencies
- List of HSI Constraints
- Preliminary HSI Risks and Requirements
- HSI Plan

3.4.2.2 Conduct HSI Options Assessment

Once the deficiencies and high level requirements for a materiel acquisition project have been defined, a series of options analyses are typically conducted. Each major "option" is a different type of solution that can address the overall requirement, and is usually not a comparison of products as much as it is a comparison of entire concepts. Each option is evaluated based on its cost and benefits, with the leading solution being selected as the final approach for the project and the focus of much more detailed analysis and evaluation in the next phase of procurement.

During this period of a project, HSI Options Assessment is conducted in order to develop a more detailed set of HSI requirements and human centred system performance measures which are then used to conduct an HSI cost-benefit assessment of each option as well as an HSI trade-off analysis if possible. These assessments are based on an analysis of the system, expected future operational and support concepts, the organization and task flow, the workspaces, and the class of human machine interfaces for each option.

Exactly which assessments will be conducted will depend on the focus of the project and the nature of acquisition. For large systems, all analyses will be appropriate (larger vehicles or C2 related systems), however on smaller equipment based acquisitions, or component upgrade projects, the impact on HSI may be more focused and all areas will not require analysis.

Each option will be assessed from an HSI perspective to answer questions such as:

- What will the staffing complement be for each option in terms of numbers and characteristics?
- Will the staffing complement for operations and maintenance alter personnel costs, training costs, recruitment criteria, or promotional career paths?
- What types of function allocation between human and machine is expected for each option? Will any function re-allocation have an impact on staff workload, staff training requirements, or staff selection criteria?
- What are the likely types of workspaces for operations and maintenance for each option? How well will these spaces facilitate task performance? Are there any safety or health hazard concerns with the types of work environments that are likely?

- What major classes of human machine interfaces are likely with each option? What will the impact of these interfaces be on staff workload, staff training requirements, or staff selection criteria?
- What are the HSI related trade-offs associated with each option?
- What is the overall cost-benefit of each option from an HSI perspective?
- What is the recommended option from an HSI perspective?
- What further analysis of the recommended option will be required from the HSI community in order to refine requirements and bid evaluation criteria based on current procurement strategy concepts?

During this process the following HSI outputs will be generated:

- Organization and Work Flow Descriptions
- Workspace and Interface Descriptions
- Updated HSI Risks and Requirements
- HSI Option Assessment Report
- Updated HSI Plan

3. Conduct HSI To-Be Analysis

Once the final option for a project is selected, it is analyzed in more detail in order to develop the performance requirements and evaluation criteria to be used as the basis of procurement. During this phase of a project the HSI team must look into the future and conduct the HSI To-Be Analysis. This analysis requires further refinement of the operational and support concepts, refinement of organization and task flow analysis for the selected option, projection and evaluation of the future Target Audience Description, analysis and predication of task and staff performance levels, development and validation of performance requirements, development and validation of evaluation criteria, and the creation of HSI related sections of procurement documents.

This process may involve mock up based evaluations, model and simulation based experimentation, or field trials to help develop and validate requirements or bid evaluation criteria. The process will end with the substantive plan for HSI during the next phases of the project, a plan that will be dependent on the project procurement strategy.

During this phase the HSI contribution should answer questions such as:

- What will be the operational and support concept for this future system?
- How will functions be allocated between human and machine for operation and maintenance tasks?
- How many personnel, with what characteristics, will be required to operate and maintain the selected option?
- Is the impact of proposed personnel impacts (personnel numbers, potential selection criteria, training requirements to retain skill levels) acceptable? OR, must requirements be established within the project to limit the impact of some of these areas?

- What are the predicted task performance levels for operation and maintenance tasks? How can these performance levels be worded as requirements for the system, and how will these requirements be evaluated during procurement?
- What training will be required to develop sufficient operator and maintainer skill, and retain that skill level through the life cycle, for the selected option?
- What training aids will be required (eg: simulators) to conduct the types of training likely to be required?
- How will new technology and function re-allocation impact human task performance and crew workload? What procurement requirements are necessary to optimize these relationships?
- Is doctrine likely to change as a result of this system?
- What design requirements or special equipment requirements are there to ensure that operators and maintainers are safe when interacting with this system?

During this process the following HSI outputs will be generated:

- Updated Organization and Work Flow Analysis
- Updated Workspace and Interface Analysis
- Task Analysis
- Updated Risks and Requirements
- HSI Inputs to Procurement Documents
- HSI Inputs to Bid Evaluation Plan
- Updated HSI Plan

3.4.2.3 HSI Evaluation, Verification, Validation, and Assurance

Each DND material acquisition project passes through an implementation phase where requirements and evaluation criteria are used to select a system among competing bids, contracts are signed with a vendor to produce the system, the project team monitors and evaluates production, and then DND finally accepts delivery.

During this period the HSI team must continue to manage the requirements and processes they have specified for the project. This involves the *evaluation* of candidate systems against HSI requirements and performance specifications, monitoring contractor/vendor HSI activities, *verifying* that HSI requirements have been met and *validating* that HSI performance measures were accurate, acceptable, and achievable. Throughout, any HSI related trade-off analysis must be conducted by the HSI team to *assure* that overall HSI related quality is maintained. These activities will involve a range of monitoring, evaluation, and testing activities in concert with requirements management activities which are standard across all engineering disciplines.

Once the final system has been delivered to DND it will be provided to the end users. This places the system in control of operational units (in many cases) on a day to day basis and a Life Cycle Materiel Manager from an NDHQ perspective. These new "owners" require a wide range of background information in each HSI domain to ensure that the system is operated and maintained as it was specified and selected, and to ensure that operation and maintenance staffing and procedures take best advantage of the strengths and weaknesses of the final system selected.

During this process the HSI contribution will answer a number of questions, such as:

- How well does each bidder meet HSI requirements?
- Does the winning vendor have a sufficient HSI capability in place?
- Is the system being developed or manufactured to the agreed upon HSI criteria?
- Is the system training being developed according to specifications, and will it achieve the training goals established?
- Is the system being developed going to achieve the necessary HSI performance levels?
- Where estimates and predictions about ease of learning, human task performance, workload, safety, and health hazards correct? If not do adjustments need to be made to the requirements or the design or the deployment concept for the system?

During this process the following HSI outputs will be generated:

- HSI Bid Evaluation Report(s).
- HSI Approvals of Relevant Design Changes.
- HSI Test Plans and Reports.
- HSI Review Progress and Evaluation Memos and Reports.
- HSI Hand Over Material.

3.4.2.4 Conduct HSI Monitoring

The Life Cycle Manager for a system in NDHQ, in addition to the responsible Requirements Directorate are both charged with monitoring the status of a system through its life cycle. This activity must include monitoring HSI related variables, preferably through the tracking of issues and incidents in electronic databases to facilitate more rapid procurement of future systems or related system upgrades.

As a result of this monitoring process a number of questions will be answered, such as:

- Is the system meeting task performance, workload, training, staffing, safety and health hazard performance levels?
- Are there any concerns with staffing concepts, work flow (doctrine), workstation design, interface design, training design, safety, or health hazards with the system?
- What incidents or accidents have occurred with the system that should be avoided in future systems or upgrades to this one?
- Have other countries had a similar experience with this or similar systems?

During this process the following HSI outputs will be generated:

- Reports of HSI related Deficiencies to the LCMM or requirements officer.

3.4.3 Proposed Sub-Processes

Within these five high level processes, a number of sub-processes are proposed. These relationships are illustrated in Figure 3.

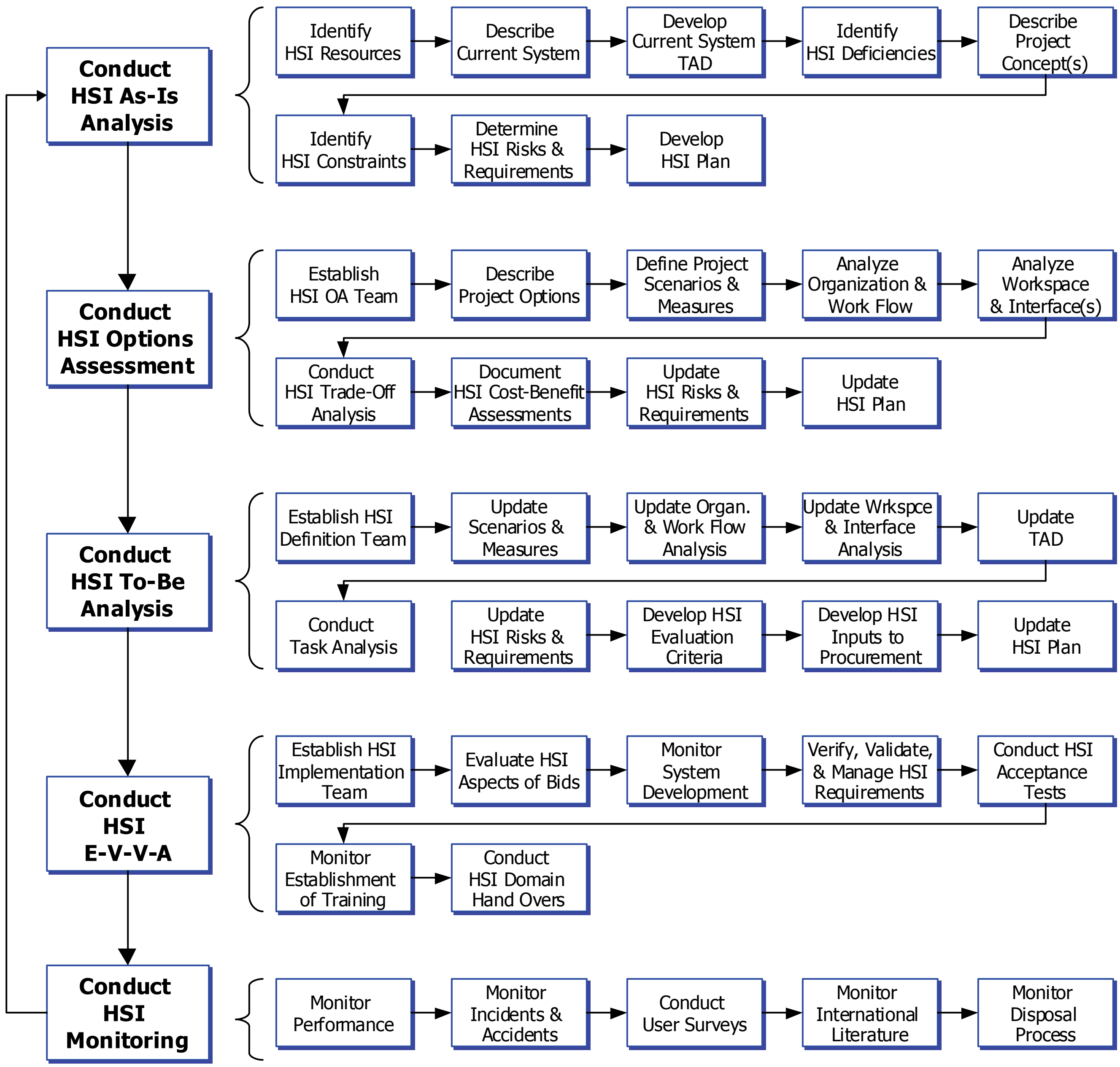

Figure 3: Proposed HSI Process and Sub-Processes

These processes are described further in Annex A to this report.

3.4.4 Core HSI Data Repositories

As a result of the focus on integration across the HSI domains, a series of core or common data repositories are evident within this process. Examples of these include:

- Organization and Work Flow
- Target Audience Description
- Workspace & Interfaces
- HSI Risks, Requirements, Measures, and Criteria

These data repositories are developed gradually throughout the project, through iterative analysis that gradually focuses in on the detailed performance specifications for the primary option. They are shared data sets across all of the HSI domains are unique within the Systems Engineering and ILS community in terms of their development and use by the HSI community.

As a result of these repositories being identified:

- The opportunity for analysis sharing across HSI domains is increased.
- HSI tools can be focused in these areas, in order to develop analysis and tracking capability that will be of use to all HSI domains.
- The opportunity for analysis libraries and subsequent analysis re-use is enhanced.
- Analysis can be better synchronized across HSI domains the project scope changes.
- Clear scope and accountability for the HSI community can be established and understood by other members of DND project teams.
- The relation between HSI and the DMS is illustrated in the following figure:

Figure 4 illustrates the relationship of these data repositories to the HSI process and the DMS process and decision documents that they "feed".

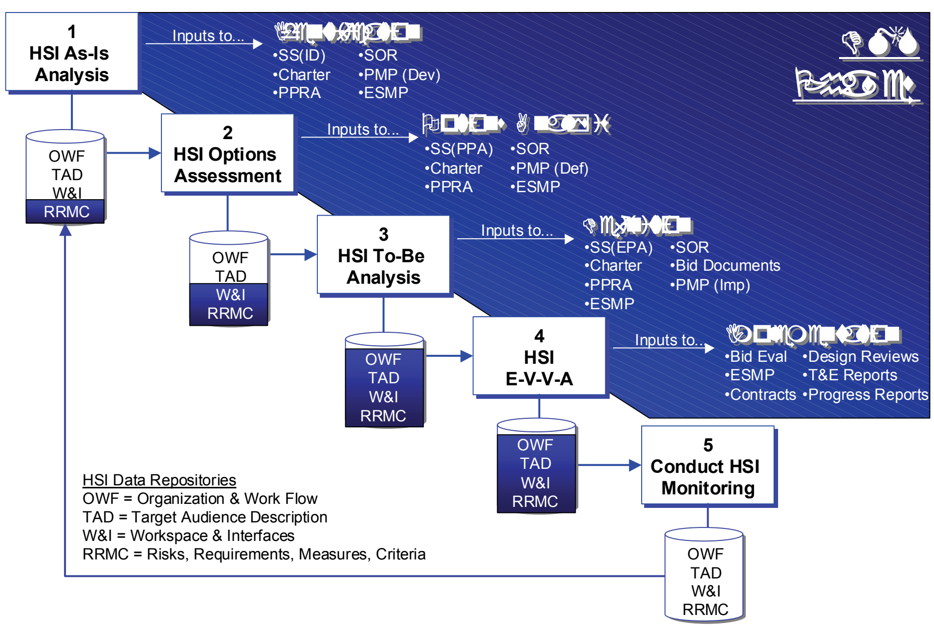

Figure 4: HSI Process Data Repositories

3.4.5 HSI Process - Development vs COTS

The development of this process to date does not clearly illustrate the difference in HSI activity between development projects and Commercial off the Shelf (COTS) acquisitions. Further review and assessment is required, prior to release to the DND community to determine if any differences in these areas can be illustrated graphically within the process, or if a separate guidance document is required on how to use the process in COTS based acquisition (the more likely option).

3.5 HSI Sub-Domain Process Summaries

In order to further encourage, illustrate, and enhance the integrative nature of this HSI process, high level descriptions were developed for each of the HSI domains based on a review of these processes in the literature.

The text descriptions of these processes is included in the annexes to this report, with the relationship between the HSI process and each domain summarized in Table 2.

Further review of these HSI domain processes is still required to better integrate them, and to validate the representations chosen with subject matter experts for human factors engineering, training, manpower, personnel, system safety, and health hazard assessment.

Table 2: Relationship Between HSI Process and HSI Domain Processes

DMS Phase	Human Systems Integration	Human Factors Engineering	Training	Manpower Personnel	System Safety	Health Hazard Assessment	HSI Tools & Techniques	HSI Outputs
Identification	1.0 Conduct HSI As-Is Analysis 1.1 Identify HSI Resources 1.2 Describe Current System 1.3 Develop Current System TAD 1.4 Identify HSI Deficiencies 1.5 Describe Project Concept(s) 1.6 Identify HSI Constraints 1.7 Determine HSI Risks and Requirements 1.8 Develop HSI Plan	Lessons Learned and HFE Deficiencies Develop HFEPP	Needs Assessment (Preliminary) Concept for: Performance Analysis, Cause Analysis, Identify Solutions Concept for Training Analysis Concept for Training Design Cost Estimate	Baseline & Lessons Learned Concept Staffing Constraints	SSPP Planning Previous Safety Concerns	Frame work for HHAR Identify Applicable Standards and Guidelines Identify previous HHARs	Deficiency Tracking Databases ACCESS Soldier's Day DOORS HSI Plan Guideline & Template	Target Audience Description List of HSI Deficiencies List of HSI Constraints Preliminary HSI Risks and Requirements HSI Plan

DMS Phase	Human Systems Integration	Human Factors Engineering	Training	Manpower Personnel	System Safety	Health Hazard Assessment	HSI Tools & Techniques	HSI Outputs
Options Analysis	2.0 Conduct HSI Options Assessment 2.1 Establish HSI OA Team 2.2 Describe Project Options 2.3 Define Project Scenarios and Measures 2.4 Conduct Organization and Work Flow Analysis 2.5 Conduct Workspace and Interface Analysis 2.6 Conduct and Document HSI Trade-Off Analysis 2.7 Document HSI Cost-Benefit Assessments 2.8 Document HSI Risks and Requirements 2.9 Update HSI Plan	Mission and Function Analysis, Function Allocation Preliminary Tasks Analysis OMI Identification OMI & Work Space Concepts Human Performance Specifications Human Performance Prediction Error Analysis Human Performance Requirements	Needs Assessment (Continued) Performance Analysis, Cause Analysis, Identify Solutions Training Analysis Initial Training Design: Initial Cadre, Conversion and Regeneration Training ID Qualifications and Instructor Req.	Organizational and Operational Concept Staffing Goals & Constraints Staffing Estimates Staffing Sensitivity Analysis Costing	Safety Performance & Design Requirements ID Hazards Assessment of Mishap Risk Risk Mitigation Measures Human Reliability Analysis	ID Health Hazards Initial Risk Assessment Initial Risk Mitigation Measures	IPME SAFEWORK LOCATE Staffing Analysis Models Soldier's Day Live Simulation (ACD, ALFCS) Behavioral Task Analysis Hazard List Development Techniques DOORS	Organization and Work Flow Descriptions Workspace and Interface Descriptions Updated HSI Risks and Requirements HSI Option Assessment Report Updated HSI Plan

DMS Phase	Human Systems Integration	Human Factors Engineering	Training	Manpower Personnel	System Safety	Health Hazard Assessment	HSI Tools & Techniques	HSI Outputs
Definition	3.0 Conduct HSI To-Be Analysis 3.1 Establish HSI Definition Team 3.2 Update Project Scenarios and Measures 3.3 Update Organization and Workflow Analysis 3.5 Update Workspace and Interface Analysis 3.4 Conduct Task Analysis 3.7 Update HSI Risks and Requirements 3.8 Develop HSI Evaluation Criteria 3.9 Develop HSI Inputs to Procurement Documents 3.10 Update HSI Plan	Mission and Function Analysis, Function Allocation Tasks Analysis OMI Design & Workspace Guidance & Documentation Mockups & Prototypes Human Performance Specifications T and E Plan	Training Analysis & Training Design Qualification Quantitative Requirement	Refined: Staffing Goals & Constraints Staffing Estimates Trade off Analysis Cost Estimate	Assessment of Mishap Risk Risk Mitigation Measures Human Reliability Analysis	Risk Assessment Risk Mitigation Measures HHAR Integrate HH Requirements in Specification	IPME SAFEWORK LOCATE Live Simulation (ACD, ALFCS) Behavioral Task Analysis Staffing Analysis Models HFE GUIDE HFE ICADD Hazard List Development Techniques Safety and Hazard Analysis Techniques Biomedical Standards, HH Standards, Prediction Models DOORS	Updated Organization and Work Flow Analysis Updated Workspace and Interface Analysis Task Analysis Updated Risks and Requirements HSI Inputs to Procurement Documents HSI Inputs to Bid Evaluation Plan Updated HSI Plan

DMS Phase	Human Systems Integration	Human Factors Engineering	Training	Manpower Personnel	System Safety	Health Hazard Assessment	HSI Tools & Techniques	HSI Outputs
Implementation	4.0 HSI Evaluation, Verification, Validation, and Assurance 4.1 Establish HSI Implementation Team 4.2 Evaluate HSI Aspects of Project Bids 4.3 Monitor System Development 4.4 Verify, Validate, and Manage HSI Requirements 4.5 Conduct HSI Acceptance Tests 4.6 Monitor Establishment of Training 4.7 Conduct Hand Over Meetings Within Each HSI Domain	Detailed Task Analysis OMI Design & Workspace Detailed Design Guidance & Documentation Mockups, Simulations and Prototypes Conduct User Reviews User Acceptance Trials Operator and Maintainer Training, Personnel Req. and Organizational Req.	Training Design & Development Conduct (Delivery) Training Evaluate Training		Reduction of Mishap Risk Verification of Mishap Risk Reduction Review of Hazards and Acceptance of Residual Mishap Risk	HHAR with Risk Reduction, Control or Elimination Recommendations /Implementation	DOORS IPME SAFEWORK LOCATE Live Simulation Critical Task Analysis Staffing Analysis Models HFE GUIDE HFE ICADD Field Trials Safety and Hazard Analysis Techniques Biomedical Standards, HH Standards, Prediction Models	HSI Bid Evaluation Report HSI Approvals of Relevant Design Changes HSI Test Plans and Reports HSI Progress Review and Evaluation Memos HSI Hand Over Material

DMS Phase	Human Systems Integration	Human Factors Engineering	Training	Manpower Personnel	System Safety	Health Hazard Assessment	HSI Tools & Techniques	HSI Outputs
In Service	5.0 Conduct HSI Monitoring 5.1 Monitor Human Performance 5.2 Monitor Incidents and Accidents 5.3 Conduct User Surveys 5.4 Monitor International Literature 5.5 Monitor Disposal Process		Training Validation		Tracking of Hazards, Closures and Residual Mishap Risk	Update HHAR with operational or equipment changes.	DOORS Deficiency Tracking Databases ACCESS Soldier's Day	HSI Deficiencies for Future Systems

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4 Conclusions and Recommendations

This project has developed an HSI process that has been integrated within the Canadian DMS process. The HSI process is consistent with international practice, but at the same time introduces a more integrated approach than many have taken which is necessary to make use of limited resources within the DND community and to encourage analysis sharing and re-use.

It is recommended that this process be further reviewed with subject matter experts in each HSI domain and the functional authorities for systems engineering and ILS in DBCM. The next edited version should then be released on the HSI Web Site for wider circulation, review, and use.

Annexes

The Annexes section contains the descriptions of process in the following areas:

A: HSI Process Description

B: HFE Process Description

C: Training Process Description

D: Manpower & Personnel Process Description

E: System Safety Process Description

F: Health Hazard Assessment Process Description

Annex A:
HSI Process Description

Human Systems Integration Process

The Human Systems Integration (HSI) process in the materiel acquisition and support process can be summarized according to five high level processes, each of which has a series of sub-processes.

1. Conduct HSI As-Is Analysis
2. Conduct HSI Options Assessment
3. Conduct HSI To-Be Analysis
4. HSI Evaluation, Verification, Validation, and Assurance
5. Conduct HSI Monitoring

These five high level processes suggest a sequential, step-by-step series of activities, HOWEVER, the sub-process are actually a series of analysis that iterate and update a number of times throughout the life cycle of a materiel system. It is the integrative nature of HSI, and the analysis re-use through iteration that provides the value of this analysis. The high level sequential process allows the HSI tasks in the defence acquisition and support process to be described in a fashion consisted with the acquisition project life cycle model described in the Canadian Defence Management System (DMS).

1. Conduct HSI As-Is Analysis

The purpose of the HSI As-Is Analysis is to develop an understanding of the current status of the "system" from an HSI perspective. This analysis requires the team to describe the current system, describe the characteristics of the operator and maintainer community, identify deficiencies with the current system in each HSI domain, describe the project, document any high level HSI related risks and requirements for the project, and develop an HSI Plan to manage HSI risk and requirements throughout the project cycle.

During this process the following questions should be answered:

- Who might have information of use to this project, or be capable of conducting requirements analysis, in the areas of human factors engineering, training, staffing, system safety, and health hazards?
- How is the current system operated and maintained?
- Who operates and maintains the current system, and what are their characteristics?
- What are the HSI related deficiencies with the current systems in areas such as human task performance, workload, human error, training, staff numbers, staff characteristics, safety hazards, or health hazards?
- What HSI constraints will be placed on this project?
- Based on the concept for the project what are the HSI Risks?
- Based on the current system, and any analysis available, what are the known high level HSI requirements?
- How will HSI risks and requirements be addressed on this project?

During this process the following key HSI outputs will be generated:

- Target Audience Description
- List of HSI Deficiencies
- List of HSI Constraints
- Preliminary HSI Risks and Requirements
- HSI Plan

SUB-PROCESSES

1.1 Identify HSI Resources

The initiation of the HSI process requires that HSI Resources be identified. Early in the project the focus will be on the human resources required and available to support the project. On small projects this may simply consist of identifying the sole HSI resource person for the project. On larger projects there may be small groups responsible for each HSI domain, with additional technical support in some areas from the Defence R&D community and industry. The primary output of this process should be the identification of the HSI leader and the contributors to early versions of the HSI Plan. However, depending on resource availability the output of this task may simply be the identification of HSI resources that can contribute to the development of early project plans and requirements development.

1.2 Describe Current System

The HSI community requires a description of the current system as a baseline for subsequent analysis. This description should summarize the operation and maintenance of the current system, including an outline of system components (personnel and equipment) and the workflow between them, along with key performance objectives. In some cases the goal of a new project might not be to replace an existing technical component in the system, however the area of operation likely to be impacted by the acquisition or development project must be understood and described. The output of this process will be a system description that may simply be a few pages of text that is re-used as the lead-in to a number of documents (small project) or it may be a document in itself that is referenced in the early phases of the project (larger projects). Other management and engineering domains are likely to require similar information, which means that a description of the current system may exist, or it may be developed by a number of members of and Integrated Project Team.

1.3 Develop Current System TAD

With the current system understood, and therefore the approximate "bounds" of the project defined, the HSI community must develop a Target Audience Description (TAD) of the current operation and maintenance personnel. This TAD will define the characteristics of operators and maintainers in terms of their numbers, training, skill levels, physical characteristics, selection criteria (eg: vision, strength, endurance, task skill levels), etc. The TAD will be developed through an analysis of existing records and/or through active survey and analysis of the operation and maintenance communities. Increasingly some elements of the "maintenance" community for military systems will be based in industry and will not include uniformed personnel, however, they should still be included in the TAD. The output of this process will be a data repository of operator and maintainer characteristics, which may exist as a document, a document section, or an actual database of information depending on the size of the project and the level of relevant TAD data already tracked and recorded.

At this point in the process the TAD will be used primarily to evaluate human factors engineering, training, and staffing issues. This baseline TAD will be used to compare with the project concept and any HSI constraints so that HSI risks related to staff levels, workload, training impacts, etc. can be estimated as early as possible and be included in the project planning. This in turn will assist with HSI resource and analysis requirements (eg: if it looks as though the project will not impact personnel numbers, or recruitment criteria certain analyses will not be required by human factors engineering, training, and staffing personnel).

1.4 Identify HSI Deficiencies

Any deficiencies with the current system must be identified in each of the HSI domains. In cases where tracking systems are in place (eg: safety and hazard incident databases) these deficiencies may be easier to obtain, whereas in a number of cases active analysis of the current systems may be required using document reviews, observation, questionnaires, and interviews to develop a structured assessment of current HSI related deficiencies. Increasingly HSI deficiencies also include human resource cost data, whereby force downsizing indicates that the numbers of personnel in larger systems must be reduced or the cost of training for very complex maintenance trades must be optimized in some fashion. The output of this analysis process will be a list of deficiencies that will passed to the Project Director for inclusion in project decision documents. This list of deficiencies will also form the HSI baseline for the project and the start of the requirements development process.

1.5 Describe Project Concept(s)

The HSI team will require a description of the current project concepts. It is likely that this description will come from the entire project team as a whole under the direction of the Project Director. However, at times the high level concept or the concept options may require further embellishment from the HSI team in the areas of staff organization, function allocation, task performance, training, or work spaces in order to "set the stage" for HSI analysis. The output of this process will be a description that will be re-used in a number of future documents and become part of the early HSI Plan.

1.6 Identify HSI Constraints

With the current system understood and the project framework defined, the HSI team must identify any HSI related constraints associated with the project concept. These constraints might include any limits on costs, limits on personnel (eg: the project cannot change the current personnel structure, or, the project must cut current maintenance personnel by 50%), limits on testing, forced integration with other projects or systems (eg: must re-use existing simulators for training). The outputs of this process will be a documented list of constraints which will be included in the HSI Plan and may be referenced by higher level strategic documents depending on the focus of the project (eg: some current naval projects list crew size constraints as one of the highest level project parameters in all of the highest level documents).

1.7 Determine HSI Risks and Requirements

Once the concept for the project is established, and the HSI constraints are identified, the HSI team must identify the high level, known, HSI risks and requirements. Risk should be documented in the HSI Plan and should also be documented in the project risk register so that the Project Director and Project Manager can include the overall Risk Management process and include them in decision documents such as the Project Profile and Risk Assessment (PPRA). Requirements should be recorded and passed to the Project Director to form part of early SOR versions. Preferably requirements are managed using electronic requirements management tools so that source, history, and evolution are tracked.

1.8 Develop HSI Plan

The high level project concept, constraints, risks and requirements and the project procurement strategy (if one has started to evolve) are used as the basis of determining the HSI Plan for the project. This plan will document what HSI analyses will be requirement, the organization and personnel required to conduct this analysis and manage the effort, the physical resources required for any analysis, access to operators and maintainers, the primary tasks, the integration of the HSI domains, schedule, budget, risks, and risk mitigation for the project. On a small project this may be the sole HSI plan that covers all HSI domains, while on larger projects this plan may focus much more on the integration of the HSI domains referencing the specific plans developed by each of the sub-domain specialist teams (eg: HFE, Training, Staffing, Safety, Health Hazard). Eventually, the HSI Plan will become part of the overall Engineering and Support Management Plan (ESMP) for the project, however, as many HSI analyses are initiated prior to systems engineering formally being established the plan may be an independent document used by the Project Director until later in the project.

2. Conduct HSI Options Assessment

Once the deficiencies and high level requirements for a materiel acquisition project have been defined, a series of options analyses are typically conducted. Each major "option" is a different type of solution that can address the overall requirement, and is usually not a comparison of products as much as it is a comparison of entire concepts. Each option is evaluated based on its cost and benefits, with the leading solution being selected as the final approach for the project and the focus of much more detailed analysis and evaluation in the next phase of procurement.

During this period of a project, HSI Options Assessment is conducted in order to develop a more detailed set of HSI requirements and human centred system performance measures which are then used to conduct an HSI cost-benefit assessment of each option as well as an HSI trade-off analysis if possible. These assessments are based on an analysis of the system, expected future operational and support concepts, the organization and task flow, the workspaces, and the class of human machine interfaces for each option.

Exactly which assessments will be conducted will depend on the focus of the project and the nature of acquisition. For large systems, all analyses will be appropriate (larger vehicles or C2 related systems), however on smaller equipment based acquisitions, or component upgrade projects, the impact on HSI may be more focused and all areas will not require analysis.

Each option will be assessed from an HSI perspective to answer questions such as:

- What will the staffing complement be for each option in terms of numbers and characteristics?
- Will the staffing complement for operations and maintenance alter personnel costs, training costs, recruitment criteria, or promotional career paths?
- What types of function allocation between human and machine is expected for each option? Will any function re-allocation have an impact on staff workload, staff training requirements, or staff selection criteria?
- What are the likely types of workspaces for operations and maintenance for each option? How well will these spaces facilitate task performance? Are there any safety or health hazard concerns with the types of work environments that are likely?

- What major classes of human machine interfaces are likely with each option? What will the impact of these interfaces be on staff workload, staff training requirements, or staff selection criteria?
- What are the HSI related trade-offs associated with each option?
- What is the overall cost-benefit of each option from an HSI perspective?
- What is the recommended option from an HSI perspective?
- What further analysis of the recommended option will be required from the HSI community in order to refine requirements and bid evaluation criteria based on current procurement strategy concepts?

During this process the following HSI outputs will be generated:

- Organization and Work Flow Descriptions
- Workspace and Interface Descriptions
- Updated HSI Risks and Requirements
- HSI Option Assessment Report
- Updated HSI Plan

SUB-PROCESSES

2.1 Establish HSI OA Team

The HSI Options Assessment (OA) process begins with the establishment of the HSI team for this activity. This team may be different than the core HSI team and may include members of the R&D community, links to the operational research community, industry support through consultants or modeling and simulation teams, and the operator and maintainer communities. The members and organization of this team should have been defined in the HSI Plan developed earlier in the project, else it will need to be defined and assembled now. The output of this process will be the establishment of agreements and communication patterns between all team members and the initiation of assessment tasks.

2.2 Describe Project Options

The Options Analysis phase of a Defence project requires each of the project options to be compared from a cost-benefit perspective. The start of this analysis must consist of a description of each option. At a high level this description should exist and have been developed by the project team earlier. At this time each option needs to be described from an HSI perspective in order to facilitate the next phases of analysis. Each option needs a reasonable operation and support concept that allows the HSI team to describe key personnel, the key technology components of the system, the organization and work flow between components, the general workspace concepts for critical areas (if relevant) and the key human machine interfaces. The output of this process will be a description for each option (at a minimum) and may include photographs, diagrams, CADD drawings, models, mockups, prototypes or existing Commercial Off the Shelf (COTS) products if they exist.

2.3 Define Project Scenarios and Measures

The analysis of system options from an HSI perspective must be completed with the future operational and support scenarios for the project, using the operational and support concepts already defined. Therefore, the primary project scenarios must be defined and described along with the key performance measures within these scenarios. Project scenarios will be linked to defence scenarios at the high level defined in the Defence Planning Guidance (DPG). Detailed analysis of scenarios during HSI Options Assessment may not include all possible scenarios, but may only focus on one of two key scenarios that demonstrate the bounds of the project and exercise the areas of the system that are high risk or critical to future performance. In some cases a "generic" scenario may be developed that crosses many of the DPG scenarios that the future system will be exercised within. Each scenario description will define the system, the system configuration, the operation and support organization, the environment, the workflow, and the key measures. The output of this process will be a scenario description document that will be referenced by many analysts and which should be used throughout the project as the basis for human centred test and evaluation activities. Scenario descriptions and associated performance measures should also be referenced and linked to the appropriate sections in the project SOR.

2.4 Conduct Organization and Work Flow Analysis

Each of the major options should be analyzed, using the operational and support concept from an organization and work flow perspective. This analysis will be of interest to all HSI domains, but especially HFE, Training, and Staffing. On smaller projects this may consist of only one analysis that evaluates task performance, workload, knowledge and skill requirements, training requirements etc. for each option, while on larger projects each HSI domain may conduct their own specialty analysis using common option descriptions and common scenario sets. The benefits of HSI come in this area whereby the system missions, function and role allocations, and behavioral task descriptions are common needs of all HSI domains and offer cost effective analysis re-use in addition to shared technology based analysis tools. The output of this analysis will be integrated into an assessment report(s) for each option that documents the costs (personnel, training, workload, human error probabilities, etc) and the benefits (task performance, cost minimization, workload or error avoidance, etc.) across the project scenarios. Increasingly models and simulations will be used for this level of analysis (for more developmental or complex projects) , in addition to field trials (for COTS based projects).

2.5 Conduct Workspace and Interface Analysis

Each of the major options should be analyzed, using the operational and support concept from a workspace and interface perspective. This analysis will be of interest to all HSI domains, but especially HFE, Training, System Safety, and Healthy Hazard Assessment. The focus of workspace and interface analysis will be an assessment of the efficiency and safety of the workspace (if relevant) and the impact of the proposed interface concepts on task performance and future training requirements. This analysis may be conducted using drawings, models, prototypes, or mockups as the basis, or it may involve actual COTS products in other situations. The output of this analysis will be integrated into an assessment report(s) for each option that documents the costs (personnel, training or skill retention costs, workload, human error probabilities, safety hazards, etc) and the benefits (task performance, cost minimization, hazard avoidance, etc.) across the project scenarios.

2.6 Conduct and Document HSI Trade-Off Analysis

The analysis of each option within each HSI domain will generate a series of cost - benefits within each domain (eg: training costs or training benefits of each option). These cost - benefits will then be summarized. However, there is also the opportunity to conduct trade-off analysis across the HSI domains as an additional input to the option assessment. For example, one option may make extensive use of function re-allocation to new technology that shows workload and human error benefits in the human factors engineering assessments but that show high training costs and enhanced selection criteria in the Training or Staffing analysis. On the other hand, another option may involve a low tech retrofit to the existing system which has little to no impact on training, but it will not reduce crew workload or eliminate some existing safety and hazard concerns associated with too many crew in a constrained space. This form of analysis must be done from a life cycle cost (LCC) and benefit perspective, and should be integrated with any additional LCC activities being conducted by the Integrated Logistics and Support (ILS) community. All of the HSI domains frequently trade-off in this fashion, and documentation of HSI trade off analysis as part of the overall HSI Options Assessment Report provides an additional, and highly beneficial, tool to guide senior management decision making.

2.7 Document HSI Cost-Benefit Assessments

Following analysis of each option within each HSI domain, the overall cost-benefits of each option must be summarized and integrated into an HSI Options Assessment Report, which will become part of or referenced in the overall project Options Analysis report that will be summarized in the SS(PPA) at the highest level as the basis for the recommended option for the project.

2.8 Document HSI Risks and Requirements

As a result of option analysis, a number of risks and requirements and performance measures will have been further developed, especially those linked with the preferred option. Risks should be documented within the project risk management process, while requirements and performance measures should be recorded and linked into the update of the project SOR, hopefully integrated using an electronic requirements management tool.

2.9 Update HSI Plan

Once the preferred option is selected, and further information on the project procurement strategy is developed, the HSI Plan must be updated to provide more substantive estimates for the next phases of the project. Sometime during the Options Analysis or Definition Phase, the HSI Plan will become a component of the Engineering and Support Management Plan (ESMP) as the Project Manager and engineering support staff (systems engineering and ILS) increase their level of project involvement.

3. Conduct HSI To-Be Analysis

Once the final option for a project is selected, it is analyzed in more detail in order to develop the performance requirements and evaluation criteria to be used as the basis of procurement. During this phase of a project the HSI team must look into the future and conduct the HSI To-Be Analysis. This analysis requires further refinement of the operational and support concepts, refinement of organization and task flow analysis for the selected option, projection and evaluation of the future Target Audience Description, analysis and predication of task and staff performance levels, development and validation of performance requirements, development and validation of evaluation criteria, and the creation of HSI related sections of procurement documents.

This process may involve mock up based evaluations, model and simulation based experimentation, or field trials to help develop and validate requirements or bid evaluation criteria. The process will end with the substantive plan for HSI during the next phases of the project, a plan that will be dependent on the project procurement strategy.

During this phase the HSI contribution should answer questions such as:

- What will be the operational and support concept for this future system?

- How will functions be allocated between human and machine for operation and maintenance tasks?
- How many personnel, with what characteristics, will be required to operate and maintain the selected option?
- Is the impact of proposed personnel impacts (personnel numbers, potential selection criteria, training requirements to retain skill levels) acceptable? OR, must requirements be established within the project to limit the impact of some of these areas?
- What are the predicted task performance levels for operation and maintenance tasks? How can these performance levels be worded as requirements for the system, and how will these requirements be evaluated during procurement?
- What training will be required to develop sufficient operator and maintainer skill, and retain that skill level through the life cycle, for the selected option?
- What training aids will be required (eg: simulators) to conduct the types of training likely to be required?
- How will new technology and function re-allocation impact human task performance and crew workload? What procurement requirements are necessary to optimize these relationships?
- Is doctrine likely to change as a result of this system?
- What design requirements or special equipment requirements are there to ensure that operators and maintainers are safe when interacting with this system?

During this process the following HSI outputs will be generated:

- Updated Organization and Work Flow Analysis
- Updated Workspace and Interface Analysis
- Task Analysis
- Updated Risks and Requirements
- HSI Inputs to Procurement Documents
- HSI Inputs to Bid Evaluation Plan
- Updated HSI Plan

SUB-PROCESSES

3.1 Establish HSI Definition Team

The Definition Phase of the acquisition process will require the HSI team to project the "To-Be" state of the future system, predict performance, and determine the requirements to achieve this level of performance. This may involve similar team members as the Options Analysis phase, or new participants may start to get involved to conduct evaluations using models, simulations, or field trials, or to conduct more focused technical analysis of the preferred option. Team members will continue to be lead by DND personnel, but may also continue to include any number of contractors as well. The output of this process will be the establishment of agreements and communication patterns between all team members and the initiation of definition tasks.

3.2 Update Project Scenarios and Measures

The project scenarios used in the Options Analysis phase may require updating based on lessons learned during the previous phase, or may require extension to cover a wider range of operational and maintenance scenarios when analyzing the primary option. The output of this process will be an update to the scenarios for the project.

3.3 Update Organization and Workflow Analysis

The organization and work flow analysis for the preferred option will need to be updated to reflect any lessons learned during the options analysis phase, or to address any changes to the operational scenarios. If modeling or simulation has been used this analysis may involve conducting further "what if" analysis (in terms of re-allocation between human and machine, or between the different humans involved in operation and maintenance) in an attempt to further refine the focus of the project concepts. The output of this activity will be projections of the staff complement for the future system, in addition to projections of high level task performance. High risk areas, performance bottlenecks, and human error opportunities may also be defined or refined as a result of this updated analysis.

3.4 Update Workspace and Interface Analysis

The updated organization, and work flow information will be used to develop an updated workspace and interface analysis for the project. This may involve obtaining more detailed information from potential vendors of the preferred option for the future system and starting to determine what requirements will be key differentiates in estimating future system performance. This process may involve photographs, drawings, CADD representations, virtual 3D reviews, simulations, or field trials using COTS products. The workspace and interface representations used on the project will allow the human factors engineering staff to evaluate workspace layout and interface task demands, allow the training staff to evaluate the future knowledge and skills required to evaluate the various interface classes, allow the system safety and health hazard staff to assess the risk of hazards within the operational environment.

3.5 Update TAD

The Target Audience Description should be updated at this time to project what the future characteristics of the operator and maintainer population should be, identifying any gaps between the current TAD an the Projected TAD, linking these gaps to the requirements for changes in recruitment, staffing, and training to fill them.

3.5 Conduct Task Analysis

The human factors engineering community is likely to conduct more detailed task analysis at this phase of the project, as might the Training, Safety, and Health Hazard communities depending on the level of task behaviour understanding they will require to finalize the definition of performance and safety requirements for the upcoming procurement. This analysis process may involve photographs, drawings, CADD representations, virtual 3D reviews, simulations, or field trials using COTS products to assist in the development of a more detailed level of task performance insight. The output of this process will be an enhanced requirements set.

3.6 Update HSI Risks and Requirements

As a result of more detailed assessment of the system to be procured, each HSI domain will have a refined set of risks and requirements. Risk should be integrated into the project Risk Management process. Requirements should be documented as true requirements in the SOR, or as performance specifications as the basis for part of the project procurement documents.

3.7 Develop HSI Evaluation Criteria

Each set of requirements and performance specifications developed will need to be evaluated at some point in the remainder of the project, either during bid evaluation or during acceptance of the final selected system. Therefore each specification requires the development of evaluation criteria. In some cases the development of evaluation criteria will require the development of the evaluation method (eg: it may be necessary for bidders to submit 3D CADD representations of their primary work space so that virtual walk-throughs can be conducted to evaluate human factors engineering and safety concerns). The output of this process will the HSI input to the project bid evaluation strategy and the evaluation plan.

3.8 Develop HSI Inputs to Procurement Documents

All requirements, specifications, evaluation measures, evaluation criteria, and weights will be integrated into the procurement documents for the project. The HSI team will be responsible for formalizing their portion of these documents and negotiating with contracting authorities about the approach taken and the fairness of the evaluation process.

3.9 Update HSI Plan

The HSI Plan will be updated at the end of the Definition phase of the acquisition to provide an enhanced substantive estimate for the implementation phase as part of the updated ESMP and a component of the updated Project Management Plan (Implementation).

4. HSI Evaluation, Verification, Validation, and Assurance

Each DND material acquisition project passes through an implementation phase where requirements and evaluation criteria are used to select a system among competing bids, contracts are signed with a vendor to produce the system, the project team monitors and evaluates production, and then DND finally accepts delivery.

During this period the HSI team must continue to manage the requirements and processes they have specified for the project. This involves the *evaluation* of candidate systems against HSI requirements and performance specifications, monitoring contractor/vendor HSI activities, *verifying* that HSI requirements have been met and *validating* that HSI performance measures were accurate, acceptable, and achievable. Throughout, any HSI related trade-off analysis must be conducted by the HSI team to *assure* that overall HSI related quality is maintained. These activities will involve a range of monitoring, evaluation, and testing activities in concert with requirements management activities which are standard across all engineering disciplines.

Once the final system has been delivered to DND it will be provided to the end users. This places the system in control of operational units (in many cases) on a day to day basis and a Life Cycle Materiel Manager from an NDHQ perspective. These new "owners" require a wide range of background information in each HSI domain to ensure that the system is operated and maintained as it was specified and selected, and to ensure that operation and maintenance staffing and procedures take best advantage of the strengths and weaknesses of the final system selected.

During this process the HSI contribution will answer a number of questions, such as:

- How well does each bidder meet HSI requirements?
- Does the winning vendor have a sufficient HSI capability in place?
- Is the system being developed or manufactured to the agreed upon HSI criteria?
- Is the system training being developed according to specifications, and will it achieve the training goals established?

- Is the system being developed going to achieve the necessary HSI performance levels?
- Where estimates and predictions about ease of learning, human task performance, workload, safety, and health hazards correct? If not do adjustments need to be made to the requirements or the design or the deployment concept for the system?

During this process the following HSI outputs will be generated:

- HSI Bid Evaluation Report(s).
- HSI Approvals of Relevant Design Changes.
- HSI Test Plans and Reports.
- HSI Review Progress and Evaluation Memos and Reports.
- HSI Hand Over Material.

SUB-PROCESSES

4.1 Establish HSI Implementation Team

During the implementation phase the HSI Team may remain large during the bid evaluation portion, but it may then drop off as the products are produced and delivered to DND. This is often the case in COTS based procurement, however, in a developmental system such as a command and control software based project the HSI team may increase in size as more evaluations of task performance, staffing, and system safety are required (in conjunction with the vendors HSI teams) in order to ensure that requirements are met. Either way, the HSI Team will need to be established for the Implementation Phase, with contracts and communications established between all parties prior to conducting analysis activities, and the implementation of this phase of the HSI Plan.

4.2 Evaluate HSI Aspects of Project Bids

Once vendor bids are received by the project team, the HSI aspects of the bids will need to be evaluated by the HSI team. This evaluation may be a document based assessment of system descriptions and the vendors HSI related capability, or it may involve evaluation of CADD drawings or models using special tools, or it may involve a straightforward comparison of COTS products with potential users during field trails to evaluate operability, maintainability, learnability, safety, and health hazards, etc.. The output of this process will the HSI evaluation report as one input into the overall project evaluation report.

4.3 Monitor System Development

Once a winning vendor is selected and contracts are signed the vendor will start to develop the system and work to deliver it to DND. During this process the HSI team must monitor the HSI aspects of system and training development by the vendor, and respond to any queries related to trade offs that must be made. On a pure COTS procurement this will be straightforward and last for a short duration, while on a complex system development project this monitoring may involve the requirement for constant analysis, studies, and evaluations and requirements re-work. The output of this process will be memos, reports, and guidance to the project management and procurement personnel to assist with project monitoring and the approval of engineering changes and vendor payments.

4.4 Verify, Validate, and Manage HSI Requirements

During the monitoring process the HSI team will be required to verify the final product (or versions of the product if it is being developed by the vendor) meets the stated HSI requirements and to track the history of this evaluation, preferably through the use of computer based requirements management tools. In development projects the HSI team may also have to conduct user based trials and evaluations (using mockups, prototypes, or built systems) to validate that the predicted requirements were in fact correct and truly achieve the desired performance levels. Throughout this process a number of trade-offs may have to be assessed and changes to requirements may have to be negotiated with the Project Director. The outputs of this process will be memos, reports, and guidance to the project management and procurement personnel to assist with project monitoring and the approval of engineering changes and payments.

4.5 Conduct HSI Acceptance Tests

If final product acceptance tests are required for the system being delivered, or evaluations of "First Off Line" production units, then the HSI Team must conduct acceptance evaluations. This will include final evaluation and acceptance of any vendor developed training programs that are going to accompany the system when it is delivered, as well as final safety and health hazard assessments.

4.6 Monitor Establishment of Training

The delivery of a new system is often associated with training that has been approved during the implementation phase of the project. The hand over of the system to the operational units must ensure that the planned training system is put in place. This process may involve simple review of manuals to be delivered with personal kit items, or it may involve final acceptance of full scope simulation facilities combined with industry contracted teams to deliver operator or maintainer training for many years to come. The output of this final hand over activity will be active training programs in the required areas.

4.7 Conduct Hand Over Meetings Within Each HSI Domain

Each of the HSI Domains that are active during the acquisition and delivery process has a "peer group" on the operational unit side that should receive a hand over briefing on the system they are receiving. For example:

- Human Factors Engineering staff will have information related to function allocation, roles, task performance, workload, etc. that will be of interest to commanders and those responsible for development of procedures and doctrine.
- Training will obviously need to pass across the training program that has been developed.
- Staffing will need to hand over selection requirements, in addition to being able to provide guidance on unit organization to those developing operations or maintenance doctrine for the system.
- System Safety and Health Hazard will need to pass on the design assumptions for health and safety to the operational health and safety community for integration into existing local OH&S programs.

5. Conduct HSI Monitoring

The Life Cycle Manager for a system in NDHQ, in addition to the responsible Requirements Directorate are both charged with monitoring the status of a system through its life cycle. This activity must include monitoring HSI related variables, preferably through the tracking of issues and incidents in electronic databases to facilitate more rapid procurement of future systems or related system upgrades.

As a result of this monitoring process a number of questions will be answered, such as:

- Is the system meeting task performance, workload, training, staffing, safety and health hazard performance levels?
- Are there any concerns with staffing concepts, work flow (doctrine), workstation design, interface design, training design, safety, or health hazards with the system?
- What incidents or accidents have occurred with the system that should be avoided in future systems or upgrades to this one?
- Have other countries had a similar experience with this or similar systems?

During this process the following HSI outputs will be generated:

- Reports of HSI related Deficiencies to the LCMM or requirements officer.

SUB-PROCESSES

5.1 Monitor Human Performance

The monitoring staff should review documentation related to the actual performance levels achieved by personnel using the system, and the standards that they are able to maintain. This data will come through exercise reports, and data from training schools, as well as through after action reports and deployment lessons learned.

5.2 Monitor Incidents and Accidents

If and when accidents happen related to the health and safety of the operators and maintainers of the system, or events that occur as a result of human error, these must be recorded, reported and tracked such that the monitoring staff can detect their occurrence. This can be done through paper based reports circulated to the LCMM and Requirements Directorate, but is preferably conducted using electronic databases.

5.3 Conduct User Surveys

Monitoring staff have the option of conducting regular user surveys of both operator and maintainer staff across the forces for the system they are responsible for. Increasingly tools are available that permit the rapid creation of surveys that can be mounted on the Defence Information Network (DIN) such that users across the country can quickly logon and provide feedback as required. At times, focused evaluations may warrant surveys followed up by focus groups in order to fully analyze deficiencies with the current system.

5.4 Monitor International Literature

There are few unique systems being deployed in the military community, and therefore monitoring the literature can provide insights into concerns with similar systems in other nations.

5.5 Monitor Disposal Process

At some point the life cycle for the system will end, and there may be equipment that must be disposed of. From an HSI perspective this process includes the requirement for some monitoring from a health hazard assessment perspective, depending on the system components being broken down and decommissioned.

Annex B:
HFE Process Description

HFE

Lessons Learned and HFE Deficiencies

Early HFE activities involve gathering information on the in-services equipment, system etc. and the concept for the new equipment, system. Information for existing systems includes "lessons learned" type information from operator/maintainer experience reviews and historical data or accident reports etc. A list of HFE issues and deficiencies is developed for consideration in the new systems. The HFE deficiency list may be included in the Statement of Capability Deficiency (SCD) portion in SS(ID).

HFE Baselines are also established to identify major HFE issues for the operation and maintenance of the current equipment, system resulting from initial project goals or constraints such as personnel, manning or operational requirements. Preliminary Mission and Function Analysis work may also be required to establish HFE baselines.

Inputs: Project team, Subject Matter Experts, similar historical project or in-service lessons learned information, Operational Concept information

Outputs: Information for use in the HFEPP, the SCD and the SOR

Develop HFEPP

A Human Factors Engineering Program Plan (HFEPP) establishes HFE involvement in the project throughout the development cycle. The PD will ensure the HFEPP considers the work of the other all other HSI disciplines (Training, Personnel and Manpower, System Safety and Health Hazard Assessment) to reduce duplication of efforts. Major areas covered by the HFEPP include management and control; major tasks and milestones; initial costs and scheduling; preliminary HFE issues; possible Guidelines, Standards; High Level Human Performance Requirements and Measures and channels of communication between disciplines. The HFEPP is updated as the project progresses.

Inputs: Project team, Lessons Learned and HFE Deficiencies, any Operational Concept information

Outputs: HFEPP, information for use in the SOR

Mission & Function Analysis, Function Allocation

Mission and Function Analysis are core areas of the HFE Analysis. The results of these and subsequent analyses contributes to all HSI domains throughout the project. Mission Analysis establishes the operational role and boundaries for the equipment, system or product. It usually begins with the Defence Planning Guidance scenarios as the base, which is refined to decompose a series of scenarios that when analyzed will establish a clear understanding of what, where, when and under what conditions the system will be required to perform to achieve its goals.

Function Analysis begins with the identification and hierarchical decomposition of the key system functions to accomplish the goals of the mission(s). Decomposition continues to the point where a determination in function assignment is required between human operators or machines.

Function Allocation is the systematic evaluation of each system function to determine weather the function should be performed by an operator or a machine (hardware/software sub-system) i.e. with consideration given to safety, operational performance requirements and to the capabilities and limitations of humans and machines. The results of these analyses and allocations identify the key interfaces between human operators/maintainers and machines.

One benefit of this analysis is that the operator/maintainer interfaces (OMIs) are linked to operational requirements. In addition, outline requirements for manpower, personnel and training are established. Any subsequent change in the operational requirements can be traced downward to determine the impact on the system's functional capabilities and operator interfaces. Conversely, restrictions placed on manning, costing etc. can be traced upward to determine the impact on operational capabilities. In both cases the Mission and Function analysis provides a decision support framework for trade-off analysis and studies.

Input: Project team, significant SMEs input, SOR

Output: Mission and Function Analysis and Function Allocation documents, information for use in Tasks Analysis, Manpower, Personnel and Training Estimates

Preliminary Tasks Analysis, Task Analysis

Task Analysis is a fundamental process used when establishing Operator Machine Interfaces (OMIs) that contribute to effective, efficient, safe and reliable system performance. The first step in task analysis is the hierarchical decomposition of each function into its component tasks. Each task is described and the following characteristics are determined and documented: inputs, outputs, relationships to other tasks, performance requirements, physical and cognitive demands etc. Tasks identified as being critical may be subject to more detailed analysis that often involves determining detailed task requirements such as information, sensory-motor, cognitive workload, task performance, communication and training. Task analysis also demonstrates the relationships to other tasks, operators and systems in order that overall crew, sub-system and system operation can be analyzed.

Task analysis is an iterative process that is performed early on to contribute to preliminary design and later in more detail as the design options progress and as critical tasks are identified. Outputs are provided to training, manpower and personnel to develop and refine training, organizational and unit concepts, manpower and personnel estimates. This allow for integrated project iterations and reduced duplication of efforts.

Some detailed task analysis activities include:

Human Performance Prediction

Detailed task analysis often involves predicting human performance for individual operators and in integrated crew environments. The purpose is to predict how well operators will perform the required tasks without exceeding their limitations (cognitive, sensory and physical). Where performance is low and/or where limitations are exceed, these tasks are analyzed in more detail and design concepts, including re-allocation of functions to machines and/or addition of manpower are considered and traded-off with continued analysis.

Error Analysis

Tasks involving human operator are identified where there is a significant task failure or inadvertent execution. These tasks are examined to determine the factors contributing to human error within the performance requirements of each task under likely operational conditions. Error analysis is integrated with system safety and health hazard assessment analysis.

Inputs: Mission and Function Analysis and Function Allocation documents, SMEs, operational and procedural documentation, training manuals.

Outputs: Task Analysis, information for use in manpower and personnel estimates, training, safety and health hazard analysis, OMI identification/design, work space concept/design requirements

OMI Identification, OMI & Work Space Concepts

Concepts for OMI & Work Space design are developed after clear identification of the key OMIs. These preliminary design activities involve developing concepts based on the function allocation and task requirements, HFE principles, standards/handbooks/guidelines and SME involvement. Note that in many cases involving new or novel system, these concepts must be developed in conjunction with the Tasks Analysis. Concept development provides a framework for trade-off analysis during Options Analysis.

Inputs: Project Team, SMEs, SOR, Task Analysis

Output: Input for OMI Design, Training, Manpower and Personnel estimates and analysis.

Human Performance Requirements and Specifications

Human Performance Requirements in all areas where humans interact with the system can be specified in the SOR. These requirements and/or specifications are based on the HFE analysis and studies at the time of SOR input e.g. as the project develops the human performance requirements will be drawn from the detailed task analysis rather than the preliminary task analysis.

Similarly, Human Performance Specifications contribute to the project's performance specifications. These requirements must be unambiguous and contain evaluation measures as they are used in both contract award decisions and system evaluation and testing.

Inputs: system performance requirements, Task Analysis, HFE Principles/guidelines/standards

Outputs: Requirements in for SOR, and specifications System Specifications

OMI Design & Workspace Guidance & Documentation

Detailed HFE design support is provided for the development of the remaining concept during Definition and Implementation. This detailed design process involves the application of HFE principles, HFE analysis and studies, guidelines, specifications, handbooks, may involve Research and Development studies and significant operator involvement during interface, sub-system or system evaluation. Design guidance is provided to the project team to provide hardware and software to ensure that HFE and operator requirements are incorporated in the.

In Defence projects some of this work may be done by DND personnel, but increasingly much of it will be performed by the contractors providing the system to DND. Even during the Definition Phase of a project there is an increasing role for contractors to conduct this level of analysis under direction from DND.

Some detailed OMI & Workspace Design guidance activities include:

Mockups, Simulations & Prototypes

At each stage of design it is crucial to engage operators/maintainers in system design to provide concept and design analysis, evaluation and testing. This often involves the use of models that progress in detail and complexity as the design progresses. In the early stages of design, operator reviews can be conducted using a variety of mockups e.g. paper based storyboards, CAD models or physical mockups. Later on, design reviews can use more sophisticated models including virtual and semi-realistic simulations right up to full blown system prototypes. Models can generally be rapidly reconfigure at relatively low cost allowing and so provide valuable human/system performance evaluation and testing support to the systems design process. In addition, the simulations often stay with the project providing a platform for future system modifications and as inputs to training and training development.

Inputs: SMEs, SOR, Performance Specifications, HFE Guidelines, Task Analysis, HFE Principles/guidelines/standards

Outputs: Design Guidance, System Specifications

Test and Evaluation Plan

System testing with "real" users will be established in the HFEPP at specific stages in the project. Documentation required prior to user evaluations is the Test and Evaluation Plan. It is likely that the Plan will mandate the use of HFE Data Item Descriptions (DID) that specify the format and major components of Test and Evaluation. In general the Plan will specify a systematic evaluation process including the test equipment, users and their characteristics, scenarios and tasks to be tested, methodology, procedures, performance expectations, test measures and experimental conditions and controls for the user evaluation.

Key evaluation activities are likely to include:

Conduct Operator Reviews

Conducting the operator review puts the Test and Evaluation Plan into effect. The reviews begin early in the project and involve test and evaluation using mockups, simulations and prototypes etc. Essential elements to successful operator reviews include: sufficient planning, selecting users that are representative of the target audience, system rehearsals prior to evaluation, providing sufficient familiarization and training prior to the evaluation, scenario and task based operator review tasks, performance measures and sound data capturing and feedback mechanisms.

User Acceptance Trials

User Acceptance Trials are a form of Operator Review conducted in later stages of design. They involve ensuring that the system meets Human Performance Requirements and Specifications under operational conditions within mission contexts. These trials tend to be more integrated and are conducted at the sub-system and system level rather than at the individual OMI and sub-system level evaluations conducted at early stages of design. Performance parameters include objective measures such as operator task performance requirements (speed, accuracy, quantity) and subjective measures such as utility, ease of use, compatibility, durability etc.

Inputs: Task Analysis, System Performance Requirements, SMEs

Outputs: User Trial Reports, Design Feedback

Annex C: Training Process Description

Training

Preliminary Needs Assessment, Needs Assessment

The Needs Assessment is core task for establishing the overall training requirement. It provides analysis to determine the minimum type and scope of training, or in some cases recommends other types of interventions, to effectively support maintenance and operation training for of the new system. A Preliminary Needs Assessment, conducted early in the process, is refined for Options Analysis where activities will focus on developing trade-off analysis for each option. The Needs Assessment is completed for the beginning of the Definition Phase and gives way to Training Analysis and Design. Key activities include reviewing project documentation to date including the SCD, the SOR and operational concepts and if applicable, the training program of the in-service equipment, system etc.

The review identifies all the personnel and their categories (military and civilian) for operation and maintenance of the system and the likely effect the new system will have on their positions and training requirements. This also requires a Preliminary Task Analysis to create a list of tasks associated with the identified personnel. In-service training is examined to determine its suitability for the new system. In either case, the Needs Assessment produces a concept and ROM costing for the minimum training requirements. In some cases where training is not the preferred option, recommendations for other interventions will be recommended.

Activities in the Needs Assessment include:

- Performance Analysis – reviewing the available project documentation to determine any shortfall in performance in the existing system or likely shortfall in performance in future systems.

- Cause Analysis – determining the reason(s) for the performance shortfall including the knowledge, skill and abilities of the population, the equipment or system or the operational environment or the organizational structure.

- Identify Solutions – proposing solution(s) that may contain a training component or other intervention to reduce the performance shortfall and achieve the target performance with the proposed system or equipment.

Inputs: SCD, SOR, existing system training program materials, Operational Concept information

Outputs: identification of occupations, number and level of training personnel, number and level of operator and maintainer personnel to be trained

Concept for Training Analysis

Activities for Training Analysis include developing the task analysis to make an initial identification of future qualifications and instructional programs, tentative qualifications and instructional requirements and estimate of cost to do this work. As the project progress, the estimates and identifications are refined.

Inputs: SCD, SOR, existing system training program materials
Outputs: initial identification of future qualifications and instructional programs, tentative qualifications and instructional requirements.

Concept for Training Design & Cost Estimate

Activities for Training Design include developing outline learning outcomes, instructional strategies, and initiation of the Training Implementation Plan. A Cost Estimation will be refined for all aspects of training design associated with the Life Cycle of the system.

Input: Cost Estimation, Training Concepts materials to this point, SCD, SOR, existing system training program materials
Output: concepts for learning outcomes, instructional strategies, an initial Training Implementation Plan, estimation of life cycle training costs

Training Analysis

Key activities in refining the training analysis are reviewing and confirming the Needs Assessment, refining the task analysis, developing performance objectives and developing concepts for all instructional programs (Initial Training Design: Initial Cadre, Conversion and Regeneration Training).

Inputs: Concept for Training Analysis, task analysis
Outputs: Performance Objectives, concepts for all instructional programs.

Training Design

Training Design activities are refined for each option with definition of the operator and maintainer characteristics, the preliminary instructional analysis, assessment plans and instructional strategies. Cost estimations at this point must be verified with the training and affected staff stakeholders.

Inputs: Concept for Training Analysis and Design, task analysis.
Outputs: Trainee characteristics definition , preliminary instructional analysis, assessment plans, instructional strategies, refine cost estimations

Qualification Quantitative Requirement

The project in conjunction with Director Military Human Resources Requirements (DMHRR), identifies the new or changed occupational categories of both military and civilian staff. This provides information necessary to create a substantive cost estimate.

Inputs: Training Analysis and Design to this point, consultation with DMHRR and stakeholders
Outputs: Qualification Quantitative Requirement, information for substantive cost estimate

Training Design & Development

When the system or design options is chosen, final Training Design is completed based on the system's technical, operation and maintenance manuals and procedures. The Development requires the detailed translation of analysis and designs into actual training materials and procedures. This requires a number of activities including: detailed definition of the numbers and categories of affected occupations or specialties, analysis of each task to define the knowledge and skills for each task, definition of Performance Objectives and Enabling Objectives, and lesson plans and materials.

These activities are performed in conjunction with the units, instructing authority, project team and contractors. Final development activities may include the acquisition of training materials such as multimedia presentations, instructional aides or even simulators.

Inputs: Training Analysis and Design to this point
Outputs: capability (materials and personnel) to deliver training to relevant operations and maintenance personnel

Conduct, Evaluate Training & Validate Training

The training delivery sequence is usually Initial Cadre Training, Conversion Training and Regeneration Training. Planning and scheduling with the appropriate maintenance and operations personnel at the units must be conducted prior to Delivery.

Training is monitored initially to workout any initial problems. In additions Trainees are evaluated to determine the success of the training in achieving its objectives. Revision to the training can be made as necessary.

When fully established, the overall training program including the costs are evaluated to determine its progress and efficiency. Major recommendations to improve the training for the system life cycle are made at this point.

Inputs: materials from Training Development, Trainees, assessment materials, Training program costs

Outputs: trained personnel, revised training

Reference Materials:

The Manual of Individual Training and Education. This is a series of 12 volumes that contains guidance on the Canadian Forces Individual Training and Education System (CFITES)

Annex D:
Manpower & Personnel Process Description

Manpower and Personnel

Lessons Learned & Manpower and Personnel Baseline

Manpower and Personnel activities at this early stage of the project involve gathering information on the current project, the system being replaced (or a similar system) to establish lessons learned and Manpower and Personnel Baseline. For Lesson Learned this will include any problems previous projects experienced at any project stage related to staffing to identify a series of issues for the current project staff to be aware of for project planning and development. In addition, a Manpower and Personnel Baseline is established that outlines the available staff and the characteristics of those personnel, for the new system based on operation and maintenance (and other support) of the current system.

Inputs: SMEs and historical Manpower and Personnel Analysis and Reports, project documentation to date (e.g. SCD, Draft SOR), Operational Concept information
Outputs: information for SOR, Organizational and Operational Concepts

Concept Staffing Constraints

The project will define a concept for staffing the new system over its life cycle. This establishes a goal for the project to achieve and is based on early projections of system requirements and future force structure and personnel characteristics. As the project develops the staffing concept provides the overall constraints or boundaries for detailed system and option analysis.

Inputs: SMEs and historical Manpower and Personnel Analysis and Reports, project documentation to date (e.g. SCD, Draft SOR)
Outputs: information for SOR, Organizational and Operational Concepts

Organizational and Operational Concept

Based on early project estimations, increasingly more refined estimates are made of the concept for the effect the new or upgraded system will have on the organization in terms of the number and type of civilian or military staff, required to operate, maintain, train and test the new system. This will include projections of the following 5 items:

- Staffing Goals & Constraints – Staffing goals for the life cycle of the project for operation, maintenance and training of the system and the relationship to the initial Manpower and Personnel Baseline.
- Staffing Estimates – The Staffing Estimate details the categories of personnel (occupation, rank, civilian etc.) their required characteristics (physical and cognitive requirements), and the concept of their employment (sustainment, maintenance and repair etc.) to operate and maintain the system to the required level of operational capability.
- Staffing Sensitivity Analysis – This analysis identifies the components of operations, maintenance tasks for the new system that will require significant maintenance or training and therefore require more staff or a change in training or recruiting.
- Cost Estimate – The cost estimate is based on the most current Manpower and Personnel analysis and provides the project with an estimate of the life cycle staffing costs.
- Trade-off Analysis – During Options Analysis, each potential system or equipment option is subjected to the following analyses: Organizational Concepts, Staffing Estimates and

Sensitivity. These analyses allow for a number of trade-off studies to be performed to investigate changes in cost and performance between the options.

Inputs: SMEs and historical Manpower and Personnel Analysis and Reports, project documentation to date (e.g. SCD, Draft SOR), task analysis

Outputs: staffing goals, constraints, analysis and cost estimates

Annex E:
System Safety Process Description

System Safety

SSPP Planning

The System Safety process attempts to identify hazards to safety and incorporate design requirements to eliminate, reduce or manage the risk associated with these hazards. The key steps included developing a clear understanding of the system, identifying and analyzing potential hazards, developing the means to eliminate or control the hazard, resolving the identified hazards, verifying hazard elimination or control effectiveness and repeating the process as required. A guiding standard for the system safety process is MIL-STD-882D Standard Practice For System Safety.

A framework for the creation of a System Safety Program Plan initiates the System Safety Process to ensure associated requirements are include at all phase of the project. This will also include establishing the “safety organization” and lines of communication and the acceptable level of mishap risk

Inputs: System and Mission Descriptions, draft SOR, Operational Concept information

Outputs: establishment of System Safety in the project

Safety Performance & Design Requirements

Safety Performance and Design Requirements are used to mandate safety in the project specifications. General safety requirements are established for the system by included them in the project specifications. Each performance or design specification should include the acceptable level of risk. The safety performance requirements can be expressed as quantitative requirements, mishap requirements and standardization requirements.

Safety design requirements are established to achieve pre-determined acceptable levels of risk through the use of regulations, standards, design handbooks and safety checklists etc.

Inputs: Project Staff (Systems Engineering), Program Requirements, SMEs , Acceptable Risk Levels, Historical Hazard and Mishap Data and Lessons Learned, System and Mission Descriptor

Output: applicable standards and guidelines and an initial identification of the key system safety issues.

Identify Hazards and Assessment of Mishap Risk

The hazard analysis process involves identify all potential Hazards and creating a Hazard List. Then each risk associated with a hazard is assessed in terms of its mishap risk (impact, probability, severity of hazard and priorities for corrective action and resolution). There are many tools and techniques in the hazard analysis process and are too numerous to discuss here. For details on these tools and techniques please see System Safety Analysis Handbook 2nd Edition.

Inputs: Project Staff (Systems Engineering), Program Requirements, SMEs , Acceptable Risk Levels, Historical Hazard and Mishap Data and Lessons Learned, System and Mission Descriptions, Task Analysis

Output: Hazard Assessment.

Risk Mitigation Measures

Using the system safety design order of precedence (eliminate through design, incorporate safety devices, provide warning devices and develop procedures and training) measure are develop to mitigate each of the identified and prioritized risks.

Inputs: Safety Engineering Analysis, Safety Guidelines and Standards etc.

Outputs: List of risk mitigation measures

Reduction of Mishap Risk and Verification of Mishap Risk Reduction

This activity requires that the project team agree on solutions (risk mitigation measures) and associated residual mishap risk brought about by the application of risk mitigation measures. As sub-systems are developed they are evaluated in order to verify the Mishap Risk Reduction effectiveness.

Inputs: Risk Mitigation Measures

Outputs: Verified Mishap Risk Reduction

Review of Hazards and Acceptance of Residual Mishap Risk

When the system is developed to the point where it integrated testing can be conducted and the overall Mishap Risk Reduction verified, the residual mishap risk must be reviewed, agreed upon and accepted by the project team.

Inputs: Verified Mishap Risk Reduction

Outputs: Acceptance of Residual Mishap Risk

Tracking of Hazards, Closures and Residual Mishap Risk

A tracking system is implemented as the system is fielded in order to provide a mechanism for reporting hazards and residual mishap risk throughout the life of the project.

Inputs: Operators and Maintainers through hazard tracking communication channels

Outputs: hazard tracking system, risk identification-risk mitigation

Annex F: Health Hazard Assessment Process Description

Health Hazard Assessment

Frame work for HHAR

The HHA process is used to eliminate or control potential hazards to humans caused by the introduction and use of a new system throughout the system life cycle. This includes health hazards associated with the operation, maintenance, support, production and testing of the system.

A framework for the creation of a Health Hazard Assessment Report initiates the HHA process and ensures HHA requirements are include at all phase of the project. This involves the following tasks:

- Identify Applicable Standards and Guidelines and previous HHARs
- Reviewing project documentation to date such as the Operational Concept and the Draft SOR

Inputs: Operational Concept and the Draft SOR

Outputs: inclusion of HHA in the project initiation of the HHA process

I/HHAR

Health Hazard Assessment activities in the Options Analysis/Definition phase include:

- Reviewing Operational Concept, Draft SOR documentation and preliminary task analysis to identify all potential health hazards (acoustical energy, radiation energy, vibration, biological substance, shock, trauma, oxygen deficiency, temperature extremes and chemical substances). Using this list of health hazards an initial risk assessment will be conducted with recommendations for initial risk mitigation measures.
- Refining Risk Assessment and Risk Mitigation Measures as the project options are developed. This culminates with the production of an Initial HHAR.

Inputs: Mission, Function and Preliminary Task Analysis, Draft SOR, System Specifications Test and Evaluation Plans and Documentation

Outputs: I/HHAR

Risk Reduction, Control or Elimination Recommendations

During the implementation phase the Risk Reduction, Control or Elimination Recommendations are tracked to ensure that they are including in the specifications and are implemented in the design. The implementation must take into account the integration with other domains such as manpower, personnel and human factors engineering.

Inputs: I/HHAR, System Specifications

Outputs: strategies/acceptance/implementation for and specifications for Risk Reduction, control or elimination

Update HHAR

Upon fielding, the Engineering Change Notices should be reviewed to determine their effect on Health Hazards and resulting risk. The HHAR is updated at appropriate times to include operational or equipment changes.

Inputs: engineering change notices

Outputs: updated HHAR, design changes

Annex D: HSI Process Development – Version 2

Version 2 of the Human Systems Integration (HSI) Process was not part of a required formal deliverable. The following document outlines the major steps that were generated during this phase of HSI Process development.

Annex D: Human Systems Integration (HSI) Process Development Version 2

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1 Conduct HSI As-Is Analysis

The sub-processes of the HSI As-Is Analysis phase are outlined below:

1.1 Identify HSI Resources

The initiation of the HSI process requires that HSI Resources be identified. Early in the project the focus will be on the human resources required and available to support the project. On small projects this may simply consist of identifying the sole HSI resource person for the project. On larger projects there may be small groups responsible for each HSI domain, with additional technical support in some areas from the Defence R&D community and industry. The primary output of this process should be the identification of the HSI leader and the contributors to early versions of the HSI Plan. However, depending on resource availability the output of this task may simply be the identification of HSI resources that can contribute to the development of early project plans and requirements development.

1.2 Describe Current System

The HSI community requires a description of the current system as a baseline for subsequent analysis. This description should summarize the operation and maintenance of the current system, including an outline of system components (personnel and equipment) and the workflow between them, along with key performance objectives. In some cases the goal of a new project might not be to replace an existing technical component in the system, however the area of operation likely to be impacted by the acquisition or development project must be understood and described. The output of this process will be a system description that may simply be a few pages of text that is re-used as the lead-in to a number of documents (small project) or it may be a document in itself that is referenced in the early phases of the project (larger projects). Other management and engineering domains are likely to require similar information, which means that a description of the current system may exist, or it may be developed by a number of members of an Integrated Project Team.

1.3 Develop Current System TAD

With the current system understood, and therefore the approximate "bounds" of the project defined, the HSI community must develop a Target Audience Description (TAD) of the current operation and maintenance personnel. This TAD will define the characteristics of operators and maintainers in terms of their numbers, training, skill levels, physical characteristics, selection criteria (eg: vision, strength, endurance, task skill levels), etc. The TAD will be developed through an analysis of existing records and/or through active survey and analysis of the operation and maintenance communities. Increasingly some elements of the "maintenance" community for military systems will be based in industry and will not include uniformed personnel, however, they should still be included in the TAD. The output of this process will be a data repository of operator and maintainer characteristics, which may exist as a document, a document section, or an actual database of information depending on the size of the project and the level of relevant TAD data already tracked and recorded.

At this point in the process the TAD will be used primarily to evaluate human factors engineering, training, and staffing issues. This baseline TAD will be used to compare with the project concept and any HSI constraints so that HSI risks related to staff levels, workload, training impacts, etc. can be estimated as early as possible and be included in the project planning. This in turn will assist with HSI resource and analysis requirements (eg: if it looks as though the project will not impact personnel numbers, or recruitment criteria certain analyses will not be required by human factors engineering, training, and staffing personnel).

1.4 Identify HSI Deficiencies

Any deficiencies with the current system must be identified in each of the HSI domains. In cases where tracking systems are in place (eg: safety and hazard incident databases) these deficiencies may be easier to obtain, whereas in a number of cases active analysis of the current systems may be required using document reviews, observation, questionnaires, and interviews to develop a structured assessment of current HSI related deficiencies. Increasingly HSI deficiencies also include human resource cost data, whereby force downsizing indicates that the numbers of personnel in larger systems must be reduced or the cost of training for very complex maintenance trades must be optimized in some fashion. The output of this analysis process will be a list of deficiencies that will passed to the Project Director for inclusion in project decision documents. This list of deficiencies will also form the HSI baseline for the project and the start of the requirements development process.

1.5 Describe Project Concept(s)

The HSI team will require a description of the current project concepts. It is likely that this description will come from the entire project team as a whole under the direction of the Project Director. However, at times the high level concept or the concept options may require further embellishment from the HSI team in the areas of staff organization, function allocation, task performance, training, or work spaces in order to "set the stage" for HSI analysis. The output of this process will be a description that will be re-used in a number of future documents and become part of the early HSI Plan.

1.6 Identify HSI Constraints

With the current system understood and the project framework defined, the HSI team must identify any HSI related constraints associated with the project concept. These constraints might include any limits on costs, limits on personnel (eg: the project cannot change the current personnel structure, or, the project must cut current maintenance personnel by 50%), limits on testing, forced integration with other projects or systems (eg: must re-use existing simulators for training). The outputs of this process will be a documented list of constraints which will be included in the HSI Plan and may be referenced by higher level strategic documents depending on the focus of the project (eg: some current naval projects list crew size constraints as one of the highest level project parameters in all of the highest level documents).

1.7 Determine HSI Risks and Requirements

Once the concept for the project is established, and the HSI constraints are identified, the HSI team must identify the high level, known, HSI risks and requirements. Risk should be documented in the HSI Plan and should also be documented in the project risk register so that the Project Director and Project Manager can include these in the overall Risk Management process and include them in decision documents such as the Project Profile and Risk Assessment (PPRA). Requirements should be recorded and passed to the Project Director to form part of early SOR versions. Preferably requirements are managed using electronic requirements management tools so that source, history, and evolution are tracked.

1.8 Develop HSI Plan

The high level project concept, constraints, risks and requirements and the project procurement strategy (if one has started to evolve) are used as the basis of determining the HSI Plan for the project. This plan will document what HSI analyses will be required, the organization and personnel required to conduct this analysis and manage the effort, the physical resources required for any analysis, access to operators and maintainers, the primary tasks, the integration of the HSI domains, schedule, budget, risks, and risk mitigation for the project. On a small project this may be the sole HSI plan that covers all HSI domains, while on larger projects this plan may focus much more on the integration of the HSI domains referencing the specific plans developed by each of the sub-domain specialist teams (eg: HFE, Training, Staffing, Safety, Health Hazard). Eventually, the HSI Plan will become part of the overall Engineering and Support Management Plan (ESMP) for the project, however, as many HSI analyses are initiated prior to systems engineering formally being established the plan may be an independent document used by the Project Director until later in the project.

2 Conduct HSI Options Assessment

The sub-processes of the HSI Options Assessment phase are outlined below:

2.1 Establish HSI OA Team

The HSI Options Assessment (OA) process begins with the establishment of the HSI team for this activity. This team may be different than the core HSI team and may include members of the R&D community, links to the operational research community, industry support through consultants or modeling and simulation teams, and the operator and maintainer communities. The members and organization of this team should have been defined in the HSI Plan developed earlier in the project, else it will need to be defined and assembled now. The output of this process will be the establishment of agreements and communication patterns between all team members and the initiation of assessment tasks.

2.2 Describe Project Options

The Options Analysis phase of a Defence project requires each of the project options to be compared from a cost-benefit perspective. The start of this analysis must consist of a description of each option. At a high level this description should exist and have been developed by the project team earlier. At this time each option needs to be described from a HSI perspective in order to facilitate the next phases of analysis. Each option needs a reasonable operation and support concept that allows the HSI team to describe key personnel, the key technology components of the system, the organization and work flow between components, the general workspace concepts for critical areas (if relevant) and the key human machine interfaces. The output of this process will be a description for each option (at a minimum) and may include photographs, diagrams, CADD drawings, models, mockups, prototypes or existing Commercial Off the Shelf (COTS) products if they exist.

2.3 Define Project Scenarios and Measures

The analysis of system options from a HSI perspective must be completed with the future operational and support scenarios for the project, using the operational and support concepts already defined. Therefore, the primary project scenarios must be defined and described along with the key performance measures within these scenarios. Project scenarios will be linked to defence scenarios at the high level defined in the Defence Planning Guidance (DPG). Detailed analysis of scenarios during HSI Options Assessment may not include all possible scenarios, but may only focus on one of two key scenarios that demonstrate the bounds of the project and exercise the areas of the system that are high risk or critical to future performance. In some cases a "generic" scenario may be developed that crosses many of the DPG scenarios within which the future system will be exercised. Each scenario description will define the system, the system configuration, the operation and support organization, the environment, the workflow, and the key measures. The output of this process will be a scenario description document that will be referenced by many analysts and which should be used throughout the project as the basis for human centred test and evaluation activities. Scenario descriptions and associated performance measures should also be referenced and linked to the appropriate sections in the project SOR.

2.4 Conduct Organization and Work Flow Analysis

Each of the major options should be analyzed, using the operational and support concept from an organization and work flow perspective. This analysis will be of interest to all HSI domains, but especially HFE, Training, and Staffing. On smaller projects this may consist of only one analysis that evaluates task performance, workload, knowledge and skill requirements, training requirements etc. for each option, while on larger projects each HSI domain may conduct their own specialty analysis using common option descriptions and common scenario sets. The benefits of HSI come in this area whereby the system missions, function and role allocations, and behavioral task descriptions are common needs of all HSI domains and offer cost effective analysis re-use in addition to shared technology based analysis tools. The output of this analysis will be integrated into an assessment report(s) for each option that documents the costs (personnel, training, workload, human error probabilities, etc.) and the benefits (task performance, cost minimization, workload or error avoidance, etc.) across the project scenarios. Increasingly models and simulations will be used for this level of analysis (for more developmental or complex projects) , in addition to field trials (for COTS based projects).

2.5 Conduct Workspace and Interface Analysis

Each of the major options should be analyzed, using the operational and support concept from a workspace and interface perspective. This analysis will be of interest to all HSI domains, but especially HFE, Training, System Safety, and Healthy Hazard Assessment. The focus of workspace and interface analysis will be an assessment of the efficiency and safety of the workspace (if relevant) and the impact of the proposed interface concepts on task performance and future training requirements. This analysis may be conducted using drawings, models, prototypes, or mockups as the basis, or it may involve actual COTS products in other situations. The output of this analysis will be integrated into an assessment report(s) for each option that documents the costs (personnel, training or skill retention costs, workload, human error probabilities, safety hazards, etc) and the benefits (task performance, cost minimization, hazard avoidance, etc.) across the project scenarios.

2.6 Conduct and Document HSI Trade-Off Analysis

The analysis of each option within each HSI domain will generate a series of cost - benefits within each domain (eg: training costs or training benefits of each option). These cost - benefits will then be summarized. However, there is also the opportunity to conduct trade-off analyses across the HSI domains as an additional input to the option assessment. For example, one option may make extensive use of function re-allocation to new technology that shows workload and human error benefits in the human factors engineering assessments but that show high training costs and enhanced selection criteria in the Training or Staffing analysis. On the other hand, another option may involve a low tech retrofit to the existing system which has little to no impact on training, but it will not reduce crew workload or eliminate some existing safety and hazard concerns associated with too many crew in a constrained space. This form of analysis must be done from a life cycle cost (LCC) and benefit perspective, and should be integrated with any additional LCC activities being conducted by the Integrated Logistics and Support (ILS) community. All of the HSI domains frequently trade-off in this fashion, and documentation of HSI trade off analysis as part of the overall HSI Options Assessment Report provides an additional, and highly beneficial tool to guide senior management decision making.

2.7 Document HSI Cost-Benefit Assessments

Following analysis of each option within each HSI domain, the overall cost-benefits of each option must be summarized and integrated into a HSI Options Assessment Report, which will become part of or referenced in the overall project Options Analysis report that will be summarized in the Synopsis Sheet Preliminary Project Approval SS(PPA) at the highest level as the basis for the recommended option for the project.

2.8 Document HSI Risks and Requirements

As a result of option analysis, a number of risks and requirements and performance measures will have been further developed, especially those linked with the preferred option. Risks should be documented within the project risk management process, while requirements and performance measures should be recorded and linked into the update of the project SOR, hopefully integrated using an electronic requirements management tool.

2.9 Update HSI Plan

Once the preferred option is selected, and further information on the project procurement strategy is developed, the HSI Plan must be updated to provide more substantive estimates for the next phases of the project. Sometime during the Options Analysis or Definition Phase, the HSI Plan will become a component of the Engineering and Support Management Plan (ESMP) as the Project Manager and engineering support staff (systems engineering and ILS) increase their level of project involvement.

3 Conduct HSI To-Be Analysis

The sub-processes of the HSI To-Be Analysis phase are outlined below:

3.1 Establish HSI Definition Team

The Definition Phase of the acquisition process will require the HSI team to project the "To-Be" state of the future system, predict performance, and determine the requirements to achieve this level of performance. This may involve similar team members as the Options Analysis phase, or new participants may start to get involved to conduct evaluations using models, simulations, or field trials, or to conduct more focused technical analyses of the preferred option. Team members will continue to be led by DND personnel, but may also continue to include any number of contractors as well. The output of this process will be the establishment of agreements and communication patterns between all team members and the initiation of definition tasks.

3.2 Update Project Scenarios and Measures

The project scenarios used in the Options Analysis phase may require updating based on lessons learned during the previous phase, or may require extension to cover a wider range of operational and maintenance scenarios when analyzing the primary option. The output of this process will be an update to the scenarios for the project.

3.3 Update Organization and Workflow Analysis

The organization and work flow analysis for the preferred option will need to be updated to reflect any lessons learned during the options analysis phase, or to address any changes to the operational scenarios. If modeling or simulation has been used this analysis may involve conducting further "what if" analyses (in terms of re-allocation between human and machine, or between the different humans involved in operation and maintenance) in an attempt to further refine the focus of the project concepts. The output of this activity will be projections of the staff complement for the future system, in addition to projections of high level task performance. High risk areas, performance bottlenecks, and human error opportunities may also be defined or refined as a result of this updated analysis.

3.4 Update Workspace and Interface Analysis

The updated organization and work flow information will be used to develop an updated workspace and interface analysis for the project. This may involve obtaining more detailed information from potential vendors of the preferred option for the future system and starting to determine what requirements will be key differentiates in estimating future system performance. This process may involve photographs, drawings, CADD representations, virtual 3D reviews, simulations, or field trials using COTS products. The workspace and interface representations used on the project will allow the human factors engineering staff to evaluate workspace layout and interface task demands, allow the training staff to evaluate the future knowledge and skills required to evaluate the various interface classes and allow the system safety and health hazard staff to assess the risk of hazards within the operational environment.

3.5 Conduct Task Analysis

The human factors engineering community is likely to conduct more detailed task analyses at this phase of the project, as might the Training, Safety, and Health Hazard communities, depending on the level of task behaviour understanding they will require to finalize the definition of performance and safety requirements for the upcoming procurement. This analysis process may involve photographs, drawings, CADD representations, virtual 3D reviews, simulations, or field trials using COTS products to assist in the development of a more detailed level of task performance insight. The output of this process will be an enhanced requirements set.

3.6 Update HSI Risks and Requirements

As a result of more detailed assessment of the system to be procured, each HSI domain will have a refined set of risks and requirements. Risk should be integrated into the project Risk Management process. Requirements should be documented as true requirements in the SOR, or as performance specifications as the basis for part of the project procurement documents.

3.7 Develop HSI Evaluation Criteria

Each set of requirements and performance specifications developed will need to be evaluated at some point in the remainder of the project, either during bid evaluation or during acceptance of the final selected system. Therefore each specification requires the development of evaluation criteria. In some cases the development of evaluation criteria will require the development of the evaluation method (eg: it may be necessary for bidders to submit 3D CADD representations of their primary work space so that virtual walk throughs can be conducted to evaluate human factors engineering and safety concerns). The output of this process will be the HSI input to the project bid evaluation strategy and the evaluation plan.

3.8 Develop HSI Inputs to Procurement Documents

All requirements, specifications, evaluation measures, evaluation criteria, and weights will be integrated into the procurement documents for the project. The HSI team will be responsible for formalizing their portion of these documents and negotiating with contracting authorities about the approach taken and the fairness of the evaluation process.

3.9 Update HSI Plan

The HSI Plan will be updated at the end of the Definition phase of the acquisition to provide an enhanced substantive estimate for the implementation phase as part of the updated ESMP and a component of the updated Project Management Plan (Implementation).

4 HSI Evaluation, Verification, Validation, and Assurance

The sub-processes of the HSI Evaluation, Verification, Validation, and Assurance phase are outlined below:

4.1 Establish HSI Implementation Team

During the implementation phase the HSI Team may remain large during the bid evaluation portion, but it may then drop off as the products are produced and delivered to DND. This is often the case in COTS based procurement, however, in a developmental system such as a command and control software based project the HSI team may increase in size as more evaluations of task performance, staffing, and system safety are required (in conjunction with the vendors HSI teams) in order to ensure that requirements are met. Either way, the HSI Team will need to be established for the Implementation Phase, with contracts and communications established between all parties prior to conducting analysis activities, and the implementation of this phase of the HSI Plan.

4.2 Evaluate HSI Aspects of Project Bids

Once vendor bids are received by the project team, the HSI aspects of the bids will need to be evaluated by the HSI team. This evaluation may be a document based assessment of system descriptions and the vendors HSI related capability, or it may involve evaluation of CADD drawings or models using special tools, or it may involve a straightforward comparison of COTS products with potential users during field trails to evaluate operability, maintainability, learnability, safety, and health hazards, etc. The output of this process will be the HSI evaluation report as one input into the overall project evaluation report.

4.3 Monitor System Development

Once a winning vendor is selected and contracts are signed, the vendor will start to develop the system and work to deliver it to DND. During this process the HSI team must monitor the HSI aspects of system and training development by the vendor, and respond to any queries related to trade offs that must be made. On a pure COTS procurement this will be straightforward and last for a short duration, while on a complex system development project this monitoring may involve the requirement for constant analyses, studies, and evaluations and requirements re-work. The output of this process will be memos, reports, and guidance to the project management and procurement personnel to assist with project monitoring and the approval of engineering changes and vendor payments.

4.4 Verify, Validate, and Manage HSI Requirements

During the monitoring process the HSI team will be required to verify the final product (or versions of the product if it is being developed by the vendor) meets the stated HSI requirements and to track the history of this evaluation, preferably through the use of computer based requirements management tools. In development projects the HSI team may also have to conduct user based trials and evaluations (using mockups, prototypes, or built systems) to validate that the predicted requirements were in fact correct and truly achieve the desired performance levels. Throughout this process a number of trade-offs may have to be assessed and changes to requirements may have to be negotiated with the Project Director. The outputs of this process will be memos, reports, and guidance to the project management and procurement personnel to assist with project monitoring and the approval of engineering changes and payments.

4.5 Conduct HSI Acceptance Tests

If final product acceptance tests are required for the system being delivered, or evaluations of "First Off Line" production units, then the HSI Team must conduct acceptance evaluations. This will include final evaluation and acceptance of any vendor developed training programs that are going to accompany the system when it is delivered, as well as final safety and health hazard assessments.

4.6 Monitor Establishment of Training

The delivery of a new system is often associated with training that has been approved during the implementation phase of the project. The hand over of the system to the operational units must ensure that the planned training system is put in place. This process may involve simple review of manuals to be delivered with personal kit items, or it may involve final acceptance of full scope simulation facilities combined with industry contracted teams to deliver operator or maintainer training for many years to come. The output of this final hand over activity will be active training programs in the required areas.

4.7 Conduct Hand Over Meetings Within Each HSI Domain

Each of the HSI Domains that are active during the acquisition and delivery process has a "peer group" on the operational unit side that should receive a hand over briefing on the system they are receiving. For example:

- Human Factors Engineering staff will have information related to function allocation, roles, task performance, workload, etc. that will be of interest to commanders and those responsible for development of procedures and doctrine.
- Training will obviously need to pass across the training program that has been developed.
- Staffing will need to hand over selection requirements, in addition to being able to provide guidance on unit organization to those developing operations or maintenance doctrine for the system.
- System Safety and Health Hazard will need to pass on the design assumptions for health and safety to the operational health and safety community for integration into existing local OH&S programs.

5 Conduct HSI Monitoring

The sub-processes of the Conduct HSI Monitoring phase are outlined below:

5.1 Monitor Human Performance

The monitoring staff should review documentation related to the actual performance levels achieved by personnel using the system, and the standards that they are able to maintain. This data will come through exercise reports, and data from training schools, as well as through after action reports and deployment lessons learned.

5.2 Monitor Incidents and Accidents

If and when accidents happen related to the health and safety of the operators and maintainers of the system, or events that occur as a result of human error, these must be recorded, reported and tracked such that the monitoring staff can detect their occurrence. This can be done through paper based reports circulated to the LCMM and Requirements Directorate, but is preferably conducted using electronic databases.

5.3 Conduct User Surveys

Monitoring staff have the option of conducting regular user surveys of both operator and maintainer staff across the forces for the system for which they are responsible. Increasingly tools are available that permit the rapid creation of surveys that can be mounted on the Defence Information Network (DIN) such that users across the country can quickly logon and provide feedback as required. At times, focused evaluations may warrant surveys followed up by focus groups in order to fully analyze deficiencies with the current system.

5.4 Monitor International Literature

There are few unique systems being deployed in the military community, and therefore monitoring the literature can provide insights into concerns with similar systems in other nations.

5.5 Monitor Disposal Process

At some point the life cycle for the system will end, and there may be equipment that must be disposed of. From a HSI perspective this process includes the requirement for some monitoring from a health hazard assessment perspective, depending on the system components being broken down and decommissioned.

Annex E: HSI Concept of Operations

The Human Systems Integration (HSI) CONOPS resulted in the official publication of the 3rd Version of the HSI process. This Concept of Operations is currently in **DRAFT** form. **The current version of the HSI Concept of Operations rests with ADM(Mat)'s DMPP 5-7.**

ADM(Mat) / DMASP

MATERIEL ACQUISITION AND SUPPORT (MA&S)

Concept of Operations

Human Systems Integration

Creation Date:	**23rd April 2004**
Version:	**Draft 1b**
OPI:	**DMASP 5-7**

Table of Contents

Concept of Operations – Human Systems Integration

1 Aim

The aim of this Concept of Operations (CONOPS) is to define the high level DND processes for Human Systems Integration (HSI) in the materiel lifecycle.

2 References

A. MIL-HDBK-46855A (1999). Human Engineering Program Process and Procedures.
B. IEEE 1220-1998 (1994). Standard for Application and Management of the Systems Engineering Process.
C. Booher, H.R. (Ed.) (2003). Handbook of Human Systems Integration. John Wiley & Sons, New Jersey, USA.
D. A-P9-000-001/PT-000. (1997). Canadian Forces Manual of Individual Training and Education Volume 1. Canadian Forces Individual Training and Education System: Introduction /Description.
E. Concept of Operations: Synthetic Environment Based Acquisition (SEBA) – DRAFT.
F. DAOD 8008-0. Modelling and Simulation – DRAFT.
G. Concept of Operations: Supportability – DRAFT.
H. Concept of Operations: Requirements Management – DRAFT.
I. Concept of Operations: Reliability and Maintainability – DRAFT.
J. DAOD 3012-0. Software Engineering.
K. DAOD 3023-0. Systems Engineering – DRAFT
L. DAOD 3011-0. Test and Evaluation – DRAFT
M. Concept of Operations: MA&S Knowledge Transfer – DRAFT

3 Scope

The main focus of this CONOPS is on HSI in materiel acquisition as defined by the Materiel Acquisition and Support (MA&S) Model, which includes the in-service and disposal lifecycle phases in addition to the acquisition phase. However, this CONOPS also considers HSI in Research and Development, as it is a primary support domain in the materiel lifecycle. Strategy and Policy for HSI in DND are described.

The initial HSI process for DND has been developed as a R&D effort through the Defence Reseach and Development Canada (DRDC) corporate office. The USA and the UK have established HSI processes and Canada has liaised with these Nations in developing the DND HSI process.

This Concept of Operations is a living document and is subject to change as the MA&S business processes evolve.

4 Key Definitions and Terms

Human Systems Integration (HSI) - The technical process of integrating the domains of Human Factors, Personnel, Training, Systems Safety, and Health Hazards, into the materiel lifecycle to ensure safe and effective operability and supportability.

HSI domains - The DND HSI process has five domains concerning the human components of systems. These domains are: Personnel, Training, Human Factors, Health Hazards and System Safety. The number of HSI domains and the terms used to describe them may differ in other nations.

Personnel domain - This domain concerns both manpower and personnel characteristics. Manpower concerns the availability, numbers and types of personnel required to operate, maintain, train and sustain the system. Personnel characteristics are the attributes (cognitive, physical, knowledge, skills and abilities) required to be able to train for, operate, maintain and sustain the system effectively.

Training domain – This domain concerns the instruction, education and on-the-job training required to provide personnel with the essential job skills, knowledge, and abilities to train, operate, maintain and sustain the system effectively.

Human Factors (HF) domain– This domain integrates information about human characteristics and performance into the system definition, design, development, and evaluation to optimize task and system performance.

Health Hazards (HH) domain – This domain aims to eliminate, minimise or control both short- and long-term hazards to health that occur as a result of system operation, maintenance and support. It considers the design features and operating characteristics of a system that can create significant risks of illness, injury or death.

System Safety (SS) domain– This domain identifies the hazards and risks that occur as a result of system operation, including the contribution of human error and human reliability. It considers the design features and operating characteristics of a system that can minimize the potential for human or machine errors or other failures that cause accidents.

Target Audience Description (TAD) – This document describes characteristics of the personnel who will operate, maintain and support the system. The purpose of the TAD is to share and co-ordinate information on the characteristics of personnel across the five HSI domains. It is a pan-HSI document that is first prepared early in acquisition, but is updated as greater detail of personnel requirements and constraints are established for the system.

MASIS - The Materiel Acquisition and Support Management Information System is one of four core DND applications (the others are FMAS, CFSS and DIHRS). MASIS provides integrated project management, procurement, and equipment/weapon system supportability functionality as part of the MA&S capability.

Needs Assessment – Technique specified in CFITES (Canadian Forces Individual Training and Education System) to identify the performance issues associated with a new or revised requirement for Individual Training and Education (IT&E) and to recommend a solution, which may be other than training. Training Needs Assessment is followed by Analysis, Design, Development, Conduct Evaluation and Validation of IT&E.

Materiel Lifecycle - The series of stages through which an operational requirement is transformed into a materiel component of a defence capability. This begins with the identification of a need, encompasses the activities of design, test, manufacture, deployment and support, may involve modifications or upgrades and ends with disposal.

5 Background

5.1 Rationale for the HSI CONOPS

The Materiel Acquisition and Support Information System (MASIS) project is implementing an enterprise resource management system. MASIS requires process descriptions for business processes related to MA&S that cross organizational boundaries and have multiple or conflicting demands from clients or policy owners. The HSI process crosses both the organizational boundaries within DND and the areas of responsibility in an acquisition project. The high level HSI process is therefore documented in this CONOPS.

5.2 Overview of HSI in the Materiel Lifecycle

The Human Systems Integration (HSI) process is a management and technical strategy to integrate the five domains of Human Factors, Training, Personnel, Health Hazards and System Safety into the materiel life-cycle. These domains collectively define how the human parts of the system impact on system or capability performance, e.g. mission performance, safety, supportability, and cost. The HSI domains also identify how the system impacts on the human aspects of the system, e.g. the trade structures, skill gaps and training requirements, workload and manning levels, and operator/maintainer characteristics such as body size and strength. The human parts of the system include the whole range of system stakeholders, that is, the system, supporters, trainers, operators and maintainers.

The relationship between the HSI domains and system performance is shown in Figure 1:

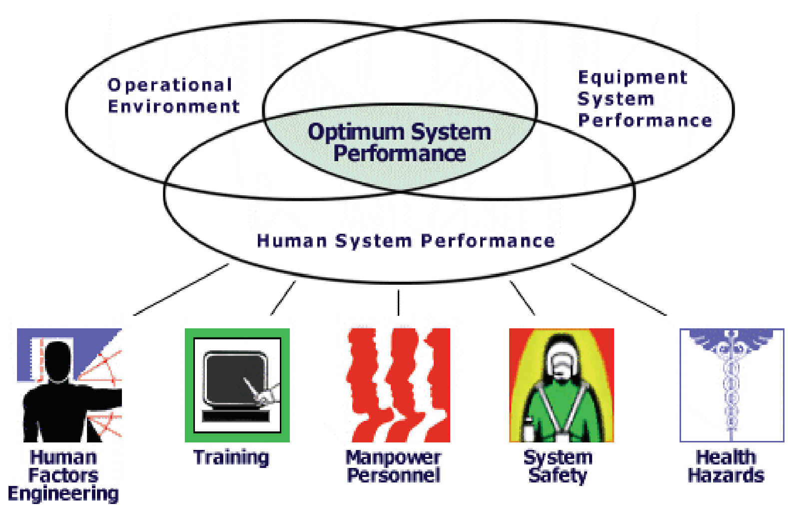

Figure 1 – HSI Domains and System Performance

Across the materiel life-cycle, complex systems have high demands for co-ordination of design issues that impact the human system components. HSI formalizes this co-ordination of technical specialists in the acquisition process.

The goals of HSI in the materiel lifecycle are to:

1. Incorporate effective human-system interfaces,
2. Minimize life-cycle costs, and
3. Manage risk of loss or injury to personnel, equipment or environment, by
   - Assessing and managing the impact of system design on the HSI domains from the earliest stages of materiel acquisition;
   - Assessing and managing the impact of the HSI domains on the system design and total life-cycle costs from the earliest stages of materiel acquisition;
   - Achieving the required levels of human performance; and
   - Making economical demands upon personnel resources, skills and training.

The DND approach to the HSI process is founded on MIL-HDBK-46855A, Human Engineering Program Process and Procedures (Ref. A). This guidance document describes the application of human factors to the acquisition of military systems in the context of the total systems approach of HSI. The DND approach is also aligned with IEEE 1220-1998 standard for Application and Management of the Systems Engineering Process, which includes explicit consideration of the HSI domains across the systems engineering process. HSI initiatives in the UK and USA have also been considered in the development of DND's HSI process.

In a successful system the personnel, training, human factors, safety, and health hazards considerations are optimized with each other, as well as with the rest of the system design considerations. Trade-offs made in the acquisition process must consider the HSI domains, with a goal of improving system performance and reducing life-cycle costs. Harmonization of requirements across the HSI domains is required from the earliest stages of the acquisition process, because of their high impact on life-cycle cost. Personnel costs are frequently cited as the highest lifecycle cost drivers of military weapons platforms. Re-evaluation of the developing HSI requirements and their impact on the system should occur as a continuous process across the materiel lifecycle.

The HSI process is not an attempt to rationalize the HSI domains, but to leverage the technical integration of the domains. This enables the most effective, efficient and affordable solutions, to be determined through systematic and formalized consideration of human-centred requirements. Under the former "stovepipe" approach, each HSI domain had to find its own way to contribute to acquisition decisions, which often occurred too little and too late in the acquisition and deployment process. DND's approach is to integrate the HSI domains, thereby ensuring the domain experience remains with the responsible groups throughout DND. Implementation of the HSI process brings the domains together and considers their interdependencies as a formal part of the acquisition process.

Information sharing across the HSI domains avoids duplication that was inherent in the former "stovepipe " approach and leads to a more complete and powerful understanding of the human aspects of the system in making procurement decisions. The sharing of information from different MA&S streams within one integrated process provides deeper insight into the dependencies and trade-offs when developing the system. Examples of shared data and analyses in the HSI process are shown in Figure 2.

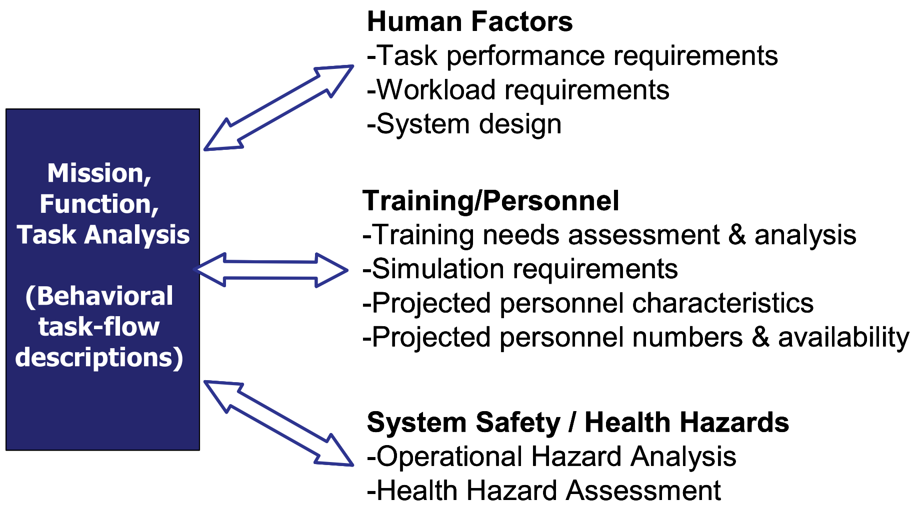

Figure 2 – Examples of Analysis Use and Re-Use

The HSI process therefore:

- Co-ordinates sharing of human centred analyses and analysis tools;
- Identifies where re-use of analyses and data can occur;
- Synchronizes linked analyses, performance requirements, performance measures and evaluation techniques across the domains;
- Facilitates sharing of Research and Development efforts;
- Formally introduces the presence of the HSI domains earlier in the materiel acquisition and support cycle, where the biggest gains can be made; and
- Realizes a cost savings through the above, while adding value through more effective consideration of human-centred requirements and project success drivers.

Currently the HSI process is specified in the MA&S model under the 'Define Engineering Requirements' process but the HSI process also has links with the MA&S process 'Define Supportability Requirements'. Further definition and design of the HSI process is ongoing, and this CONOPS describes the high level DND processes for Human Systems Integration (HSI) in the materiel lifecycle.

5.3 The Human Factors Domain

The Human Factors (HF) domain applies knowledge about human capabilities and limitations to the total system design, including hardware, software, equipment, and facilities. This achieves efficient, effective, and safe system performance at least cost, consistent with allocated manpower, skill and training resources. The HF domain identifies and integrates into system design the cognitive, physical, and sensory characteristics of the people who operate, maintain or support the system or capability, because these people can directly enhance or constrain system performance as a consequence of system design. The Human Factors domain draws on the other HSI domains to understand what the human components of the system are like and how they will perform in various environments and conditions.

The primary aims of the Human Factors domain are to:

- Make systems and equipment easier to operate, maintain, and support;
- Optimize human performance within the overall system performance;
- Reduce the chance of human error and accidents;
- Reduce the amount and cost of operator training; and
- Reduce the need for selection and recruitment of personnel with special backgrounds, characteristics or capabilities.

The human factors domain has the primary responsibility for defining human performance objectives and performance indicators during acquisition. Equipment performance must be considered in conjunction with the human performance requirements and capabilities in specified environments, taking a total systems approach. Examples of areas considered by the Human Factors domain are:

- Human perceptual and performance characteristics, including workload and selection issues;
- Design of workspaces, workstations, displays and controls;
- Design of the organization, jobs and tasks (in collaboration with other domains);
- Automation in human-machine systems;
- Environmental conditions;
- Health and safety;
- Effects of design on knowledge, skills and abilities and training requirements;
- Effects of design on human reliability and human error; and
- Simplicity and effectiveness of system operation, maintenance and support.

5.4 The Personnel Domain

This domain assesses, evaluates and determines the human experience, aptitudes, knowledge, skills, and abilities required for personnel to perform tasks to operate, maintain and support the materiel system. The Canadian Forces has a finite pool of personnel so that personnel characteristics can become the limiting factor in achieving system effectiveness.

The Personnel domain identifies and reviews the job tasks and the associated workload to determine the personnel numbers and mix of human characteristics that are needed by the system. The manpower requirements in terms of numbers and required characteristics of personnel are assessed against the actual and projected personnel availability and constraints. Recruiting and retention issues are considered, as well as the impact of the materiel system on trade structures, promotions and career development.

Personnel skill shortfalls cannot be overcome by putting more, but lesser skilled people in the job. The new system may require more, the same, or fewer people than the predecessor system, and the skills, trades and rank distribution may change. These issues are assessed and managed in the materiel life-cycle in the context of the system design.

Personnel characteristics must be considered in conjunction with the Training and Human Factors domains and also with Engineering and Supportability issues for optimal design trade-offs to be made. For example, the corrective and preventive maintenance tasks generated as part of Logistics Support Analysis (LSA) must be considered within the larger context cited below:

Personnel considerations include:

- Personnel selection and classification;
- Personnel characteristics (e.g. cognitive and psychomotor abilities, body size and strength, knowledge, skills and abilities and aptitudes);
- Demographics;
- Accession and attrition rates;
- Career progression and promotion flow;
- Training flow;
- Projected personnel characteristics and numbers;
- Recruitment and retention;
- Wartime and peacetime manpower requirements;
- Deployment considerations;
- Force and organizational structure; and
- Manpower strategies, policies and concepts.

5.5 The Training Domain

The Canadian Forces Individual Training and Education System (CFITES) specifies Needs Assessment, Analysis, Design, Development, Conduct, Evaluation and Validation of Individual Training and Education (IT&E). This identifies and develops the instruction, education, on the job and team training to provide people and teams with the knowledge and job skills needed to support the system at the specified levels of performance. The Training domain also considers the tools, devices (including embedded training systems), training simulators, techniques, procedures, training materials and technical manuals to be developed and used to provide training for all tasks required by the materiel system.

The system must be designed so that the specified target populations can be cost-effectively trained to meet specified performance standards. This means that the ‘who, what, when, where, how, timing, and costs’ of training need to be considered. Training cannot usually overcome poor system design and it cannot make up for deficits in personnel characteristics, such as incompatible aptitudes, physical characteristics and experience.

The training domain specifies performance requirements for training and monitors training results, so shortfalls can be identified, analysed and corrected. Training considerations include:

- Training requirements;
- Training concepts and strategy;

- Tasks and training development methods;
- Media, equipment and facilities;
- Simulation;
- Training system suitability, effectiveness, efficiency and costs; and
- Concurrency of the materiel system with trainers.

5.6 The Health Hazards Domain

The Health Hazards (HH) domain aims to eliminate, minimise or control both short- and long-term hazards to health that occur as a result of system operation. It considers the design features and operating characteristics of a system that can create significant risks of death, injury, acute chronic illness, disability, or which can reduce job performance of personnel who operate, maintain, or support the system.

Health Hazards considerations include:

- Hazards induced by systems, environments or task requirements;
- Noise and vibration;
- Electrical shock and electromagnetic fields;
- Radiation energy and laser protection;
- Chemical and biological substances;
- Extremes of temperature;
- Oxygen deficiency and extremes of air pressure; and
- Impact forces.

The Health Hazards domain also includes aspects of survivability, i.e. limiting the probability of personal injury, disability or death of personnel in their interactions with the system. This can include providing protection from attack, and reducing detectability, fratricide, system damage, personnel injury and cognitive and physical fatigue.

5.7 The System Safety Domain

The System Safety domain is typically driven by MIL STD 882 or its equivalent. System safety deals with the safety of the materiel system, as well as the operators, maintainers and support personnel. It eliminates safety-related hazards through design, or controls them to acceptable levels to prevent accidents through the forward-looking identification and control of hazards throughout the lifecycle of a system. The System Safety goal is to optimize operational readiness and mission effectiveness by ensuring that appropriate hazard elimination or control measures are designed into the total system, thus preventing accidents.

A hazard is a condition, event, or circumstance that could lead to or contribute to an unplanned or undesired event. Risk is an expression of the impact of an undesired event in terms of event severity and event likelihood.

The System Safety process is a formal but flexible process that identifies hazards, analyses, assesses and prioritises risks, and documents the findings for decision-making. A systematic approach to System Safety involves proactively searching for opportunities to improve the system throughout the system lifecycle, not simply identifying deficiencies after an undesired event. As such, System Safety plays a core role in acquisition to reduce the probability and severity of accidents through total systems design. This involves designing hazard control measures into the total system, which includes the materiel, system performance, procedures and training for operators, maintainers and support personnel.

System Safety includes aspects of survivability, i.e. limiting the probability of personal injury, disability or death of personnel in their interactions with the system. This can include providing protection from attack, and reducing detectability, fratricide, system damage, personnel injury and cognitive and physical fatigue.

The Risk Assessment results from the System Safety domain are integrated with other project considerations to make decisions about the need for risk reduction and to identify suitable methods to achieve it. This process is referred to as Risk Management in the MA&S model.

The System Safety domain considers:

- Safety of design and procedures;
- Human error and human reliability;
- Software and hardware failure modes;
- Total system reliability and fault reduction; and
- Total system risk reduction.

6 HSI Strategy and Policy in the Canadian Forces

Work is ongoing to integrate Human Systems Integration into the business of DND at three levels, including:

1. High level strategic and capability planning through the Strategic Capability Investment Plan (SCIP);
2. The overall acquisition process through the Defence Planning and Management (DP&M) process; and
3. The Materiel Acquisition and Support processes through the MA&S model and MA&S Desktop.

6.1 Strategic Planning and the SCIP

The Strategic Capability Investment Plan (SCIP) and the analysis process to generate it references HSI as a critical area of analysis when determining and planning for the impact of future defence capability. At this level HSI analyses are required to ensure that the impact of future capabilities is determined, especially in terms of the impact of a future capability on the training and personnel infrastructure of DND. The HR (Human Resources) Annex to the SCIP specifically causes this to be addressed. More detailed processes on how this can be achieved are being established through the work of ADM(HR MIL), and also through the Capability Engineering, or System-of-System engineering processes, being developed through the CapDEM

Technology Demonstration Project (TDP) conducted by Defence Research and Development Canada (DRDC) in collaboration with ADM(Mat) and others.

6.2 Acquisition Planning and the DP&M Process

Once a defence capability needs to be acquired, that acquisition is guided by the Defence Planning and Management (DP&M) process through the phases of Identification, Options Analysis, Definition, and Implementation. The DP&M process needs to be enhanced to ensure that:

1. HSI planning is undertaken and a HSI Plan is written at the start of the Options Analysis phase for each acquisition;
2. Options Analysis includes HSI issues, whereby candidate solutions are compared in terms of their potential impact on the number and types of personnel, human performance and safety, and the lifecycle cost impact from a personnel perspective;
3. Definition Phase analysis develops human performance-based specifications to then guide bid evaluation and later system testing, and that a HSI Statement of Work (SOW) is included to ensure that the domains of HSI are fully considered and integrated through final delivery of the system; and
4. Implementation Phase activities ensure effective execution of that HSI Statement of Work.

To achieve these requirements in a systematic fashion:

- A HSI checklist will be developed for use at each of the 'gates' in the DP&M process to ensure that HSI issues have been considered. This checklist will be reviewed at SS(PPA) and again at SS(EPA).
- The Options Analysis (OA) Report template must include consideration of the HSI issues.
- A HSI SOW, Contract Data Requirements List (CDRL), and Data Item Description (DID) template series is under preparation, for tailoring and inclusion in bid documents and to guide contractor activity during Implementation.

6.3 HSI Stakeholders in the DND Community

The implementation of an HSI program requires the co-ordinated involvement of technical specialists throughout the DND community. Examples of these personnel include:

1. An HSI Coordination office, currently in the final stages of definition, which will have the responsibility to provide coordinated HSI support and act as a liaison with members of the Human Factors, Training, Personnel, Health Hazards, and System Safety communities;
2. DMASP functional authorities responsible for the HSI Process, Systems Engineering Process, Supportability Process and Project Management within the MA&S process;
3. ADM(HR MIL) personnel responsible for manpower and personnel modelling, analysis, career management systems, recruitment, etc.;

4. Director Recruiting Education and Training (DRET) personnel responsible for the Canadian Forces Individual Training and Education System (CFITES);
5. Director General Health Services (DGHS) personnel focused on health hazard assessment of military systems and operations;
6. The Synthetic Environment Co-ordination Office (SECO), which co-ordinates modelling and simulation in the DND and CF;
7. Human Factors trained personnel working in the Director of Land Requirements (DLR), who regularly send officers to the United Kingdom to obtain a Masters Degree in Human Factors/Ergonomics;
8. Human Factors personnel in the Directorate of Technical Airworthiness (DTA) and the new Directorate of Aerospace Engineering Support (DAES);
9. Human Factors/Human Systems Integration positions in large acquisition projects, such as the HSI Manager in the Maritime Helicopter Project (MHP) who reports to the Systems Engineering Manager;
10. Human Factors responsible personnel in the Maritime project community, such as the Naval Human Factors/Habitability function in the Directorate of Maritime Ship Support (DP&MS);
11. Training personnel across all projects;
12. Joint Human Factors personnel, such as those employed at the Canadian Forces Experimentation Centre (CFEC);
13. Joint Capability Engineering Team (CET) members, such as those in the pilot CET within the Deputy Chief of Defence Staff (DCDS) community which includes two HSI positions;
14. Experimentation Centre personnel who integrate evaluation of HSI issues in studies and experiments;
15. Defence R&D Canada personnel involved in research on HSI issues, or who provide Human Factors research support to technology development projects. Such personnel currently exist at Defence Research and Development Canada (DRDC) Toronto, Ottawa, Valcartier, and Atlantic, and National Defence Headquarters; and
16. MAO Bio Officers at the Canadian Forces Medical Group (CFMG) and Defence Research and Development Canada (DRDC).

6.4 Project Management, Engineering, and the MA&S Process

As any system acquisition enters the Definition Phase of the DP&M process, the Materiel Acquisition and Support (MA&S) processes are invoked to guide the detailed Project Management and Engineering process through the remainder of the lifecycle for that system. This MA&S process is being enhanced to include the detailed HSI processes within it, and to provide the document templates to be made available through the MA&S Desktop.

7 Phases of the Materiel Acquisition and Support Process

The MA&S process is conducted within the context of the Lifecycle Management System (LCMS), and the Defence Planning and Management (DP&M) process when larger acquisition projects are conducted. In combination, these processes frame the overall materiel acquisition and support process, which can be preceded by a Research and Development (R&D) process or a

Concept Development and Experimentation (CDE) process to assist with requirements definition. Both CDE and R&D can span the full materiel life cycle, but both are increasing in emphasis and importance during the pre-acquisition stage.

The MA&S lifecycle combines the LCMS stages and the DP&M process phases. These are:

- Identification;
- Options Analysis;
- Definition;
- Implementation;
- In-Service; and
- Disposal.

The stages of the materiel lifecycle are shown in Figure 3:

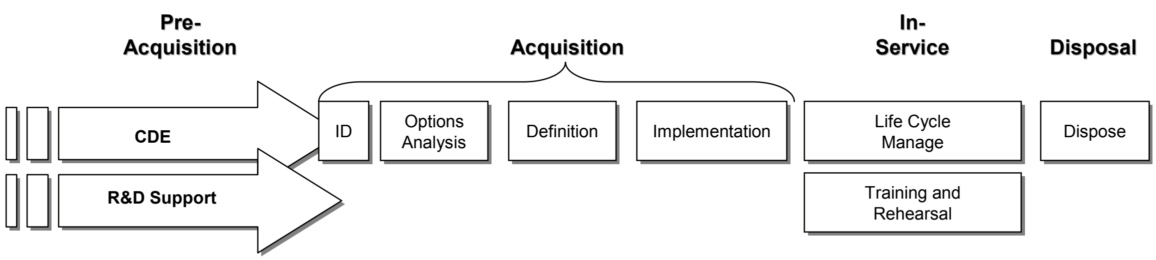

Figure 3 – The DND Materiel Life Cycle

8 HSI Processes in the MA&S model

8.1 Overview

Analysis work is underway to further develop the HSI process in the MA&S model, to integrate HSI with related MA&S processes and to provide guidance in the MA&S desktop. The current framework is presented in Annex A, where the HSI processes are mapped to the key processes in the MA&S model.

The HSI process across the MA&S lifecycle is summarised in Figure 4. The HSI process considers the In-service and Disposal phases during materiel acquisition because of concerns for in-service use and lifecycle costs, but it also plays a role within these phases themselves.

The HSI process iterates throughout the materiel lifecycle, as illustrated by the repetition of key analyses during both the Options Analysis and Definition phases of the DP&M process. In addition, the summary processes in Figure 4 are not conducted sequentially. Instead they are carried out to iterate and update throughout the lifecycle of a materiel system so the same process can be conducted in one or more MA&S phase.

A major benefit of this iteration and update of analysis across the MA&S lifecycle is the re-use and sharing of data within and between the five HSI domains, which ensures affordable, timely, input as the lifecycle gets more time pressured, for example during late Definition and Implementation Phases.

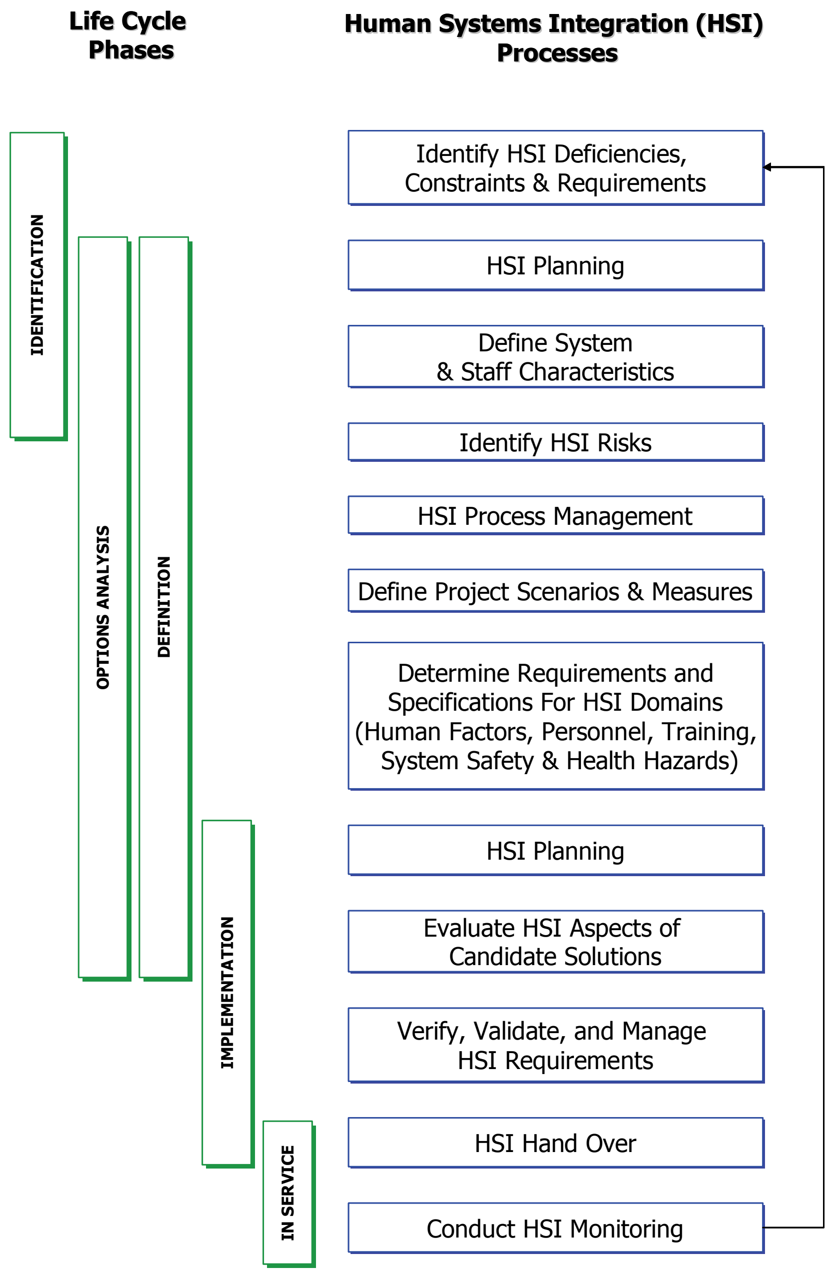

Figure 4 – Summary Of Human System Integration Processes Across The Materiel Acquisition And Support Lifecycle.

The HSI processes in Figure 4 are described in Annex A.

9 Implementers of HSI Within the MA&S Process

Technical specialists need to be responsible for the HSI domains in an acquisition project. During the Identification phase all domains could be represented by an individual with a working knowledge of all five of the HSI domains. In the Options Analysis, Definition, Implementation and In-Service phases it may often be required to have separate technical specialists to be responsible for the five HSI domains, in collaboration with the range of technical stakeholders listed in Section 6.3.

Access to the appropriate personnel is planned to be coordinated through a future Human Systems Integration (HSI) Office within DND, which will have the responsibility to provide coordinated HSI support and act as a liaison with members of the Human Factors, Training, Personnel, Health Hazards, and System Safety communities (see sample list in Section 6.3). Until that time, a directory of key points of contact in each of these areas is provided through the HSI Web Site.

The Canadian industrial base may also be relied upon to provide technical HSI support through any of the lifecycle phases.

10 HSI Requirements Before the MA&S Process

While HSI is formally being integrated into the SCIP, DP&M process, and MA&S process, the entire HSI process can be exercised during both Concept Development and Experimentation (CDE) and Research and Development (R&D) processes. The decision to conduct CDE and R&D effort to develop requirements is dependent on factors such as the complexity, novelty and technical risk (including HSI risk) of the new system.

10.1 Concept Development and Experimentation

The Concept Development and Experimentation (CDE) process is increasingly driven by the experimentation centres being established at the Joint level through the Canadian Forces Experimentation Centre (CFEC) and at the environment level through the Army, Maritime, and Air Experimentation Centres. These groups work to define future concepts for both operations and systems and then conduct experiments to evaluate those concepts. All of these experiments should be employing structured HSI analysis involving the HSI community, to determine the impact of those future concepts on the human centred aspects of the system. As there is no documented CDE process, the integration of HSI is dependent on the personnel involved and the method they choose to employ. However, the documented HSI process is relevant to the CDE community and can/should be used as a reference.

10.2 Research and Development

The Research and Development (R&D) process is largely conducted by Defence R&D Canada (DRDC). R&D for system concepts that will lead directly to input into future acquisition programs are increasingly being conducted through the Technology Demonstration Program (TDP). This program has a documented lifecycle but at this time it does not contain a formal HSI component. It is currently proposed that the TDP lifecycle should include a HSI component in the TDP plan, and that a checklist be provided for TDP Senior Review Boards (SRBs) to ensure that the HSI impact of a future system or concept is considered in the original R&D

process. Thus the documented HSI process applies to the R&D cycle in terms of the nature and types of HSI analyses to be conducted.

11 Development vs. Commercial Off The Shelf (COTS)

Where major system components are 'off the shelf' instead of being developed, it is essential that HSI analysis and inputs are made ***prior*** to equipment selection. If deficiencies of the proposed system are not anticipated and not identified before the equipment or system is selected, any problems can be rectified only by modifying the equipment, which is usually not possible or is prohibitively expensive. Although a COTS system may be initially cheaper, COTS systems or equipment can suffer high down-stream human-related costs and poor system performance. Thus COTS procurements carry a high HSI risk if there is insufficient analysis of key issues and insufficient application of HSI processes early in the acquisition.

If the equipment or system cannot be modified, its operators and maintainers will be forced to accommodate it. Consequently the required system performance and reliability may not be met, which can result in high total lifecycle costs, where personnel and training issues are affected.

From a process perspective, **the HSI process outlined in Figure 4 fully applies in both Developmental and COTS acquisitions**. The only difference is that in the COTS acquisition there is not a full HSI analysis driving the design of the system as it already exists, however the types of HSI analysis performed during Options Analysis and Definition do not change. The DND team must still determine the impact of the acquisition on human performance, safety, training, and personnel and evaluate both options and bid contenders on this basis. The DND team must continue to work with the solution provider to ensure that the system is integrated with the operational and maintenance constructs, personnel, and training systems of DND regardless of whether the system is COTS or developmental.

It has been argued that HSI is even more important as more system acquisition are COTS, because DND cannot influence physical system design, and must therefore fully analyze and manipulate the impact of that system on human performance through procedures, TTPs (Tactics Training and Procedures), training, and personnel development.

The same issues apply to Military Off The Shelf (MOTS) procurements.

12 Optimized Weapons System Management (OWSM)

The Optimized Weapons System Management (OWSM) program is a DND strategic thrust, focused on changing Equipment Program Management to meet evolving requirements across all required Weapons System support activities. The OWSM concept is to identify the complete lifecycle support requirements of a Weapons System, and to determine what support should be provided by DND (the internal support component) and what support should be provided by an external service provider (the contracted support component). OWSM includes the concept of full life support, which goes beyond the currently recognised ILS/Supportability elements and system engineering requirements, to include issues such as configuration management, obsolescence monitoring, maintenance of the technical data package and many others.

The OWSM concept defines the complete lifecycle support requirements, preferably during system acquisition or at some later point in the lifecycle. The aims of OWSM are supported by HSI processes, which can provide cost savings and performance gains. It is recommended that HSI processes are considered in OWSM program activities and are tailored to match the scope of each OWSM project and its HSI risks. As OWSM is applied primarily to the In Service phase, particular attention should be paid to specifying HSI performance standards, collecting HSI performance data and defining procedures for modifying hardware, software or training as a result of HSI deficiencies.

13 Synthetic Environment Based Acquisition (SEBA)

Synthetic Environments provide an integrated platform for the conduct of different levels of studies that occur throughout the systems engineering lifecycle. This helps to define and manage the scope of acquisition projects, whereby the Project Management Process (concerned with scope, schedule and cost, among other knowledge areas) is facilitated through the use of simulation in defining, managing, testing and implementing the technical requirements of an acquisition project. SEBA is based on the premise that simulation and synthetic environments will facilitate faster and more complete evaluation of system concepts at an earlier phase of the engineering or acquisition process, resulting in more informed decision-making and less re-engineering throughout the lifecycle. This saves time and increases quality.

The SEBA process (Refs. E and F) will eventually result in modeling, simulation, and synthetic environments being increasingly used as the basis for requirements analysis, options analysis, bid evaluation, and system test and evaluation during Implementation. The SEBA process spans multiple disciplines, including HSI. SEBA is a way of doing business that is tightly linked with the concept of HSI, whereby centralized representations of the system are used by multiple linked analytical domains to synchronize, accelerate, and improve shared analyses and resulting decision making. HSI currently relies on modeling and simulation as the basis for some HSI analyses, so HSI analysis and measures will be a central focus in any evolving SEBA program.

14 HSI Interactions With Other Processes and Domains

The HSI process interacts with a number of other processes and domains in the MA&S community. These links will continue to be analyzed and formalized by the various domain function authorities in DMASP, DRET, and ADM(HR MIL).

Related Processes and Domains include:

- Systems Engineering (Refs. B and K).
- Integrated Logistics Support/Support and Supportability (Ref. G).
- Safety Engineering
- Software Engineering (Ref. K)
- Reliability and Maintainability (Ref. I)
- Risk Management
- Test and Evaluation (Ref. L)
- Training (Ref. D).

Annex A - Description of HSI Processes

The HSI processes described below are shown in Figure 4 of the HSI CONOPS.

1. Identify HSI Deficiencies, Constraints and Requirements

This HSI process is conducted in the Identification Phase and it links with the following MA&S model processes:

- 2.1.1 Conduct User Focus Groups
- 2.1.3 Conduct Operational Requirements Validation
- 2.1.5 Document Capability Gap
- 2.2.2.1.3 Define Human Systems Integration Requirements
- 2.2.2.4.1 Develop Concept of Support
- 2.2.2.6.1 Identify Fielding Requirements
- 2.2.2.6.5 Identify Equipment System Directive Requirements
- 2.2.2.6.6 Identify In-service Equipment System Requirements
- 2.2.2.6.7 Identify in-service performance measurement requirements
- 2.2.2.6.8 Identify Interim Support Requirements
- 2.2.2.9 Develop Materiel Concept of Operations

Process Outputs: List of HSI deficiencies and constraints, Preliminary list of HSI requirements, Information for use in the HSI Project Plan.

Early HSI activities involve gathering information on predecessor or similar in-service equipment and systems and on the concept for the new system. Deficiencies of the predecessor system must be identified in each of the HSI domains. Deficiencies regarding the operation and maintenance of the predecessor /similar system that resulted from initial project goals or constraints such as personnel, manning or operational requirements are of specific importance at this early stage. Deficiencies may be viewed in terms as opportunities for improvement in the new system, and these opportunities should be recorded.

Where tracking systems are in place, e.g. safety and hazard incident databases or operational Lessons Learned databases, some HSI aspects of system deficiencies may be easier to identify. Active analysis of predecessor systems is usually needed through document reviews, observation, questionnaires, and interviews to develop a structured list of HSI-related deficiencies. Preliminary Mission and Function Analysis work may also be required at this stage. Human resource cost data should be examined for indications that reductions are needed in numbers of personnel or in the cost of training.

The output of this process is a List of Deficiencies for inclusion in project decision documents. It may be included in the Statement of Capability Deficiency (SCD) portion in SS(ID). This list of deficiencies will also form the start of the HSI requirements development process, unless there has been a pre-acquisition effort to support requirements definition through Research and Development or Concept Development and Experimentation.

2. HSI Planning

This HSI process is conducted in the Identification, Options Analysis, Definition and Implementation Phases and it links with the following MA&S model processes:

- 2.1.4 Plan Scope /Develop Charter
- 2.2.1 Integrate Project Management Plans
- 2.2.2 Define E&S Scope
- 2.2.3 Plan Schedule
- 2.2.4 Plan Cost
- 2.2.5 Plan Organization
- 2.2.6 Plan Communications
- 2.2.7 Plan Quality
- 2.2.8 Plan Continuous Risk Analysis
- 2.2.9 Plan Procurement
- 2.2.2.10.1 Develop WBS
- 2.2.2.10.4 Plan E&S
- 2.2.4.2 Develop Cost Estimates

Process Outputs: HSI Program Plan (several iterations), HSI aspects of the Procurement Management Plan.

HSI planning starts early in the acquisition process, initially to assess the scope of the HSI effort, given the HSI deficiencies of predecessor or similar systems and the early identification of HSI risks. The scope of the HSI program for the project should be determined by the HSI risks instead of the type and cost of the procurement. For example, a low-budget COTS procurement can have very high HSI risks, which would require detailed HSI analysis of key issues to be conducted early in the acquisition process.

The HSI Program Plan defines the tasks and dependencies across the five HSI domains and with the overall Project Management Plan to determine how and where the domains of HSI will be applied, and where analysis, tools and techniques will be shared across the domains and with other acquisition functions and processes. The HSI Program Plan includes the HSI program scope, schedule, cost, organization, communications, quality and risks. It is updated at the start of each acquisition phase, and as required.

A template for the HSI Program Plan will be made available on the MA&S Desktop.

3. Define System and Staff Characteristics

This HSI process is conducted throughout the materiel lifecycle from Identification, to Disposal, although the main effort is conducted in Identification, Options Analysis and Definition Phases. This process links with the following MA&S model processes:

- 2.1.1 Conduct User Focus Groups
- 2.1.3 Conduct Operational Requirements Validation
- 2.1.5 Document Capability Gap
- 2.2.2.1.3 Define Human Systems Integration Requirements
- 2.2.2.4.1 Develop Concept of Support

- 2.2.2.9 Develop Materiel Concept of Operations

Process Outputs: HSI aspects of the System Description, Target Audience Description (TAD).

The HSI domains initially require a description of the predecessor or a similar system as a baseline for subsequent analysis, or a conceptual description of a future system that may have resulted from a CDE or R&D process. This description should summarize the operation, maintenance and support of the system, including an outline of system components (personnel and equipment) and the workflow between them, along with key performance objectives. Other management and engineering domains require similar information, so the system description may be developed by or alongside a range of technical specialists. The system description is updated across the Identification, Options Analysis and Definition phases as the new system is developed and refined. This material may often be contained in a Concept of Operations and Concept of Support document set for the project in question.

During the identification phase an initial, formal description is developed of the current operations, maintenance and support personnel. This forms a document or database known as the Target Audience Description (TAD), which is an historical term to emphasise the need to consider maintainers and others who support the system as well as the operational users.

The TAD defines the characteristics of personnel in terms of their required numbers, experience, training, skills, aptitudes, knowledge and abilities, physical characteristics and physical abilities. The main development of the TAD is in the Identification, Options Analysis and Definition Phases, through analysis of existing records and using active survey or analysis of the operation, maintenance and support communities. It also needs to be updated in the Implementation and In-Service Phases as more detail about the system stakeholders becomes known or when there are changes in the types of people or their characteristics that are documented in the TAD. Projects will document the impact of the future system on personnel through the updates to the TAD, or a specific Personnel Impact Assessment will be created for the project.

4. Identify HSI Risks

This HSI process is conducted in the Options Analysis and Definition Phases and it links with the following MA&S model processes:

- 2.1.1 Conduct User Focus Groups
- 2.2.2.1.3 Define Human Systems Integration Requirements
- 2.2.2.4.1 Develop Concept of Support
- 2.2.2.7 Evaluate Operational Impacts
- 2.2.2.8 Select Options
- 2.2.2.9 Develop Materiel Concept of Operations
- 2.2.8 Plan Continuous Risk Management

Process Outputs –HSI Risk List, HSI Risk Information Sheets, HSI Risk Action Plans, HSI Risk Assessment Reports.

The HSI team must identify the HSI risks, which are then documented in the Project Risk Register so that HSI risks are included in the overall Risk Management process and in decision documents such as the Project Profile and Risk Assessment (PPRA). HSI risks should also be documented in the HSI Plan.

Factors that magnify HSI risks include:

- Commercial Off The Shelf (COTS) or Military Off The Shelf (MOTS) procurements that will need to be accommodated by personnel and procedures;
- A system whose overall performance will be highly dependent on effective human (individual or team) performance;
- Changes of personnel groups where a significant difference is likely in the user, maintainer or support groups compared with the predecessor system;
- Changes in job allocation, e.g. maintenance being conducted by operators or instead of maintenance personnel, or by civilian contractors instead of military personnel;
- Changes in service entrants who will use the new system; and
- When the system is to be used in a different way from predecessor systems.

5. HSI Process Management

This HSI process is conducted in the Options Analysis and Definition Phases and it links with the following MA&S model processes:

- 2.2.6.1 Identify Project Stakeholders
- 2.2.6.2 Determine Data Communications Requirements
- 2.2.6.4 Specify Management Systems
- 2.2.6.6 Specify and Implement Information Management Systems
- 2.2.6.7 Tailor Tool Configuration
- 2.2.6.8 Develop Communications Management Plan
- 2.2.2.10 Define E&S Scope Management Plan
- 2.2.2.5 Define E&S Management Requirements
- 2.2.2.5.3 Identify Requirements Management Needs
- 2.2.2.5.5 Identify Technical Data Management Requirements
- 2.2.2.6.2 Identify Data Migration Requirements
- 2.2.2.6.4 Identify Responsibility Handover Requirements
- 2.3.2.Assure Quality
- 2.4.1 Report Performance
- 2.4.2 Control Product Change
- 2.4.3 Control Product Quality
- 2.5 Close Acquisition

Process Outputs – Inputs to the HSI Program Plan, HSI inputs to MA&S performance reports, HSI performance measurement framework, HSI management requirements.

HSI Process Management includes planning and managing the HSI aspects of project management such as co-ordination of the reporting, data, and analyses of the HSI domains, management of HSI technical data and requirements management.

The HSI process to be followed will be documented in the HSI Program Plan. A single point of contact should be established within any project as the HSI Co-ordinator. This individual could have a title such as HSI Manager, or they could be the Human Factors, Personnel, Training, or System Safety lead for the project which the added responsibility for overall HSI Process coordination on the project. This HSI management responsibility must ensure that the coordinated HSI process is documented in the HSI Plan, and that activity execution is carried out in accordance with that plan to realize the benefits of HSI on the project.

6. *Define Project Scenarios and Measures*

This HSI process is conducted in the Options Analysis and Definition Phases and it links with the following MA&S model processes:

- 2.1.1 Conduct User Focus Groups
- 2.1.3 Conduct Operational Requirements Validation
- 2.2.2.1.3 Define Human Systems Integration Requirements
- 2.2.2.4.1 Develop Concept of Support
- 2.2.2.9 Develop Materiel Concept of Operations
- 2.2.2.10.2 Compile SOR
- 2.2.2.10.3 Define T&E Requirements

Process Outputs – Mission/Function/Task Analysis, HSI aspects of the Concept of Operations and the Concept of Support, Workload Analysis.

It is often the case on acquisition projects that a CONOPS and CONSUP exist for the project, and that these documents in combination with SOR material provide a high level overview of the operational and support scenarios that the system will be involved in. However, the HSI analysis process typically requires these higher level scenarios to be further decomposed with more detail of the scenarios, and an assessment of the function allocation that will result from achieving the CONOPS and CONSUP, (i.e. a determination of what the role of the human will be in the system). This analysis also provides the high level performance Measures for human performance that will be perpetuated throughout the acquisition process. The Human Engineering System Analysis Report (HESAR) Data Item Description (DID) in the Human Systems Integration DID series is the most appropriate document template to start capturing this information and building up the mission, function, and task analysis for the project. This is required by all five HSI domains as the basis for their analysis of the human portions of the system and this analysis is the coordination point for the role of the human in the system.

7. *Determine Requirements and Specifications for the HSI Domains*

This HSI process is conducted in the Options Analysis and Definition Phases and it links with the following MA&S model processes:

- 2.2.2.1.3 Define Human Systems Integration Requirements
- 2.2.2.1.1 Identify Communications Engineering Requirements
- 2.2.2.1.4 Identify Reliability and Maintainability Requirements
- 2.2.2.1.5 Identify Safety Engineering requirements
- 2.2.2.1.6 Identify Software Engineering Requirements
- 2.2.2.1.7 Identify Engineering Design Requirements

- 2.2.2.1.9 Identify Standardization and Interoperability Requirements
- 2.2.2.1.10 Define Environmental Protection Requirements
- 2.2.2.4.1 Develop Concept of Support
- 2.2.2.4.2 Identify LSA Requirements
- 2.2.2.4.3 Define ILS Requirements
- 2.2.2.6.5 Identify Equipment System Directive Requirements
- 2.2.2.6.7 Identify In-service Performance Measurement Requirements
- 2.2.2.6.8 Identify Interim Support Requirements
- 2.2.2.9 Develop Materiel Concept of Operations
- 2.2.2.10.3 Define T&E Requirements
- 2.2.9.2 1 Prepare Statement of Work (SOW)
- 2.2.9.2.2 Prepare Performance Specification
- 2.2.9.2.3 Prepare SOO (Statement of Objectives)
- 2.2.9.2.4 Develop Requirements Verification Matrix
- 2.2.9.2.5 Prepare Data Item Description
- 2.2.9.2.6 Prepare CDRL
- 2.2.9.2.9 Prepare Bid Evaluation Criteria
- 2.2.9.3 Develop Evaluation Plan

Process Outputs – HSI Evaluation sections of the Options Analysis Report, System Requirements and Specifications for Human Factors, Personnel, Training, System Safety, and Health Hazards domains for input to the SOR, SOW, SOO, HSI evaluation criteria and methods, HSI CDRL items and DIDs.

During the Options Analysis phase key HSI performance requirements are determined, and candidate options are evaluated to consider these requirements. In the Definition Phase these high level performance requirements are further decomposed and defined to complete bid evaluation criteria for the system.

During the Definition phase the HSI sections of the Statement of Work (SOW) are prepared, to include the Contract Data Requirements List (CDRL) and Data Item Descriptions (DIDs) that define the deliverables. The types and scope of HSI-related DIDs will vary from project to project. Generic templates for HSI DIDs are under development and examples of HSI DIDs are listed below. At this time the focus on DIDs development has been on overarching HSI documents, Human Factors Documents, and System Safety documents. Continued work in this area will integrate Training, Personnel, and Health Hazard DIDs through collaboration with the ADM(HR MIL), DRET, and DGHS communities.

- Human Systems Integration Program Plan
- Human Factors Program Plan
- Human Factors Progress Report
- System Safety Program Plan (SSPP)
- Human Engineering System Analysis Report (HESAR)
- Critical Task Analysis Report (CTAR)
- Human Engineering Design Approach Document – Operator (HEDAD-O)

- Human Engineering Design Approach Document – Maintainer (HEDAD-M)
- Preliminary Hazard List (PHL)
- Preliminary Hazard Analysis (PHA)
- Functional Hazard Assessment (FHA)
- Preliminary System Safety Assessment (PSSA)
- System Safety Assessment (SSA)
- Operating and Support Hazard Analysis (O&SHA)
- Safety Compliance Assessment Report
- Health Hazard Assessment (HHA)
- System Safety Case
- Human Factors Simulation and Test Plan
- Human Factors Test Plan
- Human Factors Test Report
- Workload Analysis Report
- Target Audience Description (TAD)
- Workload Analysis Database

8. Evaluate HSI Aspects of Candidate Solutions

This HSI process is conducted in the Options Analysis and Definition Phases and it links with the following MA&S model processes:

- 2.2.2.2 Conduct Market Research
- 2.2.2.3 Identify Product Options
- 2.2.2.7 Evaluate Operational Impacts
- 2.2.2.8 Select Options
- 2.2.2.8.1 Determine Hardware Development Effort
- 2.2.2.8.2 Determine Support Development Effort
- 2.2.2.8.3 Determine LSA Effort
- 2.2.2.8.4 Determine Software Development Effort
- 2.2.2.8.5 Determine Integration Effort
- 2.2.2.8.6 Perform Lifecycle Cost Benefit Analysis
- 2.2.2.8.7 Analyse Product and Support Options
- 2.2.2.8.8 Select Product and Support Option
- 2.2.9.7.2 Conduct Bidders Conference
- 2.2.9.7.3 Conduct Industry Site Visits
- 2.2.9.7.4 Evaluate Proposals
- 2.3.1.1 Plan Product Implementation
- 2.3.1.3 Develop In-Service Support Documents

Process Outputs – HSI Evaluation inputs to the Options Analysis Report, HSI Evaluation inputs to the Bid Evaluation Report.

The HSI team will have measures that will be assessed during Options Analysis and in Bid Evaluation processes. The team will be responsible to include their measures in overall evaluation processes, to complete their analyses, and to contribute the HSI-related results to the overall project reports that are written.

9. Verify, Validate and Manage HSI Requirements

This HSI process is conducted in the Implementation Phases and it links with the following MA&S model processes:

- 2.3 Execute Acquisition
- 2.4 Control Acquisition
- 2.3.1.1 Plan Product Implementation
- 2.3.1.1.1 Plan T&E
- 2.3.1.2 Implement E&S Requirements
- 2.3.1.2.7 Integrate and Test System
- 2.3.1.3 Develop In-Service Support Documents
- 2.3.2.Assure Quality
- 2.4.3.1 Perform E&S Reviews
- 3.4.5 Prepare Materiel Support Instructions
- 2.2.2.6.7 Identify In-Service Performance Measurement Requirements

Process Outputs – Review, Comment, and Acceptance of HSI CDRL items.

Throughout the Implementation Phase of a project, the contractor team will conduct a series of HSI-related activities in accordance with the HSI section of the Statement of Work (SOW). This will result in HSI related Data Items (DIs) being submitted in accordance with the Contract Data Requirements List (CDRL). The DND project team will therefore be required to maintain oversight of these HSI activities in accordance with the HSI Program Plan for the project.

10. HSI Handover

This HSI process is conducted in the Implementation and In-Service Phases and it links with the following MA&S model processes:

- 2.3.1.4 Introduce Product Into Service
- 2.2.2.6.4 Identify Responsibility Handover Requirements
- 2.2.2.6.8 Identify Interim Support Requirements
- 3.4 Provide Materiel Support To Operations
- 3.4.5 Prepare Materiel Support Instructions

Process Outputs – Formal handover of the design basis for a new system or capability to the operational and lifecycle management community from an HSI perspective.

As a new system or capability is delivered to the Canadian Forces (CF), the design basis for that system must be understood by those who will operate it (the operational community) and those who will support it (the Life Cycle Materiel Manager). These personnel must understand the design intent from an HSI perspective, and therefore formal sessions must be conducted to transfer HSI concepts, analysis, assumptions, constraints, and implications from the

CDE/R&D/Acquisition teams to the Operational and Support teams. A Concept of Operations (Conops) has been developed for MA&S Knowledge Transfer (Ref M).

11. Conduct HSI Monitoring

This HSI process is conducted in the Implementation and In-Service Phases and it links with the following MA&S model process:

- 1.1.2 Collect Performance Data
- 1.1.3 Validate Equipment System Data
- 1.1.4 Assess Equipment Performance
- 1.1.5 Assess Equipment Support Performance
- 1.1.7 Assess Observed Shortfall Against Expected Performance
- 2.2.2.6.7 Identify In-Service Performance Measurement Requirements
- 2.3.1.7 Produce E&S /Scope Statue Report
- 3.1 Manage Equipment System Lifecycle
- 3.3 Maintain Equipment

Process Outputs – Identification of HSI deficiencies.

Throughout the operational life of a system or capability the performance of that system must be monitored from an HSI perspective. This monitoring is conducted by both the operational and support community.

HSI monitoring occurs from three viewpoints:

1. Monitoring of MA&S Program Performance with a view to improving it;
2. Monitoring in-service materiel and support deficiencies in order to correct them; and
3. Monitoring in-service system performance from an operational and support concept perspective, to identify any HSI changes (personnel, training, procedures, and task flow) that may be required to continuously optimize system performance.

Any identified HSI deficiencies must be addressed through:

- Minor system improvements implemented by the LCMM;
- Major system improvements implemented through major acquisitions (Mid Life Upgrades or Replacement System Acquisition) and
- Operational and support concept changes implemented by the operational community.

Annex F: HSI Case Studies

These Human Systems Integration (HSI) application case studies have been organized into a number of categories to associate tasks with shared objectives. The group categories include:

- HSI Program Development;
- Case Studies Exercising Most of the HSI Process;
- Case Studies Exercising a Sub-Set of the HSI Process;
- Case Studies Focused on HSI Tool Evaluation; and
- Provision of HSI and Project Definition Support to Programs.

The case studies that follow are presented in table format describing for each project the objective, phase of the defense life cycle (schematic provided in table), HSI process phases exercised (schematic provided in table), project output, cost and benefit/impact and lessons learned.

Annex F: Human Systems Integration (HSI) Case Studies

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1 Introduction

This document is an annex to report, The Development and Validation of a Human Systems Integration (HSI) Program for the Canadian Department of National Defence (DND) and contains the case studies that were completed during the project. While the vast majority of projects analyzed were conducted as part of the HSI Project itself, some where ongoing projects with significant HSI process application that were simply observed by the HSI Project team to further add to the case study data base.

1.1 Case Studies

Throughout the course of the HSI Program Development project, a series of tasks and case studies were completed to:

- Develop the HSI program,
- Evaluate the impact of HSI on projects,
- Explore new HSI Tools, and
- Extend the application of HSI to Defence Program Management.

These HSI application case studies have been organized into a number of categories to associate tasks with shared objectives. The group categories include:

- HSI Program Development (Case Studies 1-5),
- Case Studies Exercising Most of the HSI Process (Case Studies 6-13),
- Case Studies Exercising a Sub-Set of the HSI Process (Case Studies 14-17),
- Case Studies Focused on HSI Tool Evaluation (Case Studies 18-22), and
- Provision of HSI and Project Definition Support to Programs (Case Studies 23-31).

The case studies that follow are presented in table format describing for each project the objective, phase of the defense life cycle (schematic provided in table), HSI process phases exercised (schematic provided in table), project output, cost and benefit/impact and lessons learned.

<table>
<tr><td>#1.</td><td colspan="2">1 HSI Program - People, Process, Tools, & Communications</td></tr>
<tr><td colspan="3">Overview and Objectives
Multiple tasks were conducted to define the personnel involved in HSI execution, the recommended HSI process, the relevant HSI tools, and HSI community communication mechanisms.</td></tr>
<tr><td colspan="2">Phase of Defence Life Cycle
N/A</td><td>HSI Process Phases Exercised
N/A</td></tr>
<tr><td colspan="3">Description of Project Activities
This work stream was a culmination of a number of taskings and call ups. The work tasks under these program development taskings included:
Definition of HSI Concept
Definition of HSI Team
Development and Iteration of the HSI Process
Integration of HSI Process with Core DND Business Processes
Development of HSI Web Site
Development of HSI Newsletter
Documentation of HSI Case Study Summaries
Development of HSI Final Report (this report)</td></tr>
<tr><td colspan="3">Project Output
The outputs of this work stream included:
HSI Concept
HSI Team
HSI Process
HSI Statement of Work and Data Item Description Templates
HSI Web Site
HSI Newsletter Mechanism
HSI Community Registration Mechanism
HSI Case Study Summaries
HSI Section of the Strategic Capability Initiative Plan (SCIP)
HSI Final Report</td></tr>
<tr><td colspan="3">Cost and Benefit/Impact
The effort expended on core HSI program development over five years was $273,000.
This represented the entire investment in program development from DRDC corporate. DND project teams produced an additional $3,965,000 to fund the case study applications listed. This represents a 1450% return on the DRDC investment in terms of the additional funding drawn toward this research and development activity. In essence, an entire Technology Demonstration project was conducted to research, development, demonstrate, and evaluate a HSI program with $273,000 of Human Performance thrust funding spread across 5 fiscal years.
The overall impact was that a HSI Program was defined, the initial steps were taken to integrate the program within core defence business processes, and is steadily gaining acceptance as common practice. Terminology within core processes have switched to HSI, and HSI groups have started to evolve throughout the department.
The foundation for a HSI policy requiring all projects to have a HSI approach was set, and was left as an action for the HSI stakeholder communities to implement.</td></tr>
<tr><td colspan="3">Lessons Learned
There is a strong desire for HSI within the defence community, as human centric questions increasingly drive complex weapon system development and procurement.
Projects are willing to invest portions of their R&D, CD&E, or Acquisition Funds on HSI support.
A formal HSI program in the department is sustainable as long as a few central resources are provided for coordination, and contract mechanisms are in place with competent HSI contractors. This core requirement allows project teams to bring their funding and access the necessary HSI</td></tr>
</table>

support using a range of HSI tools and techniques.

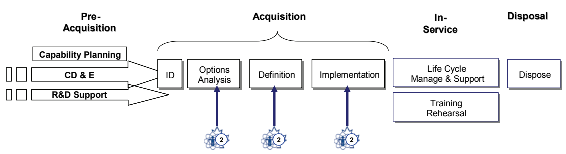
4. The HSI project web site is a required communications resource.
5. Documentation of the HSI process must point to application examples.
6. Documentation of the HSI tools must ensure that there is a link between processes and the tools that could or should be used in the execution of that process.

#2.	2 DTA HSI Support

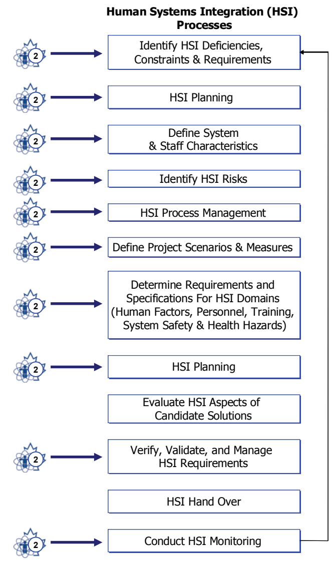
Overview and Objectives

Multiple tasks to provide HSI support to the Directorate of Technical Airworthiness (DTA), to develop the human centric aspects of the airworthiness certification process, and to monitor (and at times apply) HSI to aircraft design and upgrade programs. Focused on evaluation of the impact of standard processes and techniques applied by DND project teams and contract communities in the absence of policy, but with a strong requirement for HSI defined in the aircraft basis of certification.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

This effort was focused on the development of a HSI program within the air force community, in the Directorate of Technical Airworthiness (DTA).

The focus of the effort was on the definition of HSI requirements for the certification of military aircraft, the definition of the process to follow to certify the human systems aspects of military aircraft design changes, providing HSI oversight support to several aircraft modification and acquisition programs, and providing input into modifications to the HSI approach, and to documented lessons learned.

This effort was also able to contribute significantly to the core HSI Program Development by sharing analysis, work products, and lessons learned with the core team.

Project Output

Key outputs of this DTA effort included:

- HSI sections of the Airworthiness Design Standard Manual
- HSI Basis of Certification for Military Aircraft
- Listing of Educational Programs for Human Factors Engineering
- Extensive Human Factors in Aviation Reference Database
- Canada was invited to update the NATO Standardization Agreement (STANAG) 3994: Application of Human Engineering to Advanced in Aircrew Systems, to include a HSI approach at the request of other nations. The result was universally accepted and the update is currently in the ratification process. Acceptance and implementation by most NATO nations is anticipated.

Cost and Benefit/Impact

The effort expended by the Directorate of Technical Airworthiness on HSI support was $1,155,000 over a four year period.

The impacts of this investment included:

- A well documented HSI approach to military aircraft airworthiness assessment
- A set of standards for airworthiness certification

- A suite of well documented aircraft modernization programs with documented human factors engineering airworthiness programs
- Select projects were required to adhere to human factors engineering requirements prior to obtaining airworthiness certification allowing them to operate the aircraft with its modifications. While this delayed the flight of new designs in some cases, it did ensure that aircraft with significant modifications to cockpit human-machine interfaces addressed HSI concerns, which in turn had the potential to prevent unsafe flight, failure of the human component in the system, and the resulting incidents or accidents that could have occurred.

Lessons Learned

1. The Airworthiness process, the defined requirements, and the need for a documented Basis of Certification are all strong procedural requirements for the application of elements of the HSI approach. Even with these strong hooks into process, the absence of an official policy in ADM(Mat) requiring the systematic consideration of HSI resulted in projects either “skirting” the requirement for consideration of HSI (even in aircraft cockpit upgrades), or not considering HSI early enough in the acquisition cycle to maximize impact.
2. The primary lesson from this effort is that a policy is required to ensure that projects integrate HSI into their acquisition projects.

#3.	3 Modeling and Simulation (M&S) Coordination Office Definition
Overview and Objectives A survey of M&S tools conducted in DND indicated that of 400 possible tools available for use in the M&S domain, over 200 of those tools had a HSI analysis or evaluation application. This clearly indicated that modelling and simulation is a key tool category in support of HSI, but also that HSI is a key user/influencer in the evolving world of M&S management. As the M&S Coordination Office (later named the DND/CF Synthetic Environment Coordination Office [SECO]) was being conceived, an opportunity presented itself to support the definition of this office, to transition programmatic products from the HSI program to the SECO program, and to investigate the role of HSI within the evolving M&S community.	
Phase of Defence Life Cycle N/A	**HSI Process Phases Exercised** N/A
Description of Project Activities This project leveraged the model for the HSI Program Development, and extended the People-Process-Tools paradigm to the creation of the DND\CF Synthetic Environment Coordination Office, ensuring the integration of the HSI Tools and interests within it. The project defined the roles and responsibilities of DND SECO, conducted a survey of M&S Tools, registered M&S community participants, and published a directory of the M&S community, publishing all outputs on an initial DND SECO Web Site Portal.	
Project Output The primary outputs of the project included: • DND SECO Definition • M&S Tools Catalogue, with indication of which tools support HSI • M&S Community Registration Tool • "Who's Who in M&S" Directory • DND SECO Web Site Portal	
Cost and Benefit/Impact The effort expended on the definition and setup of DND SECO through this project was $91,000. The impact was the rapid establishment of a DND SECO capability, with a documentation of the M&S tools available to support projects, and a clear indication of which tools supported HSI analysis, further extending the reach of HSI into the M&S community from its initiation.	
Lessons Learned The HSI program model – including the relation between People-Process-Tools can be applied to any number of transformational programmatic development projects. Well over half of the M&S tools available to the DND M&S community have a role in HSI analysis.	

<table>
<tr><td>#4.</td><td colspan="2">4 HSI CONOPS for ADM(Mat)</td></tr>
<tr><td colspan="3">Task
The purpose of this SOW was to define the requirement to provide DMASP with a Concept of Operations for HSI within the MA&S Process.</td></tr>
<tr><td colspan="2">Phase of Defence Life Cycle
N/A</td><td>HSI Process Phases Exercised
N/A</td></tr>
<tr><td colspan="3">Description of Project Activities
This activity involved developing a Concept of Operations (CONOPS) for the introduction and integration of HSI within the Assistant Deputy Minister of Materiel (ADM[Mat])'s Materiel Acquisition & Support (MA&S) community. The CONOPS is a document that the Directorate of Materiel Acquisition and Support (DMASP) issues when new concepts are introduced that span multiple disciplines, in order to provide guidance to the community. This CONOPS was a high level description of the HSI business processes within DND. It included background issues, the aim, business process descriptions, stakeholders and process owners, roles and responsibilities, DND IS or business process interfaces, and MA&S IS data requirements</td></tr>
<tr><td colspan="3">Project Output
The primary outputs of this activity included:
• A report containing a Concept of Operations for HSI in the DND.
• HSI Process Version 3
• A PPT overview of the CONOP , which was presented at the TTCP HSI Workshop (project #5)</td></tr>
<tr><td colspan="3">Cost and Benefit/Impact
The investment in the development of the HSI Concept of Operations was $18,000.
This minor investment permitted the rapid creation of a CONOPS for a specific directorate/community by being able to leverage the re-usable knowledge base, process, and templates that the HSI project had created.
At the same time, this minor investment enabled the creation of the 3rd version of the HSI process, tailoring it in ways that allowed it to better align with the Defence Management System and Materiel Acquisition and Support (MA&S) Process. It also forced clearer definition of terms, concepts and tasks within the Canadian Forces HSI framework.</td></tr>
<tr><td colspan="3">Lessons Learned
The core HSI Process, Tools, and Techniques material can be rapidly tailored to the specific interests of directorates within the Department of National Defence (DND), if local guidance within the overall HSI program is desired.
The HSI Process can be integrated into the Defence Management System and Materiel Acquisition and Support (MA&S) Process.</td></tr>
</table>

#5.	5 TTCP HSI Workshop

Overview and Objectives

Conduct of international workshop on the application of HSI, hosted in Canada, with delegates from Canada, USA, United Kingdom, and Australia. This provided an opportunity at end of the project to compare and contrast Canada's efforts in HSI with those of other nations.

Phase of Defence Life Cycle	HSI Process Phases Exercised
N/A	N/A

Description of Project Activities

This activity involved the design, coordination, execution, and reporting of a TTCP Workshop on HSI.

TTCP is The Technical Cooperation Program, and involves participation of defence scientists and military personnel from Canada, the United States, the United Kingdom, Australia, and New Zealand.

Participants included representatives from each nation participating in HUM TP 9, which is a technical panel focused on Human Factors Integration for Naval Systems, however the discussion included a range of Human Systems program and practice papers.

Project Output

The output of this activity was:

- Published proceedings of the TTCP HSI workshop
- A document summarizing the workshop and the themes within it

Cost and Benefit/Impact

The cost of hosting and conducting this workshop was $36,000 which included the services of a professional conference management firm.

The impact of the workshop was a validation of the Canadian HSI approach, process, and lessons learned in the acquisition process, through the comparison of work with other nations, and the feedback obtained.

The workshop had the added benefit of collecting the Canadian HSI community as a community, especially representatives from the naval community, to focus on the application of HSI within their community.

Lessons Learned

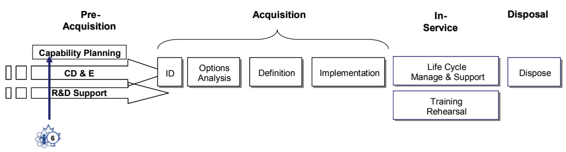
1. Canada is aligned with other nations in the definition and application of HSI, from a conceptual perspective.
2. Canada has a strong focus on "Integration" of the HSI domains, as opposed to running HSI programs to simply ensure that all HSI domains are considered in the acquisition cycle. While this concept is not unique to Canada, achieving integration is difficult in practice. HSI programs generally do not produce the double integration (within HSI domains and between HSI and engineering domains). However, the consideration of the HSI domains is desirable in acquisition, irrespective of the degree of integration between them.
3. Canada lags other countries (specifically UK and USA) in the definition of policy requiring HSI on acquisition programs.

#6.	6 Joint Intelligent Information Fusion Capability (JIIFC)

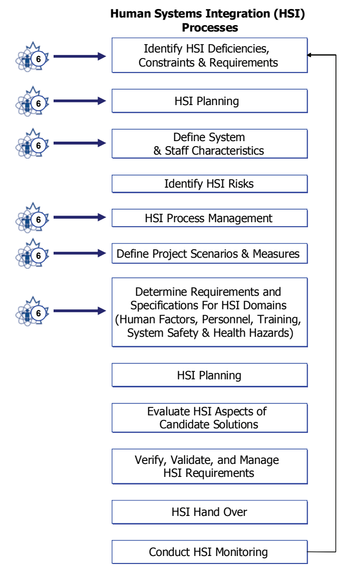
Overview and Objectives

Joint capability level project, focused on Capability Engineering approach to capability requirements analysis and concept definition very early in the process. Capability Engineering approach included application of HSI approach with HSI tools to demonstrate and evaluate the disciplines that should be included in the JIIFC capability definition, and to provide a first test of integration of HSI within the Capability Engineering draft process.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

This project involved the following activities:

- Review of JIIFC concept and identification of constraints
- Development of HSI Plan for JIIFC, including first integration of HSI incorporated into a draft Capability Engineering construct
- Conduct of Function analysis in concert with a multi-disciplinary group of systems engineers.
- Extrapolation of function analysis to task analysis
- Application of Task Network Modelling as a tool to evaluate alternative staffing concepts in a command centre environment, and the associated impact on task performance and workload
- Application of 3D visualization/simulation as a tool for design reviews of command environment concepts from a HSI perspective
- Integration of a HSI tool for conducting performance prediction analyses (Integrated Performance Modelling Environment [IPME]) into the Capability Engineering Integrated Engineering Environment (IEE)

Project Output

The outputs of this activity included:

- HSI Plan
- JIIFC Function Analysis
- DoDAF Architecture Views
- DODAF OV-2: JIIFC Operational Node Connectivity
- DODAF OV-3: JIIFC Operational Information Exchange Matrix
- DODAF OV-5: JIIFC Activity Models (framework)
- Requirements Definition and Management Plan - HSI-related sections
- Prototype JIIFC Task Network Model

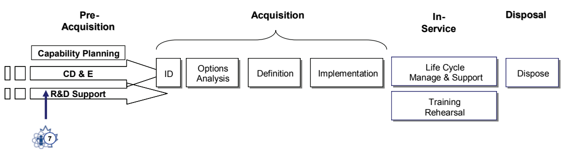
• Prototype JIIFC Visualization/Simulation
Cost and Benefit/Impact The effort applied to the application of HSI to the JIIFC capability project was $223,000. As a result of the integrated, multi-disciplinary, approach to capability engineering, and the inclusion of HSI, it was possible to ensure the consideration of the "human" component within the architectural analysis. Without this involvement, the functional decomposition and architecture views would have clearly focused on the technological aspects of the capability, and re-work would have been required at a later date to initiate human centric analysis, that would have then lead to re-work of the technology based aspects to accommodate the human centric analysis. Total savings of the integrated approach was estimated at $125,000 of saved re-work that would have been required [Calculated based on a savings of 1250 hours of analytical re-work at $100/hr that would have been required to modify analysis to properly consider the human component from both a human factors and personnel perspective. This was saved by taking an integrated HSI approach, integrated within the Capability Engineering effort.]. At the end of the first phase of JIIFC work, the JIIFC project office conducted a workshop, a range of Capability Engineering analyses were rated in terms of their utility to the capability engineering/management team responsible for the JIIFC requirements analysis and concept development. The rating data from this exercise resulted in HSI analysis receiving the highest rating across the disciplines.
Lessons Learned 1. Integration of HSI analysis into a Capability Engineering approach saves time and money in the capability architecture analysis process, and ensures that the human component is considered throughout. 2. Within the architectural analysis methods (DoDAF, MoDAF), in addition to Operational Views (OVs), System Views (SVs), Technical Views (TVs), etc. there is a need for Human Views (HVs) that clearly isolate the human component of the capability analysis, and the impact of alternative capability configurations on the organization and the personnel within it. 3. The HSI effort on a C4ISR Capability Engineering team was approximately 11% of the engineering effort.

#7.	7 Advanced Land Fire Control System (ALFCS)

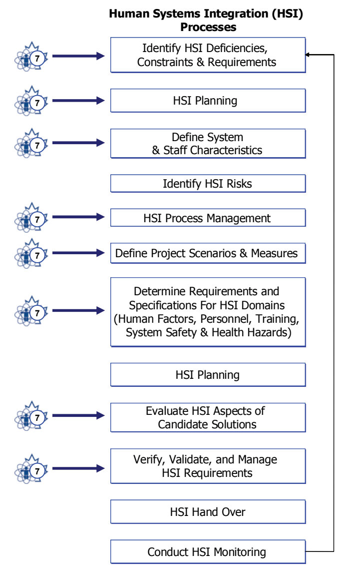
Overview and Objectives

A multiple year technology demonstration project focused on the development and evaluation of new armoured vehicle fire control system technologies within a medium fidelity armoured vehicle full motion simulation test bed environment. This program involved a strong human factors engineering program that was extended to include impacts of the new concepts on training and personnel. This R&D activity, and the HSI study results in the areas of design requirements, personnel, and training requirements fed directly into the Statement of Operational Requirements (SOR) for new armoured vehicle acquisition.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Core project activities included a repeatable iterative sequence of activity that was repeated through 4 Build and Test cycles in support of the lead engineering team:

- HSI Planning
- Analysis of the Future User Community
- Definition of Operational Scenarios and Classes of Engagement
- Mission/Function/Task Analysis
- Generation of Design Inputs
- Creation of HSI Evaluation Plans
- Verification of Design Against HSI Design Requirements
- Conduct of Simulation Based Design Evaluations

Project Output

Key outputs from this HSI activity included:

- HSI Plans
- Mission/Function/Task Analysis
- Operator Machine Interface Design Descriptions
- Evaluation Plans
- Evaluation Reports
- ALFCS Training Curriculum
- Requirements Statements for armoured fighting vehicle (AFV) Capital Acquisition Program

Cost and Benefit/Impact

The investment in HSI was approximately $460,000.

The HSI effort early in the project resulted in a significant reduction of originally planned system functionality where user feedback indicated that the initial concepts would not be of benefit to the armoured vehicle community. If these features had remained in the system through the R&D phase, and if they had been left in the system through the final system production the additional life cycle product costs for a Canadian fleet of vehicles with that fire control system would have been over $5,000,000 [Very conservative rough calculation based on additional engineering and test and evaluation costs through R&D, additional engineering costs during final design, and production and delivery costs to fleet of 3 squadrons of vehicles or approximately 60 vehicles].

The HSI analysis validated that an armoured vehicle crew with an autoloader could complete the Canadian suite of missions using Canadian doctrine and tactics. This conclusion resulted in the confirmation that a crew member (loader) could be eliminated from the armoured vehicle concept. This reduction of 1 crew member per vehicle, across a Canadian fleet of vehicles (min 3 squadrons), results in an approximate life cycle savings cost of over $100,000,000 through a 20 year service life. (Calculated based on conservative annual personnel cost of $80,000/yr per loader saved, times 60 vehicle fleet, plus the annual training savings over 20 years which was estimated conservatively at $50,000/yr per 60 vehicles over the 20 years, for a total of $156,000,000 in savings, from which $30,000,000 was subtracted as an approximate cost of adding the autoloaders to the vehicle costs. For the purpose of the cost benefit analysis presentation in the main body of the HSI Final Report the two figures are summed for a total of $131,000,000.

Achieved a 1/3 reduction in "buttonology" in the interface of the fire control system through iterative analysis, design, evaluation, re-design activities. Simpler interface decreased training requirement, and engineering development requirement.

Proven requirements related to the user interface, and personnel and training were inserted into the Statement of Operational Requirements for acquisition as a result of the studies conducted during this effort. This would have further avoided additional re-engineering costs later if the requirements had not been as complete and user focused.

Lessons Learned

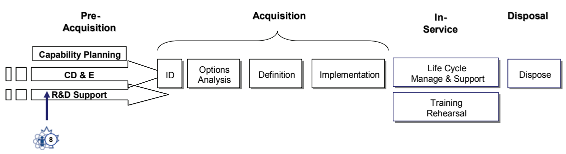
1. Simulation based, iterative design and experimentation cycles can effectively address the full range of HSI variables. Military operators are able to effectively extrapolate their experiences in medium fidelity virtual simulation environments to provide structured feedback on task performance, workload, situational awareness, usability, training, system safety, health hazard, and personnel impacts of future system designs. Objective measures used in virtual simulation based experimentation can provide data sets on task performance, workload, usability, and learning time.
2. Distributed virtual simulation provides an effective experimental platform for the investigation of team tactics and associated procedures, in support of HSI evaluations.
3. The HSI effort on this project represented approximately 10% of the engineering effort.

#8.	8 **Future Armoured Vehicle System (FAVS)**

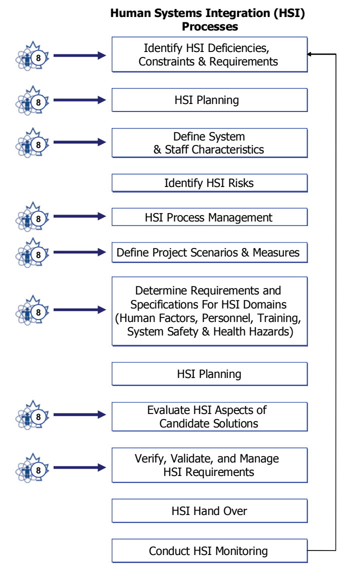
Overview and Objectives

A multi year technology demonstration project focused on the definition, development, and evaluation of advanced concepts including fusion of sensor and battlefield management system information, defensive aides suites systems, vehicle's weapons and fire control system and map information into an immersive user display for future armoured vehicles. Requirements analysis and evaluation include consideration of human factors, health hazards, training, and personnel in an integrated analysis approach. Application of constructive and virtual simulation environments provided the opportunity to explore the role and validity of task network modelling as a predictive tool for individual and crew workload, as an aid towards analyzing crew size, composition, and skill impacts of a future concept.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Core project activities included an iterative sequence of activity that was repeated through 3 Build and Test cycles in support of the lead engineering team:

- HSI Planning
- Analysis of the Future User Community
- Definition of Operational Scenarios and
- Mission/Function/Task Analysis
- Task Network Modelling of Alternative Designs
- Generation of Design Inputs
- Creation of HSI Evaluation Plans
- Verification of Design Against HSI Design Requirements
- Conduct of Virtual Simulation Based Design Evaluations
- Predictive Workload Estimates Using Task Network Modelling
- Live field trials of actual system design in Light Armoured Vehicle

Project Output

Key outputs from this HSI activity included:

- HSI Plans
- Mission/Function/Task Analysis
- Operator Machine Interface Design Descriptions
- Evaluation Plans
- Evaluation Reports

- FAVS Training Curriculum

Cost and Benefit/Impact

The investment in HSI on this project was approximately $300,000.

As a result of the HSI activity, the concept that a Helmet Mounted Display could be used in an armoured vehicle as the basis of an immersive, fused, display medium was rejected. This decision would have saved millions of dollars in ongoing R&D if the human centric studies had not generated the data necessary to make this decision conclusively.

Tactics for interim army combined arms teams generated through the simulation based experiments were shared by the R&D community with the land force community. This saved additional time and effort in other departments to generate this same information.

There was a savings of approximately $75,000 in HSI analysis effort, as a result of the ability to re-use existing armoured vehicle HSI analysis from a previous project (ALFCS). (Calculated based on a savings of 750 hours of effort charged at $100/hr).

Lessons Learned

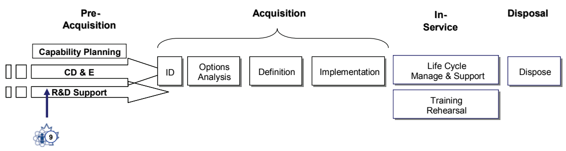
1. Part task evaluations of new concepts can be replicated in Constructive Simulation (Task Network Modelling), Virtual Simulation, and Live Simulation in support of an integrated HSI Experimental Campaign.
2. Distributed federations of military land and air vehicles can effectively be linked to create future force experimental environments to study HSI issues in a coalition force context.
3. Task Network Modelling can predict crew task performance and support design evaluation of HSI issues.
4. Historical HSI analysis can be re-used to effectively reduce the required effort in the conduct of HSI, especially when the same functions and high level tasks are being analyzed in the same class of vehicles.
5. The HSI portion of the engineering effort was approximately 16%.

#9.	9 Multi Mission Effects Vehicle (MMEV)

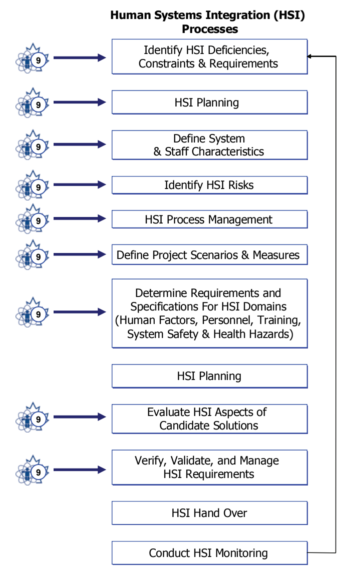
Overview and Objectives

A multi year technology demonstration project established to evaluate a future armoured vehicle concept that would integrate direct fire, indirect fire, and air defence on the same vehicle. This project was established to answer HSI questions raised by the Commander of the Army, specifically (a) Can a two or three person crew operate such a system?; (b) If yes, what type of skill levels will be required in that crew?; (c) What type of skill fading will be expected based on the complexity of such a system, and what will the impact be on simulation based training requirements?; and (d) Based on the required skill levels what is the impact of acquisition of such a system in 15 years going to be on organizational structure and career progression in the army? This entire R&D effort was focused on answering these HSI centric questions, using an integrated HSI approach, and extending the exploration of task network modelling as a predictive analytical tool for workload and personnel impact assessments.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Core project activities included an iterative sequence of activities that were repeated through 2 Build and Test cycles in support of the lead engineering team:

- HSI Planning
- Analysis of the Future User Community
- Definition of Operational Scenarios
- Mission/Function/Task Analysis
- Task Network Modelling of Alternative Designs
- Generation of Design Inputs
- Creation of HSI Evaluation Plans
- Verification of Design Against HSI Design Requirements
- Conduct of Virtual Simulation Based Design Evaluations
- Predictive Workload Estimates Using Task Network Modelling

Project Output

Key outputs from this HSI activity included:

- HSI Plans
- Mission/Function/Task Analysis
- Operator Machine Interface Design Descriptions
- Evaluation Plans

- Evaluation Reports
- MMEV Training Curriculum

Cost and Benefit/Impact

The approximate HSI investment in this initiative will be close to $600,000.

The benefits are only just beginning to be realized but tactics for interim army combined arms teams generated through the simulation based experiments have been shared by the R&D community with the land force community and design requirements are feeding directly into the MMEV acquisition project. The savings to the acquisition community as a result of receiving these requirements is approximately $175,000 based on the fact that the air defence anti-tank system (ADATS) upgrade project was able to re-use analyses saving approximately $100,000, and the analyses generated will be of benefit to additional parallel acquisition activities. (Calculated as 1750 hours saved at $100/hr).

There will be many other cost savings in HSI analysis effort, as a result of the ability to re-use existing HSI analyses and support personnel and training analysis for maintaining and operating these future armoured fighting vehicles.

Lessons Learned

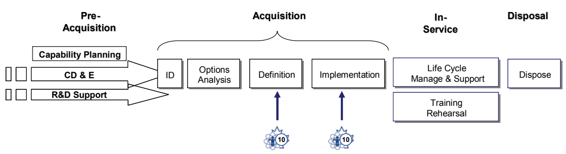
1. The driving questions in military future weapons platforms, especially those that are part of a network centric operating concept, are HSI questions. These questions focus on what the impact of a new technology and concept will be on individual task performance and workload, team performance and workload, situational awareness, skill level requirements, organizational structure requirements, the numbers and types of personnel needed to staff the organization with the required skills, and the impact on recruitment and career progression. Structured HSI analysis can cost effectively address these concerns, and HSI driven experimentation campaigns using simulation based experimental environments provide the analytical backbone for data driven, defensible, guidance to future weapon system teams.
2. Distributed federations of military land and air vehicles can effectively be linked to create future force experimental environments to study HSI issues in a coalition force context.
3. Part task evaluations of new concepts can be replicated in Constructive Simulation (Task Network Modelling), and Virtual Simulation, with the results extrapolated from one or four vehicles from virtual simulation studies into constructive war gaming with a full squadron of vehicles.
4. Task Network Modelling can predict crew task performance and support design evaluation of HSI issues.
5. Historical HSI analysis can be re-used to effectively reduce the required effort in the conduct of HSI, especially when the same functions and high level tasks are being analyzed in the same class of vehicles.
6. The HSI portion of the engineering effort was close to 20%.

#10.	**10 Maritime Helicopter Project (MHP)**

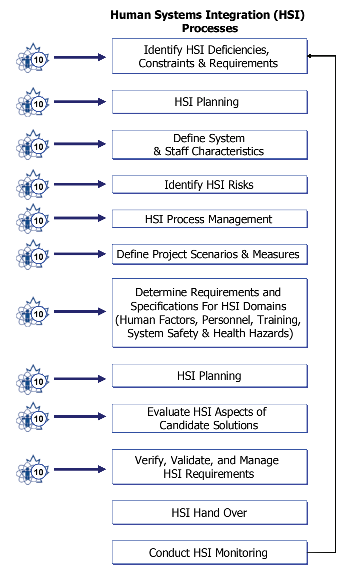
Overview and Objectives

The MHP project involved the acquisition of a new fleet of maritime helicopters for the Canadian Forces. The project was a key case study for the application of HSI, and provided the multi-year opportunity required to officially integrate HSI concepts, HSI Requirements, HSI Statements of Work (SOW), HSI Data Items Descriptions (DIDs), the HSI Capability Maturity Model, and HSI Bid Evaluation Items into a formal capital acquisition project while monitoring cost and benefit. This project allowed the establishment the role of a HSI Manager, and business approach that integrated Human Factors Engineering, System Safety, Health Hazard Assessment, Training, and Personnel on both the government side and the contractor side of the acquisition process.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

This project, more than any other case study, enabled the full application of the HSI Process to a capital acquisition of a $3B scope.

A number of activities were conducted in support of the MHP team over a 4 year period, including:

- Definition of HSI Concept, Team with the Project Office, and High Level HSI Plan
- Generation of Target Audience Description
- Definition of HSI Risks into Project Risk Database
- Management of HSI Process throughout Definition, Bid Evaluation, and Implementation Phases
- Mission/Function/Task Analysis leading to airframe and mission suite requirements definition for both operations and maintenance.
- Definition of relevant military specifications in support of HSI
- Creation of HSI Statement of Work for major aircraft acquisition
- Creation of HSI Data Item Descriptions
- Definition of HSI Capability Maturity Model and associated requirements for inclusion in acquisition strategy
- Creation of HSI Bid Evaluation Strategy
- Conduct of Evaluation of Contenders Against HSI Criteria
- Early Verification of the HSI Approach Taken by Bid Teams

Project Output

Key outputs from this HSI effort included:

- HSI Plan
- Human Engineering Systems Analysis Report (HESAR) Update

- HSI Requirements
- HSI Statement of Work
- HSI Data Items Descriptions
- HSI Bid Evaluation Criteria
- HSI Bid Evaluation Report

Cost and Benefit/Impact

The HSI effort applied to MHP over 4 years was approximately $1,200,000.

The HSI approach saved more money than was spent. A core reason for this was the systematic re-use of Mission/Function/Data analysis across the HSI domains. For example, a $500,000 analysis was re-used three separate times in support of Human Factors, Training, and Safety analysis, and then leveraged further into workload assessment (discussed as a separate case study). This analysis was then provided to the industry team as the basis for their efforts. This analysis re-use was conservatively estimated to have saved $2,000,000 of effort and 12 to 16 months of time during the acquisition process in direct support of HSI requirements generation and industrial team final design/delivery activity. (Calculated based on the re-use of a $500,000 analysis four times, that would have normally been repeated. On two occasions this analysis was slated to be repeated by personnel in different HSI domains until prevented by the integrated HSI approach taken).

The HSI approach resulted in a common behavioural task description for operations and maintenance being shared by Human Factors Engineering, System Safety, and Training. This resulted in repeated multi-disciplinary interaction, and a shared analysis being used throughout the definition phase and bid evaluation, and passed to the contractor HSI team as Government Furnished Information (GFI).

HSI analysis of the helicopter recovery system indicated that an additional display was not required to support the original concept. If this recommendation follows through the project there will be a minimum of $2M in savings within the original plan. [Calculated conservatively based on saved additional engineering analysis time for the display within the recovery system, and the engineering and manufacturing costs for installing the additional display system on all ships].

Lessons Learned

1. A HSI team can effectively be run within a major capital acquisition project office.
2. To achieve the benefits of an integrated HSI approach, additional numbers of personnel are not required, but a strong HSI coordinator is required, who maintains a focus on the integration of the domains. Human Factors personnel are well positioned to perform this function.
3. HSI is best integrated when it occurs at the Systems Engineering Manager Level or equivalent. The HSI Manager must report at least to the Systems Engineering Manager (SEM).
4. Integration of the Systems Engineering based HSI domains (Human Factors, Health Hazards, and System Safety) with the Integrated Logistics Support HSI domains (Human Factors for maintenance, Health Hazard and Safety for maintenance, and Training) requires significant effort and a pre-planned focus. When this is not in place, the integration won't occur. This "operations" vs "support" integration requirement is significant, offers additional benefits for HSI, but must be focused on throughout the program.
5. A HSI team in support of a capital acquisition requires access to the HSI Statement of Work and DID templates for the HSI process.
6. Links between the acquisition project and the personnel staff (ADM[HR]) should be maintained during the analysis phases to check the currency and validity of any personnel requirements or assumptions within which the project is working.
7. While in this case study the complete system safety domain was managed through the HSI team, on many projects the HSI effort will be focuses on human centric aspects of system safety analysis integrated with other members of the engineering team who have dedicated system safety staff focused on hardware and software aspects of system safety.
8. A HSI cell in support of a capital acquisition project requires access to Modelling and Simulation based tools, such as human form mannequin software and task network modelling.
9. Centralized task analyses for the primary missions of a capital acquisition project are required. These should be located in centralized task analysis databases accessible by human factors engineering, system safety, and training personnel.
10. Human Factors Engineering personnel can adequately address Health Hazard Assessment issues on a capital acquisition team, if they have access to health hazard assessment (HHA) experts from the R&D labs to assist in requirements selection and bid evaluation criteria selection.

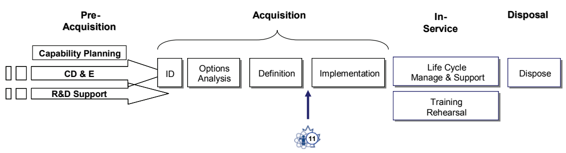
11. The HSI effort in the government Project Office represented approximately 5% of the engineering/management effort to define and acquire the helicopter.
12. The HSI effort on the contractor team was estimated/observed (based on personnel in org charts) to represent approximately 60% of the COTS airframe delivery (human factors, system safety, and training) and 20% of the mission suite delivery (human factors, system safety, and training) efforts.

#11.	**11 MHP Modelling**

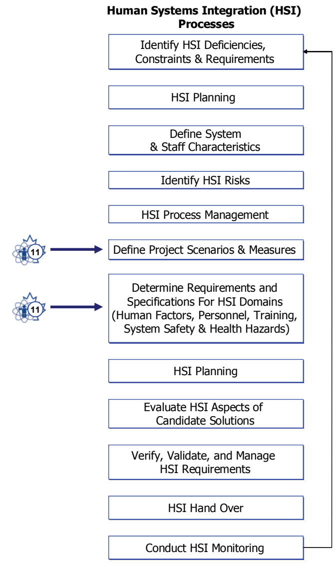
Overview and Objectives

A portion of the MHP HSI initiative but also a task within itself with a specific focus which was to utilize 3D models of the aircraft of each bidder in order to determine if the full anthropometric range of personnel with their clothing and equipment could perform their operational tasks in the rear of the aircraft, and to determine if maintenance would be able to be performed by personnel within the ship hangar. This case study focused on the role of "simulation based acquisition" in the evaluation of HSI driven performance requirements within the helicopter bid evaluation process.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

This project required the following tasks to be conducted:

- Define critical tasks for the rear of the aircraft.
- Analyze those tasks in the existing aircraft (Sea King) as a reference validation data set.
- Configure model of candidate aircraft for simulation analysis.
- Configure model of ship hangar for simulation analysis.
- Conduct simulation based analysis of crew's ability to perform tasks within aircraft (operations tasks) and within ship hangar space with aircraft in hangar (maintenance tasks).

Project Output

The output of this project was an evaluation of each candidate aircraft against a sub-set of the helicopter bid criteria.

Cost and Benefit/Impact

The investment in this activity was approximately $200,000.

This effort played a very significant role in the selection of aircraft within the competitive bidding process. The HSI analysis demonstrated that certain aspects of the missions could not be completed by CF personnel with their clothing and equipment within all of the contending aircraft. Had this analysis not been conducted, and had some other potential aircraft been selected and fielded, this may have resulted in decreased operational effectiveness, and potential loss of lives (the aircraft would have had to return to ship to be reconfigured for specific missions, such as Search and Rescue, as opposed to being a full time multi role aircraft).

Lessons Learned

1. HSI analysis can be a key contributor to the selection of the winning contender in acquisition bid evaluation processes.

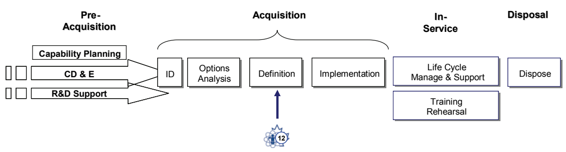
2. Simulation based analysis can enable performance based HSI evaluations, historically not possible.
3. Focus efforts on the legal and procedural aspects of simulation based analysis are required when used as the basis for bid evaluation.

#12. **12 MHP Workload**

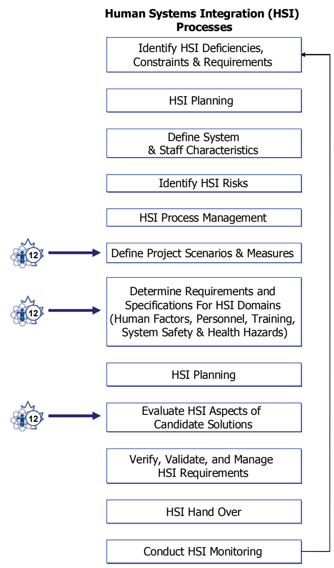
Overview and Objectives

A portion of the MHP HSI initiative, but also a task within itself, with a specific focus which was to investigate the role of Task Network Modelling as a tool to predict crew workload, linking that analysis with personnel impact assessments, whereby the analysis was used to determine, and later defend the requirements in the procurement documents for the number of personnel that the aircraft required. This analysis was re-used several times to examine the distribution of roles amongst the defined crew to balance workload and operational effectiveness and to finalize operational and support concepts prior to the release of acquisition documents. This analysis was completed by a team of human factors engineering and training personnel, with the core analysis being re-used in support of HFE workload analysis and personnel impact analysis. This was then extended so that the core function and task analysis was used as the basis for training needs analysis to determine the training and simulation requirements for the aircraft as inputs to the project requirements documents.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Modified Existing Scenarios
- Update Task Analysis with future MH Crews
- Integrate Task Analysis Results
- Created Task Network Models (TNM)
- Created TNM Experimental Cases
- Ran Models
- Collected & Analyzed Data

Project Output

Key outputs from this project included:

- TNM Models for Re-Use by Contractors
- Identification of High Workload Situations
- Design, Training and Personnel Recommendations to Deal with High Workload Situations

Cost and Benefit/Impact

The level of investment in this activity was approximately $85,000.

As a result of this HSI activity the requirement for a 4 person versus a 3 person crew was clearly proven,

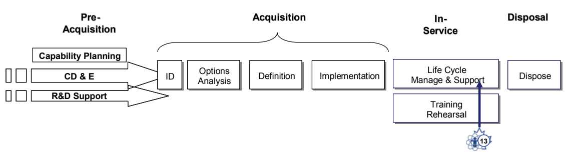
first through low fidelity analysis with subjective workload assessments integrated into Training Needs Analysis (TNA) sessions with Subject Matter Experts (SMEs), and later through medium fidelity assessments using Task Network Models of the various mission profiles, evaluating alternative crew configurations and measuring the predicted impact on crew workload. If this HSI analysis had not clearly defended the need for a 4 person crew, a 3 person crew requirement may have been permitted in the acquisition process. This would have potentially allowed the acquisition of an aircraft that would not have been able to meet mission requirements, resulting in continual re-engineering, retrofits, and modified mission profiles to accommodate crew workload problems. Re-engineering and re-fit costs alone would have easily exceeded $1,000,000 over the life of the aircraft, with the value of the lack of operational performance and potential loss of life being more difficult to estimate. As a result of the integrated HSI program, the TNA activity, and the Task Network Modelling activity the team was able to re-use existing scenarios and task analysis, saving at least 3 months of time, and $120,000 in costs. The Training community received an ADM(Mat) award for excellence as a result of their efforts on this project, and their demonstrated ability to leverage an integrated HSI approach to rapidly complete their assessments in support of key acquisition project decision making requirements.
Lessons Learned 1. This project was a good example of sharing and re-using existing date, and demonstrated the integration of human factors engineering and training particularly well in terms of common analysis and common goals. 2. The benefit to the system engineering group was very directly demonstrated in terms of having valid analysis on which to base the acquisition support documents. 3. Due to the re-use of existing analysis, this effort was completed in a timely manner to directly support procurement that was moving quickly during this phase. 4. This analysis is continuing to be re-used by contractors working on the HSI program.

#13.	13 Very Short Range Air Defence (VSHORAD): Grizzly 6x6 LAV

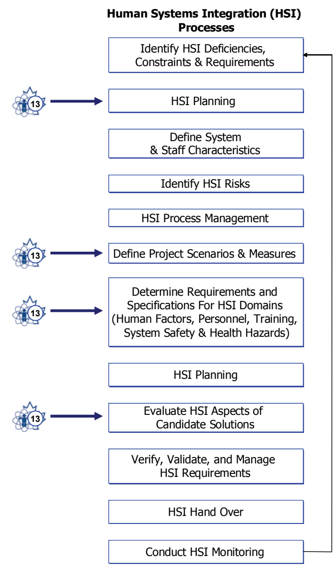
Overview and Objectives

This project involved the application of the HSI approach to a mid life upgrade suggestion for the land staff air defence community. A proposal had been made to upgrade the Grizzly light armoured vehicle (LAV) to permit a two person crew to operate a Very Short Range Air Defence system from within the vehicle, essentially “popping up” through a new hatch on the rear of the vehicle, and engaging aircraft with VSHORAD weapons from this position. This concept introduced a number of concerns in the area of human factors, system safety, and health hazards. An integrated HSI approach resulted in a study with a series of subject matter experts from each of the stated HSI domains conducting analysis around a common functional and task analysis of the crew roles, leading to an integrated HSI assessment being passed to the vehicle life cycle manager and the military requirements officer.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Human Factors Engineering assessment of vehicle layout using human form mannequins.
- Usability Assessment of design with future users.
- Blast Overpressure Assessment during field trials.
- Toxicology Assessment during field trials.
- Biomedical Assessment (wind velocity impacts on toxicological flow of missile exhaust)

Project Output

Key outputs from this project included:

- HSI Evaluation Plan
- HSI Evaluation Report (integrating the results of HFE and HHA assessments).

Cost and Benefit/Impact

Approximately $80,000 was invested in this study, including the work by DRDC TORONTO personnel, Human Factors contractors, and HSI contractors.

As a result of this study a series of vehicle design modifications, and a series of personal protection and procedural recommendations were made that will ensure effective task performance and human safety, thereby preventing future injuries.

Lessons Learned

1. An integrated HSI assessment of a complex mid life upgrade is achievable.

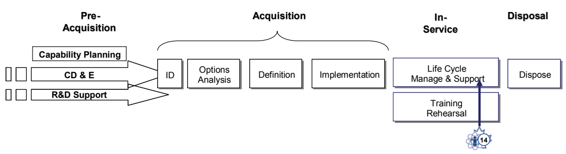
2. Centralized function and task analysis is the integrating analysis that "pulls together" and focuses human factors engineering and health hazard assessment investigations of weapon system and vehicle modifications. Human Factors leads with task analysis and workspace layout, followed by Health Hazard Assessments of hazard variables, whereby if the hazards are too great, HFE and HHA work together to iteratively create and evaluate design alternatives.
3. Combinations of simulation based evaluations and field trial measurements work well together for a comprehensive HFE and HHA assessment of weapon system modifications.
4. Environment and HHA can contribute to assessment of the impact of alternative design configurations on skill transfer from one operating concept to another.

#14.	**14 Visual Acuity for Divers**

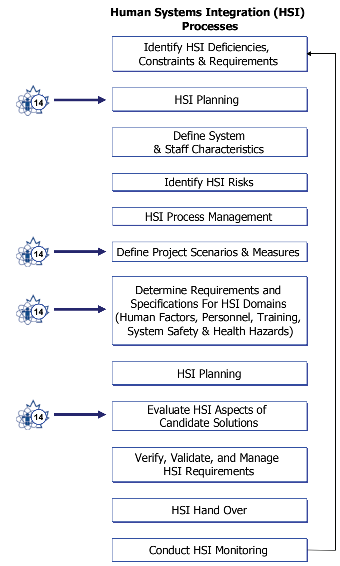
Overview and Objectives

The Navy identified the requirement to determine the minimum visual acuity required both army and navy divers. This requirement provided the opportunity for a HSI project to demonstrate an integrated approach including elements of human factors engineering, system safety, and personnel assessment (screening criteria).

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- A targeted review of relevant literature was conducted.
- A scenario based task analysis was conducted with Subject Matter Experts (SMEs) from the ship's, clearance and combat diving community to develop a prioritized set of visual task requirements performed by divers.
- Two experiments were conducted to determine the uncorrected visual acuity necessary to perform typical diving tasks in an operational environment. These were conducted with 9 divers at the Fleet Diving Unit Atlantic (FDU[A]) involving tasks completed with a series of visual acuity correction e.g. detecting and identify submerged ordnance in a pool and locating a Rigid Hull Inflatable Boat (RHIB) during night time hours, Halifax harbour.
- Recommendations were made prescribing minimum requirements for Navy and Combat diver visual acuity (uncorrected).

Project Output

Key outputs from this project included:

- Literature review
- Task analysis
- Experimental plan
- Visual acuity standard recommendations

Cost and Benefit/Impact

This project involved a $85,000 investment. The recommendations required an increase in the visual acuity standard making it "more difficult" for the navy to recruit divers from the ship's company, and for the army to recruit divers from the combat engineering community and potentially for both to recruit divers from the public. At this time, the standard has not been updated and is still undergoing review.

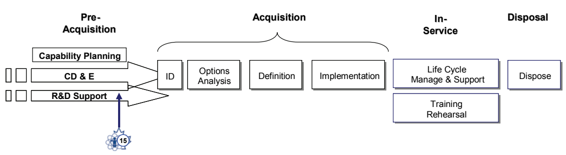
However, the personnel community was provided with the tools (via the recommendations) to build a bona fide standard based on the tasks required in the field which allows them to potentially react to this recruiting need. The impact on safety is significant to individual divers and diving teams. Some of the key diver tasks behind the recommended increase in the visual acuity standard were related to lost divers being able to locate the dive tender or the rendezvous point. Hence, the cost saving is in the potential to avoid serious injury or deaths to DND divers.
Lessons Learned 1. The derivation of task based, bona fide performance standards are essential for recruiting and retainment, and for successful performance during operations. 2. Significant link integration between personnel and human factors and the operational community was demonstrated.

#15.	**15 Grasshopper UAV**

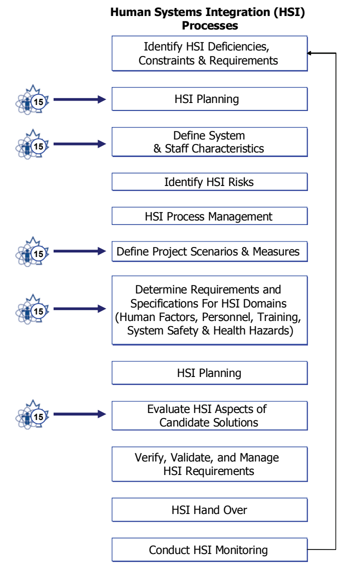
Overview and Objectives

Uninhabited Aerial Vehicles (UAVs) were increasingly being considered for use by the Canadian Forces. UAV application opportunities included both the operational and tactical level. The Grasshopper UAV was a specific instance of a tactical UAV that was proposed to DND, and an evaluation of this UAV during field trials was specified. A HSI evaluation was conducted as part of the overall evaluation of the UAV, whereby HSI evaluation variables in the areas of human factors engineering, system safety, health hazards, training, and personnel were incorporated into a HSI trial plan, which was a component of the overall trial plan. Field exercises in Canada and the USA generated a HSI evaluation dataset for UAVs.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Conduct SME-based high level reconnaissance task analysis.
- Create trial plan.
- Conduct trial in Valcartier and Fort Drum (New York).
- Analyze results.
- Create report and recommendations.

Project Output

Key outputs from this project included:

High level task analysis of reconnaissance operations, functions and tasks

Human Factors trial plan

Human Factors trial report

Task performance analysis (workload, usability, situation awareness)

Training and Personnel Impact assessment

Cost and Benefit/Impact

This project involved a $25,000 assessment of the UAV concept.

The project was able to re-use historical analysis of UAVs, and previously used measures from other HSI evaluations, resulting in a savings of approximately $20,000 in analysis and methodology development that did not have to be done specifically for this project. In addition, the trial was able to fully consider issues for human factors, personnel, training, and system safety simultaneously during the evaluation, thereby preventing the need for separate evaluation trials for these separate HSI domains (as has happened in the past on other programs using non-integrated approaches).

The potential integration of the UAV at the tactical level was explored in the report resulting in benefits to the training and personnel community. The benefits included data to modify the MOC and training of staff with

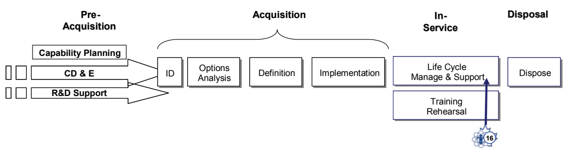
Recce Troops. In addition, DND and the UAV contract team gained significant insight into training users and in safety issues associated with the UAV operations, as a result of the HSI analysis (thereby preventing future injuries).
Lessons Learned 1. It is a very small effort to transition a Human Factors Engineering trial plan into a HSI Trial plan. The additional effort requires the addition of measures related to health hazards, safety, training, and personnel impact into the evaluation set. The result of incorporating these additions is a significantly more comprehensive analysis of the "human component" in the system. 2. Sharing lessons learned with all the stakeholders i.e. operations, ADM(HR) and Training, is one of the biggest HSI challenges in technology demonstration projects. The reason is that while all stakeholders are all interested in the lessons learned, they may not be in a position (timing wise) to exploit them. A central HSI repository that can be actively promoted to users and searched by users would substantially improve the usefulness and re-use of HSI data and analysis.

#16.	16 Patrol Frigate Accommodation

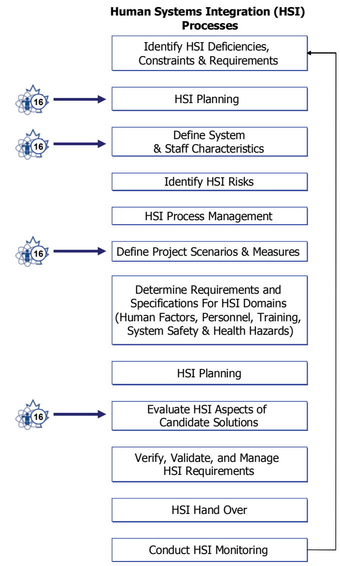
Overview and Objectives

A proposal had been made to alter the living arrangements on board the Canadian Patrol frigate. The navy required an evaluation of the impact of this on human task performance and quality of life. A HSI study was conducted to evaluate the impact of the proposed changes including consideration of human factors engineering, safety, and personnel issues. A review was conducted of the concept itself, followed by evaluation of a modified ship that was exercised through sea trials.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Review design modifications.
- Create study approach.
- Develop Trial plan and data capture instruments.
- Conduct Pre-Deployment Interviews.
- Distribute Deployment Survey Log.
- Conduct Post-Deployment Interviews*.
- Analyze Data and Report Findings.

* Post-Deployment Interviews were not conducted due to deployment delays that caused the ship to remain at sea well beyond the close of the contract. However, the data acquired up to that point was sufficient to be analyzed and a report was produced based on this data.

Project Output

Key outputs from this project included:

- Trial Plan.
- Data Capture Instruments.
- Report and Recommendations.

Cost and Benefit/Impact

This activity was forecast to cost approximately $28,000, but due to a portion of the activities (see * in Description of Project Activities) being cancelled, approximately $20,000 was spent.

The findings clearly demonstrated the Personnel Impact of the ship modification to ships crews. The operational community can use this information as an input to their analysis to deal with serge accommodation on board the Canadian Patrol Frigates.

Lessons Learned

1. The analytical "backbone" of HSI within the engineering process provides opportunities for the systematic consideration of "soft" variables such as the impact of a design change on morale, and the subsequent impact on personnel quality of life.

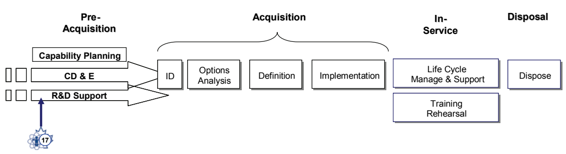
#17.

17 Advanced Linked Extended Reconnaissance and Targeting (ALERT) Experimental Design Support

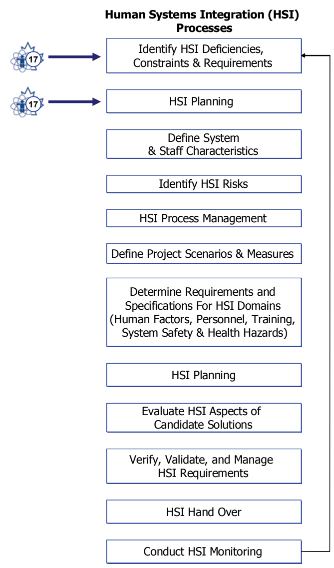
Overview and Objectives

The ALERT technology demonstration project was designed to investigate enhancements to the Coyote reconnaissance vehicle and its associated sensor suites and communication systems. The proposed changes included the addition of new sensors, significant integration of sensors, and a number of options for the fusion and transition of information through higher level commanders. This concept required systematic consideration and evaluation of crew roles, task flow alternations based on alternative crew roles, and the impact of design changes on task performance, personnel, and training requirements. As a result, a HSI study was conducted to develop the experimentation campaign for the ALERT technology demonstration project ensuring that the design of the R&D program, and the various levels of simulation based experimentation (constructive, virtual, and live) would properly address the core HSI questions in the R&D activity.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Project activities included familiarization and review of ALERT TD Scope, the future operational environment, and capabilities of the ALERT Vehicle. Experimental objectives of ALERT TD were identified. Future Operational Scenarios and ALERT-Enhanced Coyote Operational Concepts were defined to support the development of a Human Performance Measurement Framework.

Project Output

A report entitled “Experimental Framework for the ALERT TD Project” was produced. It documented an overview of the Coyote Vehicle, the enhanced Coyote and ALERT TD, ALERT TD Scenarios, CONOPS and measurement, and a proposed experimentation schedule.

Cost and Benefit/Impact

Approximately $53,000 was spent on this HSI Planning effort.

The impact of the work was that the R&D project (ALERT TD) was effectively planned around a human centred experimental plan, thereby ensuring full consideration of the human performance impacts of the new technologies being evaluated in multiple HSI domains through constructive, virtual, and live simulation trials.

Lessons Learned

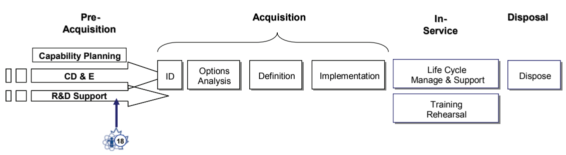
HSI experimental design activities, when applied to simulation based experimentation campaigns evaluating Interim or Future Force concepts, can clearly lead the overall experimental design, and can complete the first two steps of the federation development process (FEDEP) Process which his used in distributed simulation experiments.

#18.	**18 Helmet Mounted Display for the CF18**

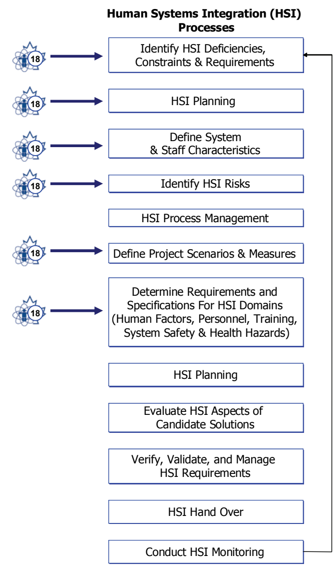
Overview and Objectives

The CF18 community was interested in exploring the role of Helmet Mounted Displays (HMDs) in the cockpit to support situational awareness in general, and also to support advanced engagement techniques such as head cued engagements. A HSI approach was desired to systematically consider the human factors, personnel, and training requirements associated with an HMD concept, within the context of formalized scenarios and mission profiles. The required analysis presented the opportunity to utilize the DND Decision Support System (DSS), a wireless network of 25 laptop computers with groupware installed that enables anonymous interaction among subject matter experts in a facilitated focus group to more efficiently and effectively collect data from the SMEs. This environment was explored as an 'integrating tool' in support of the rapid generation of linked sets of HSI requirements.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Review of historical Mission/Function/Task Analysis Data.
- Creation of a user review method based on re-use of mission, function and task analysis (MFTA) data.
- Creation of concept design presentation for HMD.
- Creation of user group method, including configuration of DND Decision Support System
- Conduct of HMD requirements review, within context of mission scenarios, using Mission/Function/Task Analysis data as a framework, and the DSS as the tool to capture and prioritize requirements.
- Output of HMD review into report format.

Project Output

The output of the project was a set of requirements and R&D issues for CF18 HMDs.

Cost and Benefit/Impact

Approximately $17,000 was invested in this HSI requirements analysis.

The impact of this project was that a user centred set of requirements and R&D foci were rapidly generated through the use of the DSS tool. The same quality and content of output would not have been possible to generate as quickly without the use of this tool.

Lessons Learned

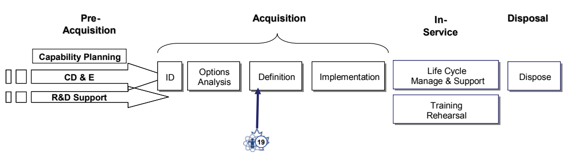
The DND Decision Support System (or any multi-user networked groupware facilitation tool) is a cost effective technology for the rapid assimilation of HSI requirements from a diverse multi-disciplinary user community, and for the rapid high level evaluation of alternative concepts.

#19. **19 Clothe the Mounted Soldier Survey**

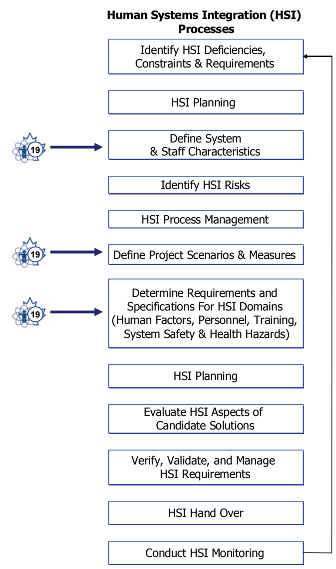
Overview and Objectives

One of the challenges across the HSI community is the need to analyze requirements and design alternatives with the "user community" in a cost effective manner. Within the tool sets available to the HSI community was the army combat clothing and equipment system (ACCESS) survey methodology developed by DRDC Toronto, whereby a multi-level survey system was designed for systematic extraction and validation of requirements and/or design feedback. Within the HSI project the concept of a "web based" initial survey was further explored to ensure that the entry into a multi-level survey program could start from an even broader base of users from across the country. The On-Line Survey tool was created and employed both within the DND Wide Area Network (DWAN) and on the Internet (allowing soldiers to access it from home). This survey tool was used to survey the HSI requirements for Crew Suits for land staff mounted in armoured vehicles.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- High-level Background read in, literature review and internet review.
- Create questionnaire input and verify with SMEs.
- Create web compatible questionnaires.
- Post questionnaires to web, promote availability and monitor data reception.
- Reduce and analyze data.
- Produce report and recommendations.

Project Output

Key outputs from this project included.

- Questionnaire set.
- Prioritized set of Crew Suite requirements.
- Recommendations for next step in requirements definition process.

Cost and Benefit/Impact

Approximately $10,000 was spent on the effort associated with this activity.

It was estimated that a paper based survey, executed in focus group formats, with the same number of respondents from across the country (executed by visiting their units) would have cost a minimum of $60,000. (Calculated based on two analysts working, collecting 200 respondents worth of data through visits to 5 bases, with manual data reduction).

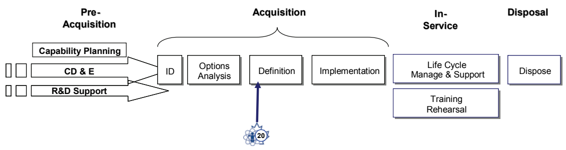
Lessons Learned
1. On-line surveys are a cost effective method of rapidly accessing an entire user community and obtaining initial high level structured feedback on user requirements and concept alternatives. 2. Military personnel will complete on-line requirements surveys both at home and at work when given the opportunity to do so. 3. Effort is required in promoting the survey, directly to unit commanders. They must buy in to the benefits of involving soldiers in requirements definition so that they pass along the message to their subordinates.

#20.	**20 MLVW Survey**

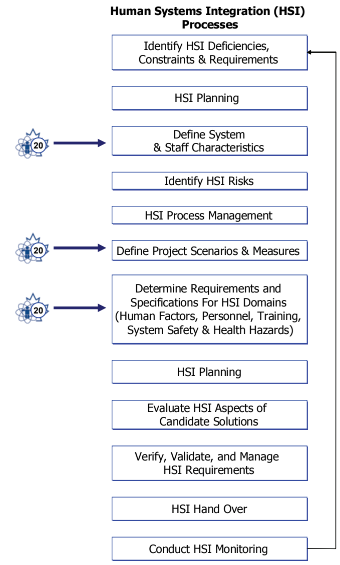
Overview and Objectives

The On-line Survey tool (discussed in case study 19) was re-used with content modifications to survey the HSI requirements for medium logistics vehicle wheeled MLVW class of vehicles as a first step in a multi-level investigation of requirements for acquisition.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- High-level Background read in, literature review and internet review
- Create questionnaire input and verify with SMEs
- Create web compatible questionnaires
- Post questionnaires promote availability and monitor data reception
- Reduce and analyze data
- Produce report and recommendations

Project Output

Key outputs from this project included.

- Questionnaire set
- Prioritized set of requirements
- Recommendations for next step in requirements definition process.

Cost and Benefit/Impact

This survey activity involved an investment of approximately $14,000.

It was estimated that a paper based survey, executed in focus group formats, with the same number of respondents from across the country (executed by visiting their units) would have cost a minimum of $60,000.

Lessons Learned

1. On-line surveys are a cost effective method of rapidly accessing an entire user community and obtaining initial high level structured feedback on user requirements and concept alternatives.
2. Military personnel will complete on-line requirements surveys both at home and at work when given the opportunity to do so.
3. Effort is required in promoting the survey, directly to unit commanders. They must buy in to the

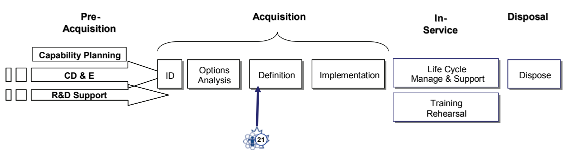
benefits of involving soldiers in requirements definition so that they pass along the message to their subordinates.

#21.	**21 Surveillance, Target Acquisition, Night Observation (STANO) Survey**

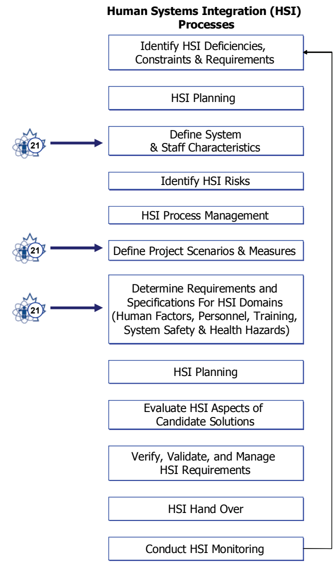
Overview and Objectives

The On-line Survey tool (discussed in case study 19) was re-used with content modifications was used to survey the HSI requirements for STANO as a first step in a multi-level investigation of requirements for acquisition.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- High-level Background read in, literature review and internet review.
- Create questionnaire input and verify with SMEs.
- Create web compatible questionnaires.
- Post questionnaires promote availability and monitor data reception.
- Reduce and analyze data.
- Produce report and recommendations.

Project Output

Key outputs from this project included.

- Questionnaire set.
- Prioritized set of requirements.
- Recommendations for next step in requirements definition process.

Cost and Benefit/Impact

This activity involved a budget of approximately $10,000.

It was estimated that a paper based survey, executed in focus group formats, with the same number of respondents from across the country (executed by visiting their units) would have cost a minimum of $60,000.

Lessons Learned

1. On-line surveys are a cost effective method of rapidly accessing an entire user community and obtaining initial high level structured feedback on user requirements and concept alternatives.
2. Military personnel will complete on-line requirements surveys both at home and at work when given the opportunity to do so.
3. Effort is required in promoting the survey, directly to unit commanders. They must buy in to the benefits of involving soldiers in requirements definition so that they pass along the message to their

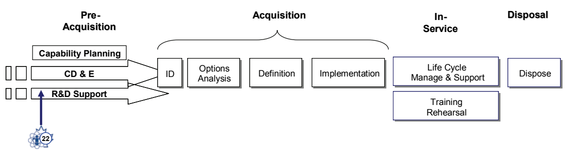
subordinates.

#22.	**22 Collaborative Displays**

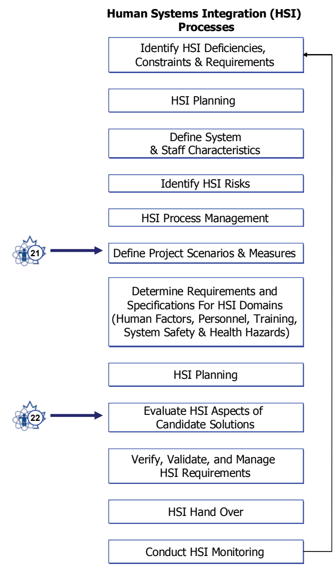
Overview and Objectives

Simulation based design reviews are increasingly being used in support of HSI studies of requirements or design evaluations. However, there is very little scientific information to guide review teams on "how much simulation fidelity" is required in support of design review activities. Two sets of studies were conducted within this project, as pilot studies, to start to explore the answers to these questions. Studies were conducted to compare four levels of visualization and immersion, and the associated impact on the ability of "users" to detect design flaws and conduct an effective design review from a HSI perspective.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Conduct literature review of design review problem.
- Develop experimental design, including data collection and evaluation measures.
- Design and implement design review environment for each workspace review medium.
- Conduct user trials using each workspace review medium.

Project Output

Key outputs from this project included:

- Comparative evaluation of workspace review media that vary in levels of fidelity, visualization and immersion.

Cost and Benefit/Impact

These pilot project studies involved an investment of $66,000.

One of the key aspects of HSI is the integration of human factors, system safety, health hazard assessment, training and personnel. One of the opportunities for integration of these domains during the acquisition cycle is during design reviews, whether they occur at the R&D phase, requirements analysis phase, preliminary design phase, or critical design review phase of a project. A proposed design must be reviewed from the perspective of each of the HSI domains to either determine or verify requirements and specifications, and to validate that the design will meet the operational requirements of the future user.

This project explored the cost-benefit of different workspace review media in terms of their ability to support groups of Subject Matter Experts (SMEs) conducting collaborative design reviews, and the relative usability of each medium for this purpose. This study contributed to a cost/benefit evaluation of different tools to be used in the HSI process, as part of HSI program development (case study 1).

Lessons Learned

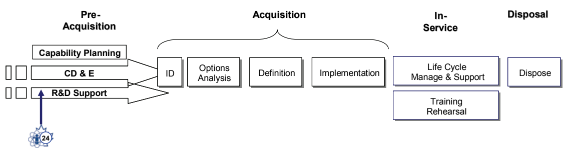
1. There has been little research conducted within this domain and future research project opportunities are widespread. This low complexity study that had small investment costs provided results that were immediately beneficial in determining tools and technologies that should be used in other projects for reviewing proposed design concepts and prototypes.

#23.	23 CB^{plus} Program Definition

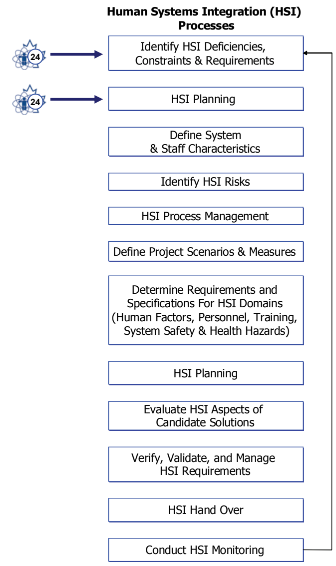
Overview and Objectives

The CB^{plus} project was focused on the development and evaluation of new protective clothing and equipment to counter chemical and biological warfare. The project concept included evaluations of new concepts in labs, in a chamber with an articulated mannequin, and in a chamber with live human subjects. The project required definition support that presented the opportunity for a HSI approach to the research, development, and experimentation processes.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Developed concept for new uniform, and associated R&D project, based on multi-stakeholder requirements analysis process.
- Developed HSI centric R&D approach to next generation clothing system development including simulation based analysis of alternative designs.

Project Output

Key outputs from this project included:

- Project Definition Documents
- Project Plan Documents
- Project Approval Documents

Cost and Benefit/Impact

This project definition effort involved an expenditure of $191,000. The impact was that a focused R&D program, with a highly user centered methodology was rapidly defined, approved, and managed, thereby ensuring the focus on HSI issues throughout the development of next generation protective clothing systems.

Lessons Learned

Lessons learned from this project included:

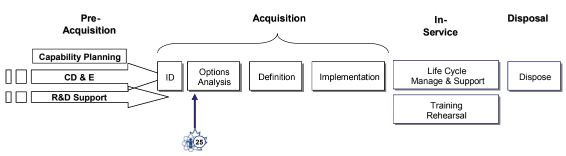
- HSI is as important in R&D and Concept Development & Experimentation projects as it is in Capital Acquisition projects.
- HSI methodologies can form the backbone of the development of the approach and Work Breakdown Structure development on projects that involve the development of user centric technology.

#24.	24 CB^plus Performance Protection Framework

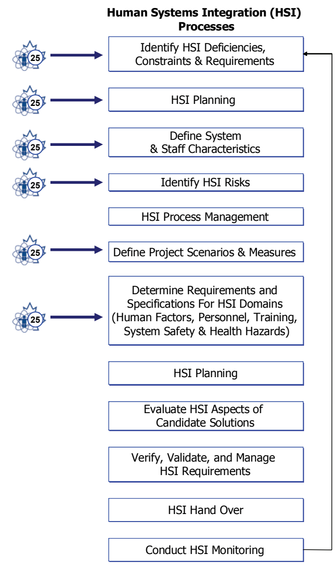
Overview and Objectives

The CB^plus project is part of the DRDC's Technology Demonstration Program (TDP). It will demonstrate how novel design and technologies for protective clothing can improve CB protection while reducing the burden on the wearer. As a sponsor of this project, the Directorate of Nuclear Biological Chemical Defence (DNBCD) was required to produce the next generation (Horizon 2) operational requirements. This required a performance-based approach, including an effective balance between human performance and the required levels of protection to shape the next generation of protective clothing. This provided further opportunities to apply the HSI approach, integrating human factors, safety, health hazard, and training considerations in the analysis and documentation of this new requirements basis for protective clothing. The project also provided the opportunity to utilize constructive simulation to evaluate alternative concepts on individual and team performance.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Core project activities included the following activities:

- HSI Planning;
- Review and analysis of the current and future threat and associated Health & Safety hazards. This included the development and simulation of release scenarios;
- Review of the existing CB protective clothing capability and its associated deficiencies;
- Literature review of NATO documents;
- Definition of Operational Scenarios;
- Development and user validation of Operational Requirements;
- Planning and conduct of a simulation based Operational Research (OR) study.

Project Output

The primary outputs of the project included:

- Comprehensive review of the CB threat and the associated Health and Safety hazards;
- Comprehensive rationalisation of NATO standards for CB protective clothing;
- Definition of the capability deficiency with existing CB protective clothing capability;
- Statement of Operational Requirements Provisional (SOR[P]) for Horizon 2 CB protective clothing;
- Operational Research study of the effects on small team performance when reducing the thermal burden associated with wearing CB protective clothing.

Cost and Benefit/Impact

The effort expended on this activity was $135,000.

The HSI domains of greater relevance to this work were: Health hazards, HFE and training.

The primary impact was that the user community had a significantly better understanding of the threat and its associated hazards. This provided the basis by which the users could understand how NATO formulates the performance and technical specifications for CB protective clothing, which forms the standard for DND/CF clothing. This allowed the user community to make some acceptable modifications in regards to physical protection so that a significant reduction could be achieved in regards to physical and thermal burden associated with wearing CB protective clothing. Testing of the CB^{plus} uniform will allow the user to verify the reduction of this burden given novel design and technologies and a modification of the protection requirements. The results of the CB^{plus} studies will enable DNBCD to make decisions based on when establishing the operational requirements for Horizon 2 CB protective clothing.

This work provided the user community with a greater understanding of the implications that the physical design of the protective equipment and clothing has on the protection, comfort and ability to perform tasks at acceptable levels of performance. Performing task analysis of the most representative tasks resulted in influencing the design of the protective clothing. By completing this type of activity early on in the development process, it was possible to significantly reduce the risk of having to make major modifications to the clothing and equipment late in the design.

Work performed under this activity was also extremely beneficial in the procurement of the new DND/CF Chemical protective clothing. A comprehensive understanding of the rational behind NATO standards helped the project team make critical decisions to ensure that the technical specifications were appropriately and correctly defined. This was extremely beneficial during the bid evaluation process for the award of contract for the production of the new DND/CF chemical protective clothing. As such, the project was able to minimize the risk (of procuring the inappropriate equipment requirement resulting in poor performance and modifications, redesign or re-procurement) and meet its project milestones targets.

Results of this work had a very critical impact on the Tactics, Techniques and Procedures (TTPs) associated with the individual physical protection equipment, and the users having a much greater understanding regarding the limitations and capabilities of their protective clothing and equipment. Training packages of TTPs were modified to help ensure that the users could maximize the protection offered by their kits. This also resulted in proposing a major modification to a NATO STANAG so that the user community was made aware of how much protection their equipment could provide against the health hazards posed by Toxic Industrial Chemicals (TIC).

Lessons Learned

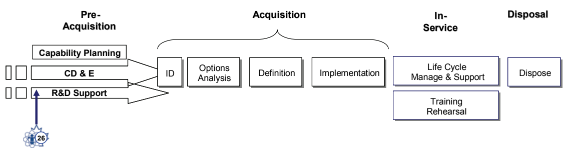
1. First and foremost, the HSI approach provided a systematic and methodical platform by which the design of protective clothing and equipment can be achieved from a user-centered perspective and avoid a situation where users must adapt themselves to a design. This essentially maximizes the protection offered by the CB protective kit while reducing the burden too often associated with this type of clothing and equipment.
2. Greater understanding of health and safety risks associated with exposure to chemical hazards was critical for the user community to define more articulated and accurate operational requirements.
3. Where protective clothing is involved, there is a critical need to strike the correct balance between protection, comfort and ability to perform tasks at acceptable levels of performance.
4. The user community must clearly understand the rational behind the performance and technical specifications.
5. CB hazard dispersion M&S tools are readily available. Although these tools have some inherent limitations, they provided a platform from which plausible release scenarios can be visualized. This offers an opportunity to better understand the potential consequences of various types of CB releases under various weather and terrain conditions.

#25. **25 Cipro Plus Requirements Definition**

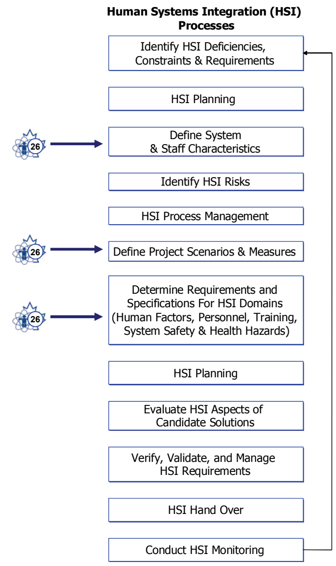
Overview and Objectives

The Cipro Plus project was focused on the research and development of liposome encapsulated ciprofloxacin, to provide an airborne delivered antibiotic that would counter airborne biological warfare agents. The definition of this project required the definition of the “user requirements” for a portable device to deliver the drug. This provided the opportunity for a HSI approach and associated support to project definition.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Developed requirements for the technology using multi-stakeholder requirements analysis process.

Project Output

Key outputs from this project included:

- Project Definition Documents
- Project Statement of Operational Requirements
- Project Plan Documents
- Project Approval Documents

Cost and Benefit/Impact

Approximately $49,000 was invested in this project definition activity. The impact was that a focused R&D program, based on a Statement of Requirements focused on the future user was rapidly defined, approved, and managed, thereby ensuring the focus on HSI issues throughout the development of next generation medical protective systems.

Lessons Learned

Lessons learned from this project included:

- HSI is as important in R&D and Concept Development & Experimentation projects as it is in Capital Acquisition projects.
- HSI methodologies can form the backbone of the development of the approach and Work Breakdown Structure development on projects that involve the development of user centric technology.
- HSI methodologies can be used to generate requirements for user centric technology R&D projects.

#26.	**26 Collaborative Planning and Management Environment (CPME) HSI Support**

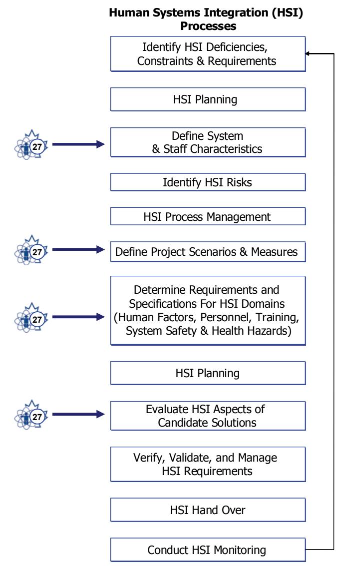
Overview and Objectives

The CPME system was developed to support the planning and management of R&D projects throughout the Defence R&D Canada (DRDC) community. Challenges associated with the application and "use" of CPME had identified concerns with the usability of the tool, but also in relation to the overall deployment concept in terms of the roles and responsibilities of users, the training requirements, and the work flow in relation to corporate business practices. These challenges provided an opportunity for an integrated HSI approach to the conduct of requirements elicitation workshops, and user evaluation of the prototype technology.

Phase of Defence Life Cycle

Not Applicable

HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- CPME prototype review.
- CPME heuristic review.
- User trials with the CPME prototype to evaluate software usability issues.

Project Output

Key outputs from this project included:

- CPME heuristic review report, outlining usability inherent in the prototype
- CPME Operator Machine Interface upgrade requirements and suggested future design concepts.

Cost and Benefit/Impact

This project involved a $26,000 assessment of the CPME prototype. The process and methodology for conducting the heuristic review and the workshop user trials can be modified and adapted by other software usability evaluation projects.

Lessons Learned

1. Low fidelity user trials and heuristic reviews with future users of the system can provide invaluable information during a software prototype phase for future design and modifications. Involving future system users in the user trials increases general acceptance of the software when implemented.

#27.	27 DTEP Defence Industrial Research (DIR) Project Definition

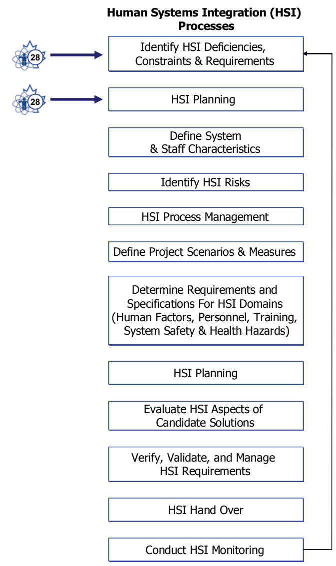
Overview and Objectives

The DND Directorate of Training and Education Programs (DTEP) established a DIR project to explore the role of a Learning Management System (LMS). This class of technology is central to effective management and delivery of modern training curriculum, and provides the traceability opportunities to link training with human factors requirements and personnel management systems. As a result, the definition of the project provided an opportunity to provide HSI, and ensure that advances in training tools and technology were integrated within the HSI community tools library.

Phase of Defence Life Cycle

Not Applicable

HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Define scope of collaborative R&D project to develop and demonstrate next generation training management system.
- Plan the project.

Project Output

Key outputs from this project included:

- Project Concepts
- Project Plans
- Project Approval Documents

Cost and Benefit/Impact

An investment of $7,900 was made in the provision of HSI Planning support to this team.

Lessons Learned

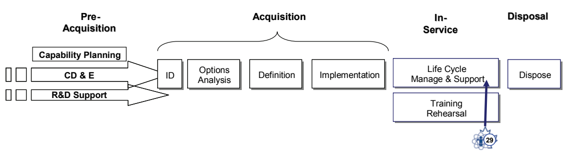
- Not applicable, simply an extension of programmatic support to include the training community.

#28.	**28 HSI Evaluation of 3D Modelling for DMASP**

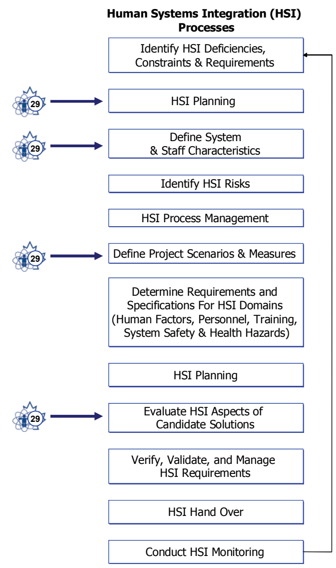
Overview and Objectives

Modelling and Simulation is increasingly being used as a tool in the analysis, design, and design evaluation of defence systems. The Directorate of Material Acquisition and Support Program (DMASP) wanted to explore the concept of stand alone and/or distributed 3D product models on the individual and team task performance, workload, and skill set requirements of the life cycle management and aircraft operational communities.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Define user scenarios.
- Define modelling & simulation application context.
- Design and conduct experiments.
- Analyze data to evaluate impact of modelling & simulation on human performance.

Project Output

Key outputs from this project included:

Assessment of the projected/predicted impact of modelling and simulation based business processes on human performance.

Cost and Benefit/Impact

The cost of this effort was $18,700. The impact was that a rapid prototyping approach to human centred experimentation was demonstrated as highly useful in the evaluation of the utility and cost benefit of new simulation based business processes.

Lessons Learned

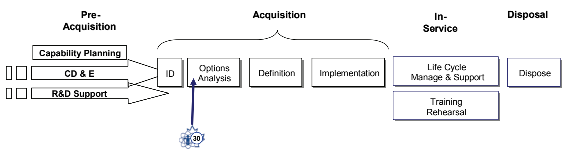
Following a HSI approach can contribute to the effective evaluation of transformational business processes in terms of the impact on performance, perceived staff workload, and required staff skill sets.

#29. **29 NBCD Respiratory Protection Program**

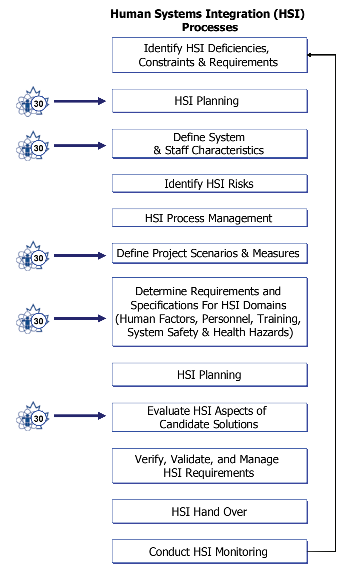
Overview and Objectives

The Directorate of NBC Defence (DNBCD) needed to complete a comprehensive review of the CF NBCD respiratory protection program. This provided an opportunity to use the HSI approach to help define the operational requirements, identify the deficiencies, analyze the health hazards associated with threat scenarios resulting in potential exposure to CBR agents, and assess if the training that supports the respiratory protection program was adequate. This work offered the opportunity to provide HSI support to an existing program to determine if design or training changes were required.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Core project activities included the following activities:

- HSI Planning;
- Analysis of the current and future threat and health and safety hazards associated with respiratory protection;
- Review of the existing CF NBCD respiratory protection program to clearly identify its capabilities and deficiencies;
- Literature review of NATO documents and civilian regulations;
- Definition of Operational Scenarios;
- Redesign of the NBCD respirator carrier bag;
- Development and user validation of Operational Requirements for NBCD respirator fit testing;
- Review of the training program;
- Planning and conduct of user trials.

Project Output

The primary outputs of the project included:

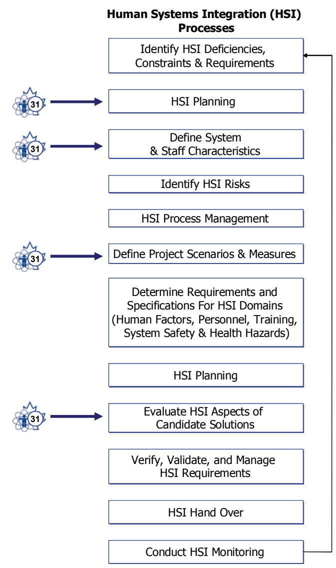
- Comprehensive review of the CBR threat and the H&S hazards for respiratory protection;
- Comprehensive rationalisation of NATO standards for NBCD respiratory protection;
- Statement of Operational Requirements (SOR) for Quantitative Fit Testing (QNFT) program;
- Redesign of the CF NBCD respirator carrier bag;
- Draft DND/CF NBCD Respiratory Protection Program (RPP) based on civilian regulations;
- Comparative analysis of existing Quantitative Fit Testing technologies;
- Overview of the US and UK Forces NBCD respiratory protection program;
- Draft modifications of NATO STANAG on Commander's guidance from potential exposures to

Toxic Industrial Chemicals (TIC); • Recommendations to modify the DND/CF NBCD respiratory protection training program.
Cost and Benefit/Impact The effort expended on this activity was $130,000. The primary benefit of this work was that it was clearly identified that the existing methods for fit testing of NBCD respirators were inadequate since it was possible to successfully complete the tests without the required protection level and in some cases, with faulty masks. During this work, it was possible to clearly define new methods to complete the testing. This was achieved through multiple user-centered trials using off the shelf commercial equipment. New methods of fit testing are now in place and are continuously used before CF troops deploy in operations. The overall benefit was that CF troops are now better prepared to protect themselves from exposure to CBR agents. Work performed under this activity included a user-centered redesign of the NBCD respirator carrier bag. This was a long-standing deficiency. Since new procurement of 4000 carrier bags was planned, this provided an ideal opportunity to resolve the problems. User-centered trials resulted in the validation of major design changes needed to resolve the deficiencies. In the long-term, it is projected that the older versions of the carrier bags (of which approximately 50,000 exist) will be replaced with the new design. A significantly improved design augments the ability for every CF member to better protect himself or herself when exposed to CBR agents. This is a significant benefit as a result of this work. A result of the work was a significant increase in the user's knowledge on how much protection is provided by the CF NBCD respirators against Toxic Industrial Chemicals (TIC). This factual information was critical in the decision to retain the existing respirator canisters and not pursue a replacement at this time. This 'fleet' replacement of existing canisters would have been of significant costs to DND. Results of this work had a critical impact on the training of the Tactics, Techniques and Procedures (TTPs) associated with NBCD respiratory protection. Since the users have a greater understanding of the limitations and capabilities of their in-service respirator, it was possible to modify the training packages to help ensure that the users could maximize the protection offered by their respirators. This work also resulted in proposing a major modification to a NATO STANAG so that the user community was made aware of how much protection their equipment could provide against the health hazards posed by Toxic Industrial Chemicals (TIC).
Lessons Learned 1. The HSI method provided a comprehensive and systematic approach to review an existing capability from a user-centered perspective. It was then possible to identify the critical deficiencies and potential solutions. 2. By involving multiple users during the redesign of the respirator carrier bags, and performing representative user tasks, it was possible to determine critical modifications to improve the design. 3. By performing defined and controlled trials, it was possible to define unequivocally the deficiencies of the existing fit testing methods. This provided clear justifications for changing the fit testing procedures.

#30.	**30 Project Activity Reporting System (PARS) HSI Support**

Overview and Objectives

The PARS was developed to support the tracking of where personnel spent their time and effort within the Defence R&D Canada (DRDC) community. The PARS concept required both requirements analysis support and user evaluations of storyboards and prototypes to ensure that the resulting solution (technology, deployment concept, and business procedures) would consider HSI concerns.

Phase of Defence Life Cycle	**HSI Process Phases Exercised**
Not Applicable	

Description of Project Activities

Key activities that were conducted on this project included:

- PARS prototype review.
- PARS heuristic review.
- User trials with the PARS prototype to evaluate software usability issues

Project Output

Key outputs from this project included:

- PARS heuristic review report, outlining usability issues inherent in the software prototype
- PARS prototype evaluation report, outlining user acceptance and primary concerns with the prototype

Cost and Benefit/Impact

This project involved a $8,000 assessment of the PARS prototype. There was significant re-use from the Collaborative Planning and Management Environment (CPME) evaluation. The project plan, heuristic review and the user trial process and methodology were adapted from the CPME evaluation.

Lessons Learned

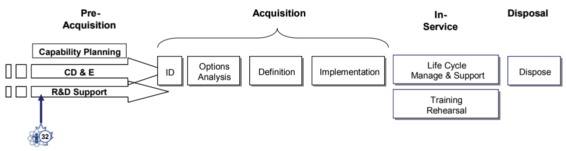
Low fidelity user trials and heuristic reviews with future users of the system can provide invaluable information during a software prototype phase for future design and modifications. Involving future system users in the user trials increases general acceptance of the software when implemented.

#31. **31 MMEV Project Definition**

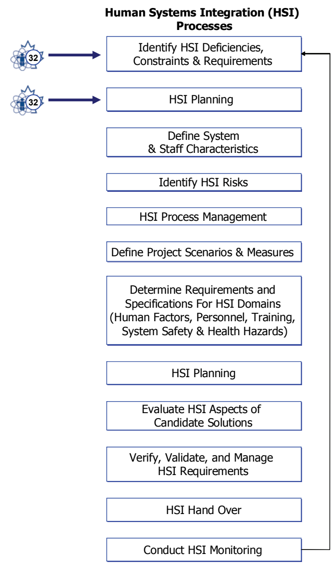
Overview and Objectives

See Case Study 9. The HSI community was provided the opportunity to shape and define the project, and the project methodology to address these HSI questions.

Phase of Defence Life Cycle



HSI Process Phases Exercised



Description of Project Activities

Key activities that were conducted on this project included:

- Define experimental protocols for the project, including scenarios, participating future force platforms, doctrine and tactics, and relevant measures.
- Conduct iterative plan development and review sessions with multiple stakeholders from Canada and United States R&D teams.

Project Output

Key outputs from this project included:

An experimental program for the research project focused on simulation based research studies to answer the HSI based questions the project was required to address.

Cost and Benefit/Impact

The cost of this effort was $42,000. The impact of the work was that the R&D project (MMEV TD) was effectively planned around a human centred experimental plan, thereby ensuring full consideration of the human performance impacts of the new technologies being evaluated in multiple HSI domains through constructive and virtual simulation trials.

Lessons Learned

Lessons learned from this project included:

- R&D projects that are developing and evaluating revolutionary technologies will result in HSI questions (impact on human performance, training and personnel) increasing in relevance. In this situation, and HSI based experimental program is required.

Annex G: HSI Tools

This Annex contains an overview of the Human Systems Integration (HSI) Tools available within DND. This document provides a description of each tool, followed by an assessment of the applicability of the tool for use at the various stages of HSI analyses.

Annex G: Human Systems Integration (HSI) Tools

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Army Combat Clothing and Equipment Survey System (ACCESS)

Description	ACCESS is a system of questionnaire and focus group investigation methods designed to identify operational item deficiencies, elicit user feedback, insights, and requirements for items in the acquisition cycle, and track the operational effectiveness of acquired items once in service. The system offers a layered approach to the acquisition of user feedback. Each layer, consisting of a preliminary survey, a detailed questionnaire, and focus group investigations, focuses the direction and efforts of each subsequent layer. Computer scoring methods are used to improve speed, accuracy and efficiency during data acquisition, reduction, and analysis.
Users	The range of potential users will vary depending on when ACCESS is employed in the life cycle of an item. During pre-acquisition, ACCESS can be employed by the Life Cycle Materiel Manager (LCMM) to evaluate user acceptance, by Requirements Staff to focus procurement and to derive performance requirements, and by Project Management staff to derive desired design features. During the acquisition cycle ACCESS could be used by Requirements Staff to further refine requirements and design features, by Researchers to focus investigation and analysis, by Engineers to guide design activities, and by Test and Evaluation staff to access design suitability. During post-acquisition, ACCESS could be used by the LCMM, Project Management and Requirements Staff to monitor the fielded acceptance of an item against the original performance requirements and technical specifications.
Military Environments	All three military environments.
Features	ACCESS is comprised of three components: a preliminary acceptance survey, a detailed questionnaire, and a focus group discussion. a) **Preliminary Acceptance Survey** is used to identify which items are perceived to be operationally deficient by the user community. Survey respondents are required to indicated overall acceptance ratings for a large number of items. This preliminary survey is used to select deficient items for further, detailed questionnaire investigation. b) **Detailed Questionnaires** are designed to determine which specific attributes, features, conditions of use, and tasks account for the overall deficiency identified in the preliminary acceptance survey. c) **Focus Group** discussions are then employed with a limited sample of respondents to elicit the causal factors underlying the deficiencies identified in the detailed questionnaire. For planned acquisition items, focus group discussion also includes an identification and prioritization of user-based performance requirements and design specifications.
Hardware and Software Environment	ACCESS is distributed as a paper based survey, completed by the users, then analyzed using automatic scoring software. In order to utilize the questionnaire template to create questionnaires and to automatically score the questionnaires, the following hardware and software is required: The hardware required includes a 486 PC computer or higher with a sheet feed scanner and a laser printer. A photocopier is also beneficial for large volume questionnaire creation. The software required includes MS Windows, with a word processor for questionnaire design, graphics software for designing item schematics, and AUTODATA software for creation and scoring of the questionnaires. Current questionnaire templates exist in MS Word.
State of Development	ACCESS is a fully operational tool being used on a number of projects.
Future Expansion	ACCESS will continue to be used on additional items within the infantry arm of the Land Environment. The results of ACCESS analysis will be integrated into corresponding clothing and equipment data bases, such as Soldiers Day. Future expansion might include extension to other

	arms within the Land Environment as well as the Air and Maritime Environments. In addition, Web-based or electronic bulletin boards should be considered as data collection mediums.

Army Combat Clothing and Equipment Survey System (ACCESS)

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency		●	
	b. Determine High Level Requirements		●	
	c. Identify Solution Options		●	
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis		●	
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping			
Test & Evaluation	a. Identification of T&E Parameters		●	
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness		●	
	b. Identify New Design/Manufacturing Deficiencies		●	

Aircraft Crewstation Demonstrator (ACD)

Description	The ACD was developed under contract to the Department of National Defence (DND), and provides an effective, low-risk HFE tool for computer-based development, test and evaluation of prototype designs of flight and tactical crewstations. The crewstation environment consists of a rapidly reconfigurable flight deck (up to two individuals) and tactical compartment (up to two individuals), with integrated flight controls and an external scene generation facility. Coupled with this physical environment is a library of low fidelity fixed and rotary wing flight models corresponding to a subset of the CF inventory, providing a variety of dynamic, realistic flight profiles.
Users	The ACD is not a product, and has been tailored to meet a specific requirement within the DND context. The role of the user is to specify the requirements associated with the target environment and the scope of the analysis. This information will dictate the modifications that need be performed by the technical/engineering staff to support the evaluation and associated analysis. Upon implementation of these modifications, the user would participate in the conduct of the experiment or the usability analysis. As such, this facility is used most appropriately by a composite team, comprised of HFE and technical personnel, and domain experts.
Military Environments	The ACD has been developed and configured for the air environment.
Features	The ACD has a number of primary components including; (a) a library of Virtual Prototyping System (VAPS) instrument prototypes for the presentation of electronic cockpit and tactical workstations; (b) Flight Simulator (FLSIM) and Helicopter Simulator (HELISIM) applications for development of fixed and rotary wing flight models; (c) VEGA/Performer graphical applications for the development/presentation of the external scene utility; (d) proprietary integration software to coordinate the independent hardware and software components; (e) a Data Collection utility to facilitate experimentation; (f) a set of low fidelity aircraft controls (including throttle quadrant, centre stick/cyclic, rudder pedals, collective, joysticks, trackballs); (g) high resolution Cathode Ray Tubes (CRTs) and Active Matrix Liquid Crystal Displays (AMLCD) displays for cockpit and tactical workstations; (h) high resolution rear projection system for the presentation of the external scene; (I) touch screen devices for interaction with instrument panel controls; (j) experimenter's console for the execution and monitoring of the experiment; (k) three Silicon Graphics workstations configured for the generation of all external scene, flight deck/tactical compartment, and experimenter's workstation graphics, and execution of the flight model software; and (l) a reconfigurable physical environment providing both flight deck and tactical workstations. As part of the requirements defined by DND, a list of aircraft was established to represent each class within the CF inventory, including: • heavy lift, fixed-wing, multi-engine turbo-prop aircraft (CC130 Hercules); • a medium lift, fixed-wing, multi-engine turbo-prop aircraft (CT142 Dash 8); • a medium lift, rotary-wing aircraft (CH146 Griffon); • a supersonic, fixed-wing jet aircraft (CF188); • a subsonic, single-engine, turbo-prop aircraft (Brazilian Tucano); • a medium lift, fixed-wing, multi-engine jet aircraft (CC144 Challenger); • a subsonic, fixed-wing, single-engine jet aircraft (CT133 Silver Star); and • a light, fixed-wing, single-engine, general aviation aircraft (Cessna B210). Flight models were established for each of the subject aircraft utilizing information as provided by DND, the Flight Research Laboratory, and the Institute of Aerospace Studies. Each flight model was evaluated by DND pilots trained on the specific aircraft. These test flights/exercises, conducted in the ACD, resulted in corrective action being taken in the form of fine tuning of the aircraft flight characteristics to a level consistent with low fidelity demonstration facility. The physical structure of the ACD has been developed such that it may be reconfigured to represent the target aircraft, in a gross sense. The seats and centre console have been mounted on individual pallets. Various cockpit masks have been provided for the different screen locations for the instrument panel representations. This modular nature of the ACD physical structure facilitates the rapid reconfiguration of the flight deck to accommodate large side-by-side (CP140 Aurora or CH146

	Griffon), small side-by-side (CT133 Silver Star) and single seat (CF188) configurations. Because of the modularity of these components, it is possible to reconfigure the ACD from a representation of the CC130 Hercules to that of a CC144 Challenger in approximately 2 minutes. A more difficult reconfiguration, such as changing from a CH146 Griffon to a CT133 Silver Star, takes about 2 hours. A series of scripts have been developed to augment the inherent capabilities of the integration software and the FLSIM and HELISIM applications to support the presentation of different instrument panels and aircraft flight models.
Hardware and Software Environment	The ACD is based on a Local Area Network (LAN) consisting of three Impact-class Silicon Graphics (SGI) workstations, connected through a standard ethernet link. To support the number of graphics channels required for the representation of four instrument panels, an external scene and an experimenters workstation, each SGI is configured with a dual-head card. A single SGI machine has been upgraded to provide Maximum Impact graphics (to support the external scene) through the integration of a MaxImpact board and the Integrated Channel Option (SGI products). The external scene is displayed using a high resolution graphics projector, with the image presented on a rear-projection screen. The control systems are integrated to the SGI machines through a SCSI serial port, enabling data transfer rates of up to 128 Kbaud for up to 16 different channels (control inputs).
State of Development	The ACD is currently fully operational within the context of its original mandate. As with most tools, its development is a function of the requirements imposed by the projects requiring its implementation. User Manuals for the operation of the COTS software and hardware elements within the ACD facility are available. The integration software is currently supported by Canadian Marconi Company (CMC), and is not documented within a User Manual. However, software design documentation does exist.
Future Expansion	The ACD was designed with an open architecture to facilitate expansion to support as large a growth capability as possible. The planned/proposed expansion includes the incorporation of: (a) increased field of view in the external scene; (b) 3-D sound; (c) MIL-STD-1553 cards; (d) force-feedback control systems; (e) auditory feedback systems; (f) motion-based seating; and (g) intercommunication system.

Aircraft Crewstation Demonstrator (ACD)

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios		●	
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis			
	b. Control Requirements Analysis			
	c. Workspace Requirements Analysis			
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters		●	
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

Chameleon

Description	Chameleon is a rapid prototyping tool used to develop new graphical user interface concepts. The tool is used within a user centred analysis approach to extract user requirements for new systems. The tool was developed by the Defence Research and Development Canada Valcartier (DRDC V) and has been used on several command, control and communications system projects to date.
Users	The users of Chameleon are software development professionals, including human factors engineering team members who are assigned responsibility for generating new interface concepts and determining user requirements. Important user skills include an understanding of task analysis, user requirements elicitation techniques, and some programming knowledge.
Military Environments	Chameleon is suitable for use by all military environments.
Features	The users of Chameleon use the interface building elements of the tool to build a dynamic mockup or prototype of the a new interface concept. This concept is created following task analysis with the user community to determine their information requirements when performing critical tasks with the system under development. Once the prototype is created, future system users then work through typical operating scenarios with the mockup. This review process generates user feedback that is used to capture and prioritize user requirements for the system. Chameleon contains features that allow the analyst to record and organize the requirements that are captured during these user review sessions.
Hardware and Software Environment	Chamelon runs on a PC using Windows.
State of Development	Chameleon is an operational software tool with documentation. DREV is currently looking for companies interested in commercializing the product.
Future Expansion	Chameleon is a complete product. Future expansion consists of the commercialization of it.

Chameleon

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
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	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis		●	
	c. Critical Task Analysis		●	
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis			
	c. Workspace Requirements Analysis			
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests			
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials			
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

Directorate of Maritime Ship Support Tools (DMSS)

Description	The mandate of Maritime Equipment Program Management (MEPM) is Materiel Acquisition and Support (MA&S) of new and existing ships, systems and equipment, including management of maintenance, change and disposal. The Directorage of Maritime Ship Support (DMSS) 2-6 is the maritime environment Design/Technical Authority for (1) Human Factors Engineering, (2) Ship Arrangements, (3) Habitability Systems LCMM, (4) System Safety Engineering, (5) Systems Analysis. These responsibilities, covering much of the HSI domain, make DMSS 2-6 the focal point for HSI in DGMEPM. Over the last several years, DMSS has sponsored the development or acquisition of a number of HSI related tools, primarily to the areas of: • Manning and Staffing Analysis • Review Drawings • Analyze Ship Hazards
Users	The DMSS tools were generally developed for use by the personnel in the DMSS 2-6 cell. There personnel have a range of engineering and technical backgrounds with at least the team leader specializing in Human Systems Integration (HSI). However, with continued reductions in DND personnel DMSS staff are quickly becoming more managers of the HSI activities on maritime projects, with the actual tools being used by contractors or R&D labs in support of their requirements.
Military Environments	DMSS is the HSI support for the maritime environment. Most of their tools contain data related to ship operation, especially the ship complement analysis tools, while others are modifiable to other environments.
Features	The tools in the DMSS toolset include: 1. MANIAC (Manning Impact Analysis Calculator). 2. ERASMUS (Establishment Roster and Simulation System). 3. SWEAT (Ship Workload and Establishment Analysis Toolset). 4. HFE ICADD (Human Factors Engineering Intelligent CADD) which is described elsewhere in this annex. 5. VAPS (Virtual Prototyping), a commercial product used to develop rapid prototypes of hardware and software product interfaces. 6. MMM (Mission Manpower Model), a tool developed in Australia for the determination of ship complement and the impact of crew tasks on staffing and ship resource (power, water) usage. 7. System Safety Database, which contains a log of ship safety issues from a variety of Canadian vessels.
Hardware and Software Environment	Most of the DMSS tools run on the MacIntosh computer environment (MANIAC, ERASMUS, SWEAT,MMM, System Safety Database), while other runs on Silicon Graphics workstations (HFE ICADD, VAPS).
State of Development	The majority of the DMSS tools are in an operational prototype state and require further enhancements and validation to become operational tools. The exceptions to this are the Safework tool within HFE-ICADD and the VAPS tool which are both fully supported commercial tools. MMM also appears to be a completed tool at this point, however further investigation is required.
Future Expansion	To make the DMSS useful in the future a number of enhancements have been identified: 1. Compatibility with PC operating systems is required, as the local Information Management strategy will not continue to support Silicon Graphics or MacIntosh computer systems. 2. ERASMUS requires updating. 3. MANIAC requires validation. 4. MMM requires validation and a PC version. 5. HFE-ICADD modules require enhancements and a PC version. Specifically the Checklist Module needs more functionality and improved usability, the Automatic Constraint Checker needs to be quicker to change, and the Deficiency Report Generator needs links to other tools.

Directorate of Maritime Ship Support Tools (DMSS)

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis		●	
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis			
	b. Control Requirements Analysis			
	c. Workspace Requirements Analysis			
	d. Environmental Analysis			
	e. Safety and Hazard Analysis		●	
	f. Personnel and Staffing Analysis		●	
Project Research	a. Studies, Experiments & Laboratory Tests			
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials			
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure		●	
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

HFE Guide

Description	HFE Guide is a hypertext software tool that contains the contents of military standards for human factors programs and design criteria, human factors Data Item Descriptions for procurement, and guidelines on user centred test and evaluation.
Users	HFE Guide can be used by both HFE and non-HFE professionals requiring insights into HFE design criteria, human factors program contents, and user centred test and evaluation.
Military Environments	A large portion of the contents of HFE Guide is applicable to all military environments, with a later version of the product being enhanced to include a number of NATO STANAGS and ASCC guidelines relating specifically to the Air Environment.
Features	HFE Guide is an information resource. It allows the user to search through the information content to locate guidance of interest. Using HFE Guide the user can search with keywords, navigate from screen to screen using hyperlinks, and cut and paste with other MacIntosh applications. HFE Guide is currently three different pieces of software, each with users manuals. 1. HFE Guide IIA contains Mil Std 1472D, with some addition design guidelines from TOPS. 2. HFE Guide IIB contains information on Test Methods and Task analysis, adapted from TOPS. 3. HFE Guide III contains hypertext versions of Mil Std 1572D, Mil Std 48855, 9 HFE DIDs,and over 50 standards for aircraft design from NATO STANAGS and the ASCC series. In addition HFE Guide III contains a Data Item Description (DID) tutorial that outlines the link between each DID to the human factors processes in Mil Std 46855, ASCC 10/64 (AIR), and STANAG 3994 (AIR).
Hardware and Software Environment	HFE Guide runs on the Macintosh with any Mac Operating system, and any HyperCard after 2.0. Approximately 14 Megabytes of hard disk space is required, plus an additional megabyte for HyperCard. The system runs best on a computer with a 68040 processor or later, with at least 2 Mb of RAM.
State of Development	HFE Guide is currently three different pieces of software, each with user manuals.
Future Expansion	No future expansion is planned at this time. Logical future expansion would include the transfer of the content to a multi-platform type of environment, such as HTML or Adobe Acrobat formats. In a multi-platform format the content could be more easily linked or used with other software tools that might benefit from rapid access to HFE information.

HFE Guide

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan	●		
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis		●	
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis	●		
	b. Control Requirements Analysis	●		
	c. Workspace Requirements Analysis	●		
	d. Environmental Analysis	●		
	e. Safety and Hazard Analysis	●		
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests			
	b. Dynamic Simulation & Rapid Prototyping			
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards	●		
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models			
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

Human Engineering Analysis and Requirements Tools (HEART)

Description	A crewstation modeling facility referred to as the Human Engineering Analysis and Requirements Tools (HEART) has been established by the Directorate Technical Airworthiness (DTA) with the scientific support of the Defence Research and Development Canada (DRDC T). HEART is a suite of integrated tools developed to support most areas of Human Factors Engineering throughout the acquisition and life cycle of aircraft crewstations.
Users	The software contained in HEART requires an experienced, very computer literate user, with some background and experience in Human Factors Engineering. Key skills include an understanding of anthropometric principles and guidelines, limited programming experience, 3-D modelling experience, and knowledge of principles of interface design.
Military Environments	HEART is currently focused on the air environment, however, the majority of the tools contained within HEART are also used by all other military environments and some industrial environments.
Features	HEART has three primary tools, comprised of 7 key components. The three primary tools include (a) an anthropometric analysis facility, (b) a design reference system, and (c) rapid prototyping applications. The primary components of the HEART system are utilized to perform a variety of analyses, ranging from the evaluation of the physical configuration of a work environment, from the perspective of relevant human factors guidelines and constraints imposed by specific user populations, to the development or modification of user interfaces for use in military systems. The 7 key components provided by the three primary tools include: 1. Anthropometric Analysis Tool: An anthropometric analysis tool was established for evaluating fit between crewstation and crew model: The System for Aiding Man-Machine Interface Evaluation (SAMMIE) application facilitates the incorporation of a crewstation model and mannequin for a review of the reach, vision, and clearance characteristics of a specific user population; 2. Aircrew/Crewstation Compatibility Evaluation: A suite of software was developed for reviewing the overall crewstation design for physical compatibility with a designated user population. To augment the interactive analyses provided by the SAMMIE utility, the Aircrew/Crewstation Compatibility Evaluation (ACCE) tool employs a series of macro programs to catalogue the fit data associated with a full population. The data may then be reduced and analyzed to identify the degree of fit in terms of reach, vision and clearance parameters; 3. Rapid Prototyping: The Virtual Applications Builder (VAPS) application allows the development of high fidelity 2-dimensional visual representations of display and control systems. These display and control elements within the prototype may then be stimulated by either internal or external stimulus to create an operational representation of the interface; 4. Sonic Digitization: This facility incorporates a commercially-available sonic digitization system and Computer Aided Design (CAD) tools to collect the data necessary to establish an accurate 3-dimensional crewstation model. The models generated by this facility are suitable for import to either the SAMMIE or VAPS utilities; 5. Design Reference System: The Design Reference System (DRS) is an on-line reference system providing an environment with a full document browse and search capability. The library will include applicable military and civilian interface and Human Factors standards, selected from the collection of Military Standards (MIL-STD), Air Standardization Coordinating Committee (ASCC) standards, North Atlantic Treaty Organization (NATO) Standardization Agreements and commercial documents. 6. Aircraft Crewstation Demonstrator: A requirement had been established for a low fidelity, fixed-base, rapidly reconfigurable aircraft crewstation modelling and simulation facility. The Aircraft Crewstation Demonstrator (ACD) was established as a testbed for the test and evaluation of proposed modifications to, or development of, aircraft flight deck or tactical compartment instrument suites. Note: The ACD is the subject of an independent discussion within the HFE Tool project (see ACD in this Annex); and 7. Mission, Function, Task and Workload Analysis: The Systems Operator Loading Evaluation (SOLE) Integrated Performance Modelling Environment (IPME) integrates a Database Management System (Sybase/SOLE) and network analysis tool (IPME by MicroAnalysis and Design) to provide an analysis process consistent with the directives established by MIL-HDBK-

	46855. Note: The SOLE facility is the subject of an independent discussion within the HFE Tool project (see later in this Annex).
Hardware and Software Environment	The HEART system requires a variety of hardware and software to be integrated. The Primary HEART Machine requires a Silcon Graphics workstation Indigo^2 with a R4000 Processor, 4 mm DAT Tape Drive, the IRIX 5.3 Operating System, a GDM-20D11 20" Monitor, a 4 GByte External Hard Drive, an external CD ROM and an external 3½" Floppy Drive. The Digitizer Kit requires the Science Accessories Corporation GP12 Sonic Digitizer with Calibration Bar, with the 0.5 m triangular Microphone array, the 1.0 m triangular Microphone array, the Offset Probe (3" and 6" tips), a series of miscellaneous Equipment (tools, spare microphones, tape, power bar, cables), the GP12 Digitizer Interface Software (RevEng, RevCAD, RevSurf, RevScan, CADKey), and a Travel Case. The SAMMIE CAD application runs on the Primary HEART machine, using the SAMMIE CAD accessories (ACCE Macros, Flail Envelope Facility, DXF Processors), and the Library of SAMMIE Aircraft Models. The VAPS Rapid Prototyping Tool operates on the Primary HEART machine, with the library of VAPS CF Aircraft Instruments. The Design Reference System also operates on the Primary HEART Machine with Electronic Books Technology (EBT) application software (DynaTag, InSted Editor, DynaText Browser) and the Electronic Books Library.
State of Development	The three primary tools in HEART (less SOLE and the ACD) are generally an integration of Commercial Off the Shelf products, and the HEART tool is therefore an operational software product with associated manuals and training available. The specifics of SOLE and ACD are discussed elsewhere in this Annex.
Future Expansion	The HEART facility is continually evolving through the inclusion of new facilities, such as the SOLE and ACD facilities. It is anticipated that this expansion will continue along the same course. Details on SOLE and ACD developments are discussed separately in this Annex. With respect to the primary elements (Anthropometric Analysis Tools, Rapid Prototyping Tools, and the Design Reference System), there are new directions which should be pursued. The SAMMIE application currently used to conduct anthropometric analyses has not undergone any significant advances over the last four years. Other tools have become available which represent an improvement in both analysis and usability. DND should consider replacing the SAMMIE kernel with the SAFEWORK application, by Genicom. Although there are some elements within SAMMIE (macro development and the ACCE protocol) that are not currently available within the candidate systems, it is anticipated that the environment to support this functionality will soon be available. The strengths associated with the Design Reference System is that it provides a browser for the review of standards documents. This browser was based on a concept developed by SGI for the display of its electronic manuals, and was quite revolutionary in the early 1990's. However, in the current environment it is more appropriate to utilize the power of HTML to convert documents into a browsable format. With the documents in this standard format, the user could utilize their preferred browser to view the information

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios		●	
System Analysis	a. Mission Analysis		●	
	b. Function Analysis		●	
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation		●	
Analysis of System & Maintainer Tasks	a. Timeline Analysis		●	
	b. Task Analysis		●	
	c. Critical Task Analysis		●	
	d. Decision Analysis		●	
	e. Error Analysis			
	f. Loading and Crew Composition Analysis		●	
	g. Training Analysis (Knowledge, Skill, Ability)		●	
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis		●	
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis		●	
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters		●	
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards	●		
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure		●	
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

Human Factors Engineering Intelligent Computer Aided Design and Development (HFE-ICADD)

Description	HFE ICADD was developed for DMSS by Defence Research and Development Canada Toronto under a broader initiative to develop human factors tools to support the application of human factors methods in the design of Canadian Naval Vessels. The HFE ICADD system was designed to support the application of Human Factors in the following ways: (1) Act as a central record of the human factors design criteria and perhaps even the HF Plan that is developed throughout preliminary design and finalized during contract design; (2) Provide the facility to act as a link between DND and the contractor, where if both sides used the system, rapid, efficient review of human factors issues and their status will be facilitated (future requirement); (3) Capture operational experience in the form of task analysis data; (4) Allow for tracking of multiple iterations of a drawing, a compartment, or a debate around a human factors concern; and (5) Provide the hardware/software flexibility necessary to support use by a range of sites at DND and at contractors.
Users	The current HFE ICADD system and associated User Manual assumes that users have some of the basic knowledge and skills listed below to learn and use the HFE ICADD system effectively. The prerequisite knowledge and skills include: (a) Computer proficiency with UNIX-based systems, such as Silicon Graphics Workstations, PC-based systems, and Peripherals including scanners, mass optical storage, and printers; (b) Familiarity with different CADD software packages and preferably proficiency with at least one, (c) Familiarity with ship design activities, and (d) Familiarity with human factors methods in design reviews. Until the HFE ICADD System modules have been populated with data such as checklists, tasks, equipment, compartment design reviews and results (completed or in-progress), it is also assumed that users have some familiarity with: (a) Human Factors principles, (b) Human Factors guidelines, (c) mannequin modeling, and (d) the role of human factors in the ship design review process.
Military Environments	The tool has been initially developed for the maritime military environment (Ship Design Review), however, the system is definitely not anchored in this environment. It can be very easily tuned to other military environments (land and air) and civil environments (car design, aircraft design, space, etc.).
Features	The features of the HFE ICADD system are best described according the modules of which it is composed. These modules include: **Project Manager:** The Project Manager allows the user to access each of the other four modules in the system, while providing the logic and file conversions necessary to allow a series of Commercial Off the Shelf (COTS) and custom developed products to work together. **Drawing Module:** The drawing module allows the user to bring ship layout drawings into the HFE ICADD system. This module accommodates the full range of drawing formats including paper which are scanned in, and electronic CADD files which are imported and manipulated with the included CADD software (currently MICROSTATION). Once a file is in electronic format the Drawing Module includes a Redliner software package that allows the user to mark up the drawing during the review, making notes and illustrations on top of the drawing itself. The Drawing Module also includes Mannequin software to allow the user to create 3D representations of complex design spaces, insert human form mannequins into the space, and conduct evaluations of reach, physical demands, line of sight, etc. The Safework tool is currently integrated into the system as the Mannequin Modeler (see the Safework Tool section of this report). **Checklist Module:** The Checklist Module allows the user to create a checklist of design criteria that a space layout is required to meet. This checklist is created by cutting and pasting from existing checklists or manually entering new checklist items into the checklist structure. Once a checklist structure is created, the checklist browser is used during the review to record the results of the layout review. **Task Module:** The task module provides a framework for the user to enter information about the tasks that must be completed in a workspace. As many layout criteria are often related to accommodating the users tasks, it is beneficial for the user to have this data available for quick

	access to information about who works in the space, where they have to travel, what they must reach, what they must see, and with whom they must communicate. By creating this task information over the life of the project the tool also provides a solid repository for task description information. As a ship is designed or built the Task Module also allows the user to attach photographs or video clips to the task information to allow the layout reviewer to better visual the space and the associated user tasks. **History or Case Based Module:** As the user completes their reviews of a layout there are a number of 'intelligent' features that can assist with the review and reporting process. These features are driven by various logic that track the contents of drawing reviews, and include: The *Previous Case Manager* allows the users to capture application knowledge and retrieve it with intelligent context-sensitive searches. A thesaurus is used as the basis for the expansion of the scope on the searches. This module is developed in Common Lisp with Java thin-client interfaces. It is designed as a knowledge-based system, allowing the system to be applied to other technical domains. The *Automatic Constraint Checker* checks the compliance of a ship compartment layout to a set of design rules automatically. This module is implemented in Common Lisp with a Java thin-client interface. First, a 2D drawing is loaded into the system and displayed on screen. Secondly, the 2D drawing is automatically analysed for compliance to human factors requirements. Non-compliance warnings are high-lighted with red squares. When these warnings involve relationships between several objects, these objects are connected with red links. Thirdly, clicking on the mouse-sensitive red squares automatically displays generated reports in html formats. The *Automatic Report Generator* automatically compiles the individual non-compliance warning messages into one single report in html format that can be either printed out of viewed with an html browser, such as Netscape or Explorer. This module is implemented in PERL. The *Interactive Help System* has been developed as part of a collaborative agreement with the National Research Council. As part of this agreement, Protogon acquired a licence of the technology and developed a Java implementation. It provides context-sensitive help as dynamic dialogs that adapt to previous messages and the users' level of knowledge as automatically evaluated by the system from the types of questions asked by the user. This module has been developed entirely in Java.
Hardware and Software Environment	The HFE ICADD currently runs on a Silicon Graphics Indigo2 R4400 Workstation. In order to operate all of the features and to store the associated data, each instance of the HFE ICADD system currently incorporates a Silicon Graphics Indigo2 R4400 Workstation (CRT, Keyboard, External CD ROM & DAT 4mm) with 32Mo RAM and XZ graphic card, a Colour Scanner (ScanJetIICX), a Printer (Lexmark Mod 4079 Ink Jet), a Digitizing Tablet (CAL COMP), and a Mass Optical Storage (Juke Box C20XT 206B). Some of the modules (The History & Case Based Modules) have been designed in Common Lisp with Java-thin client interfaces. These modules are fully portable, and can run on the PC as well as the Unix as long as a Lisp Compiler and a Java virtual machine can be obtained for the platform. Versions of Microstation, the CAD system are available both for the PC and for Unix platforms. The current version of the HFE ICADD system is operating on a SGI workstation running IRIX 5.3 or higher. The supporting COTS products that make up major components of the HFE ICADD system include CADLeaf (including Redliner CAD commenter), MicroStation (CAD software), Pixel FX (scanner software), TracTrix (vectorizing software), JOT Text Editor, Case Based Module (coded in PERL, html display format), and Safework 2.53 (3D Mannequin Modeler, see Safework description in this Annex).
State of Development	The current state of development of the modules within the HFE ICADD system varies as some modules are COTS products and some were developed. Overall the current system is a Functional Prototype with User Manuals and Training Materials that support a one day training program with sample projects. Modules purchased and integrated as COTS products are fully developed software with vendor support. Modules developed within the HFE ICADD project vary from early

	prototype to functional prototype software. The individual modules may be separated from HFE ICADD as an integrated system if specific functionalities are required for other applications.
Future Expansion	No future expansion is planned or contracted at this time. The principal opportunity for DND personnel using HFE ICADD is to use it as an interfacing tool with engineering contractors. DND staff could concentrate their activities on developing the evaluation criteria and methods, implementing them as operational layout evaluation scripts within HFE ICADD, and from that point on rely on the contractors to access HFE ICADD through a web site to check their designs themselves. This would offer the advantage of off-loading DND staff and shortening the design-review cycle. Extending the system into a multiple-user system would allow HFE ICADD to operate as a collaborative design tool. The Java thin-client architecture provides the foundation for this expansion. A study has already been conducted on porting HFE-ICADD system to Virtual Reality. This aspect of the technology could greatly improve the Human Factors Engineering function of the tool, as many other tools do right now in the process of Design. Safework has VR capabilities (electromagnetic motion capture system, head mounted displays for fully 3D immersion, data gloves, sensitive feedback) already.

Human Factors Engineering Intelligent Computer Aided Design and Development (HFE-ICADD)

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis		●	
	c. Critical Task Analysis		●	
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis		●	
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests			
	b. Dynamic Simulation & Rapid Prototyping			
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials			
Equipment Detailed Design	a. Application of Human Engineering Standards		●	
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

LOCATE

Description	LOCATE is a Computer-Aided Design (CAD) environment for creating workspaces and analysing the effectiveness of human-machine-human communication in multi-operator/machine layouts. Typically LOCATE would be applied to problems such as the layout of workstations in a command and control facility, an air traffic control centre or a ship's bridge. LOCATE can be used for other types of layout problems as well (e.g., panel layout or facility location), although its main strength lies in its ability to deal with problems that are within the near to limiting range of human sensory capabilities.
Users	The primary potential users of LOCATE are designers and human factors engineers interested in workspace layout design. These include both military and civilian designers across a wide variety of fields.
Military Environments	LOCATE can be used for projects in all three military environments.
Features	The key features of Locate include: 1. CAD Design: LOCATE contains a GUI with a tool palette for: creating typical objects found in a workspace; customising objects for inclusion in the workspace; identifying collections of objects as elemental workstations; identifying collections of objects as elemental obstructions within workstations; and identifying collections of objects as fixed obstructions outside workstations. 2. Communication Analysis: LOCATE allows users: (a) to specify any combination of four domains of communication for analysis: visual, auditory; (b) tactile and distance (or movement); (c) to indicate the type of function that defines a workstation both as a source and a receiver of information, for each communication domain being analysed; (d) to indicate functions that govern both distance and angular components of communication; and (e) to specify priority weights for every pair of workstations, with each workstation considered as a source and a receiver of information relative to the other, for each type of communication being considered. 3. Output: In order to help the user create a configuration that maximises the communication efficiency among its elements, LOCATE provides: (a) a cost function value, ranging between 0.00 and 1.00, which summarises the efficiency of a design across all communication domains of interest; (b) a cost function value window, permanently displayed in the interface, which the user can instruct the system to update automatically whenever a change is made to the design configuration; and (c) a matrix of cost function values for pairs of workstations, organised separately for each communication domain being analysed. That matrix helps users identify the location of high communication costs in the design using colour-coded, graphic displays items. 4. Help: LOCATE provides help to the user in three ways: (1) by tracking the user's actions at the interface and providing feedback appropriate to those actions in the context of design and analysis; (2) by providing a built-in browser that allows access to the World Wide Web, including sites useful in determining the types of function appropriate to analysing the communication efficiency of designs; (3) by providing access to on-line help files that explain the concepts and procedures necessary to make effective use of the LOCATE tool. In a typical task flow the users of LOCATE: • Create workspace designs either from scratch or by importing designs produced in other design environments, e.g., AutoCAD; • The user then selects any combination of four communication domains for analysis; • Functions are selected and argument values entered which characterize each workstation in the workspace. Data entry is done for each domain of communication in which the workstation is either a source or receiver of information, or both. Functions are further specified for the distance and angular components for each communication domain; • Priority weights are specified for pairs of workstations to indicate the importance of communication domains under conditions in which each workstation serves as a source and a receiver for the other; • A cost function is run for a particular arrangement of the elements in a design. A summary statistic (cost function value) is produced as an indicator of the efficiency of the total design taken

	across all communication domains selected for analysis; • More detailed output identifies costs associated with each pair of workstations for each communication domain being considered as well as for all domains combined; • Colour-coded graphical displays are generated and provide the user with a way of quickly locating the major costs for a particular configuration; and • If a user is not satisfied with the efficiency of a configuration, new arrangements may be tried, cost functions computed, graphic displays and numeric output examined until an acceptable level of efficiency is achieved.
Hardware and Software Environment	LOCATE currently runs on Macintosh and PC platforms but can be easily ported to as many as 40 different hardware platforms. In the past, LOCATE was implemented for both Power Mac and 68K Macintosh machines, while recent implementations have only supported the Power PC. Implementation on the PC was done on a 486 and Pentium I machines. The ultimate target platform for LOCATE is the SGI Iris Indigo class of machine, intended to maintain consistency with a suite of human factors tools currently under development by DRDC T. The software that allows the LOCATE tool to be ported to any of 40 operating systems is called Neuron Data, the libraries of which must be present on the computer LOCATE to run. As indicated LOCATE currently runs on the Macintosh OS, and it has been tested on Windows 95 and 97. Other major operating systems are supported such as OS/2, Windows NT and SunOS.
State of Development	LOCATE is an operational piece of software available for use. This claim should be qualified by saying that the current implementation is equivalent to a Version 1.0, which requires further development and continued testing. Hypertext help files that explain many of LOCATE's features are available to guide the user in developing an understanding of the concepts and procedures necessary to use the software. These files are available both locally and on an Internet demonstration site. Work is continuing to expand these files to reflect the addition of new features to LOCATE.
Future Expansion	Current work on LOCATE is intended to add new functionality for CAD design; update existing hypertext help files; develop a tutorial describing how to use LOCATE; expand the number and type of interface actions that LOCATE monitors; use that expanded monitoring to extend the intelligent help LOCATE provides to its users; and add functionality that supports intelligent analysis of cost function output. Future expansion is likely to be focused on designing and implementing an optimizer for automatic generation and testing of new design configurations; developing and refining LOCATE's CAD features; extending intelligent aiding and analysis within LOCATE to provide models for similar functionality to be added to other DRDC T software tools.

LOCATE

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis			
	b. Control Requirements Analysis			
	c. Workspace Requirements Analysis	●	●	●
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models			
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

SAFEWORK

Description	SAFEWORK® is a commercially available human-modelling system developed and distributed by Genicom Consultants Ltd. of Montreal. SAFEWORK® provides and accurate, digital, geometrical model of humans, taking into account the gender, the ethnic origin and 104 anthropometric variables. It can be used in a variety of applications including interior vehicle design, workspace design, product design and prototyping, process simulation and ergonomic analysis.
Users	SAFEWORK is used by technical design personnel with CAD experience, including human factors engineering personnel.
Military Environments	SAFEWORK can be applied to projects in all military environments.
Features	The **ANTHROPOMETRY MODULE** enables users to access standard male and female population statistics and allows users to assign morphological and anthropometric attributes to mannequins. These attributes originate from the statistical databases contained in SAFEWORK or from data provided by the user. One of the most important tasks is to identify critical variables in a design. This module allows the user to select the variables and assign them to the mannequin(s). The user has full control of the variables. The user can toggle between the Anrthropometry Module and the scene, select another mannequin, and then return to the module to edit its variables. The user has the option of applying the selected variables to the mannequin in the scene. There are many more easy ways to use features in this module. **ANIMATION MODULE**: Each SAFEWORK® referential type objects (mannequin, geometry, camera...) can be animated. The Animation Module can animate a mannequin to visualise (through the mannequin's eyes) the execution of a task or an operation that was defined by the user. The Animation Module can animate multiple mannequins interacting with objects in a co-operative task, and view the scene through multiple cameras. The mannequin is animated in respect of the functional limitations and joint's behaviour. The **CLOTHING MODULE** can simulate various types of clothing. This module not only affects the extra space required for the clothing and the rigid gear in terms of added encumbrance, but also allows the user to simulate the effect of the clothing on the mannequin's range of motion. The user can also define their own clothing by editing the thickness of the gear on the mannequin and the effect on the range of motion. The user can save the clothing in SAFEWORK®`s libraries and paste it on a mannequin with different anthropometry (This module was developed to meet the requirements of the Canadian Army). The **COLLISION DETECTION MODULE** enables the SAFEWORK® user to detect, verify, analyse and simulate physical contact between two objects in the scene. The collision can be calculated either during contact between surfaces (polygons) of the objects (contact detection) or as a function of a sphere or cylinder surrounding the object. The **ERGONOMICS ANALYSIS MODULE** enables the user to estimate the “safe” weight when lifting, pulling, pushing and carrying. By a simple click of a button, the user can specify the initial and the final postures and SAFEWORK calculates the recommended weight. This module is mainly based on NIOSH and Snook & Ciriello studies. The **VISION MODULE** helps model the mannequin's field of vision. Like a human, a SAFEWORK® mannequin can see its environment. That vision can be from both eyes (ambinocular, binocular), stereoscopic (both eyes independently), or limited to one eye (monocular). As well, the blind spot is simulated. Various attributes such as focus distance, ponctum, field of view, etc., are fully adjustable by the user. The **VIRTUAL REALITY MODULE** addresses various requirements and applications: The use of a Virtual Reality in ergonomic design is cost-effective as users can evaluate a design through virtual mock-ups, which is much less costly than traditional mock-ups. Another possible application is referred to as "virtual immersion", where the goal is to recreate the "look and feel" of a complete environment, by creating a controllable virtual representation of the user (or "avatar") into the simulated environment.

	Combined with the task simulation module, users can perform ergonomic analysis by using data captured from a real subject performing the task to be analysed. Users can also perform human factors evaluations of environments by using virtual immersion. These different applications share the need for an articulated virtual mannequin controlled by a set of motion capture devices placed on a human subject. The SAFEWORK® VR module takes advantage of the precision of the SAFEWORK® man model to achieve accurate movement of the virtual mannequins. The current release interfaces to MotionStar wireless sensors (from Ascension Technology) , CyberGlove, and CyberTouch peripherals (from Virtual Technologies), and helmets Datavisor 80 from n-vision and Proview 60 and 80 from Kaiser-Electro-Optics. The **CAD MODULE** provides the user with a variety of tools to easily create various geometric objects. For applications requiring more complex CAD geometry, users can easily import and export their files using SAFEWORK®`s sophisticated capabilities. SAFEWORK® incorporate the ACIS Universal File Translator. File formats supported in SAFEWORK® include IGES, STEP, STL, DXF, OBJ, COOR, Native CADDS, Native CATIA and Native PRO-E. SAFEWORK® can import and export all types of geometric entities from polygons, through all type of surfaces (trimmed, parametric, splines, bezier,etc.) up to solids. Users can export the created or modified digital environments using any of the above file formats. The actual output depends on the needs of the user and the application. The **POSTURAL ANALYSIS MODULE** provides the user with a large variety of tools including range of motion, coupled range of motion, comfort angles, and maximum force exertion. The user can generate their own tables of analyses or modify those already existing in SAFEWORK® `s unique library system. The tasks or system flow will vary somewhat depending on the application and the requirements. (Because of the nature of SAFEWORK® and its tool set of modules and features and ability to interface and work in various environments, the potential number of inputs, task flows and outputs can be considerable).
Hardware and Software Environment	SGI Workstation O2 R10000 or greater High-end graphics card 128 MB RAM or more IRIX 6.5.x operating system IBM Workstation A43P or greater GXT550P graphics card or greater 128 MB RAM or more AIX 4.3.3 operating system or greater HP Workstation HP9000/700, C200 or greater Visualize class graphics card 128 MB RAM or more HPUX 10.20 operating system or greater
State of Development	SAFEWORK is a commercially available software product, installed at over 200 sites throughout the world. It comes with user manuals and training programs are also available.
Future Expansion	The SAFEWORK® Task Module features are expected to include the following basic tasks: REACH (with one or two hands), HOLD, GRASP, RELEASE, MANIPULATE, LOOK AT and WALK. It is expected that this module will allow for the composition of more general tasks by the concatenation of basic tasks. In addition to the 11 categories of movement, the developers plan to include time required for assembling or disassembling objects using various tools combinations. SAFEWORK® is also being extended to include sophisticated human motion data to ensure the adoption of natural

	movement for the mannequin. This important study partly funded by Chrysler, will enable SAFEWORK® to perform natural movements of a driver inside a vehicle. The resulting enhancements will also be applicable to other applications. SAFEWORK® will soon be updated to integrate the texture as a new object and mannequin attribute. The texture will be applicable to different mannequin parts in order to simulate different pieces of clothing. Further development will enable users to link a SAFEWORK® scene with "Off the shelf" rendering packages.

SAFEWORK

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis			
	e. Error Analysis			
	f. Loading and Crew Composition Analysis			
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis		●	
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

SERA

Description	The Systematic Error and Risk Analysis (SERA) has been developed for investigating the human factors causes of accidents and incidents. Based on the theoretical framework provided by the Information Processing (IP) and Perceptual Control Theory (PCT) models, SERA provides a structured process for identifying both active failures and the preconditions that lead to these failures. The tool was developed by DRDC Toronto and it has been applied in most CF Air accident investigations since its creation.
Users	SERA is used by accident investigators or risk assessors, including both military and civilian, for a wide range of application fields.
Military Environments	SERA can be used for investigations in all three military environments.
Features	The key features of SERA include: 1. It is based on the framework provided by the Information Processing (IP) and Perceptual Control Theory (PCT). 2. It provides an easy to use interface. A graphical overview of the line of questioning showing where the user is in the process is available for each of the unsafe acts identified. Such overviews are useful not only in identifying exactly where the user is in the questioning but also in providing a graphical representation of the underlying theory as it is realised in the SERA model. The overview can be used to navigate quickly to different parts of a questionnaire within a given unsafe act being investigated. 3. It includes a standard and intelligent help function. Help is provided to users at each stage in the process. For each question presented, context sensitive help is readily accessible, including definitions of terms and descriptions of factors to consider in answering the particular question under review. 4. Cross-comparisons to similar results from the HFACS tool is possible. Validation of the SERA approach provides, as part of the output, cross-comparisons to equivalent terminology used in the Canadian Forces modified AGA 135 Human Factors Accident Classification System (HFACS). Information on all failures and their pre-conditions is summarised and organised into a report that is available to the investigator. AGA 135 HFACS equivalents are included in that output.
Hardware and Software Environment	SERA has a PC version and a PDA version. The PC version operates on a PC platform that runs a MS-Windows family of OSs. The PDA version operates on a Windows CE supported pocket PCs.

State of Development	SERA is a mature software tool that has been repeated used during the recent CF air accident investigations.
Future Expansion	No expansion plans have been suggested at this point.

SERA

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios			
System Analysis	a. Mission Analysis			
	b. Function Analysis			
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation			
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis			
	c. Critical Task Analysis			
	d. Decision Analysis		●	
	e. Error Analysis		●	
	f. Loading and Crew Composition Analysis		●	
	g. Training Analysis (Knowledge, Skill, Ability)		●	
Preliminary System & Sub-system Design	a. Information Requirements Analysis			
	b. Control Requirements Analysis			
	c. Workspace Requirements Analysis			
	d. Environmental Analysis		●	

	e. Safety and Hazard Analysis		●	
	f. Personnel and Staffing Analysis		●	
Project Research	a. Studies, Experiments & Laboratory Tests			
	b. Dynamic Simulation & Rapid Prototyping			
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials			
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototyping, Mockups, and Models			
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

SOLDIERS DAY

Description	Soldier's Day is a multi-media database created to support the design, development, and evaluation phases of the acquisition process for dismounted infantry (e.g. Clothe the Soldier and IPCE projects). The Soldier's Day database provides a compendium of multimedia information about infantry soldiers tasks, current clothing and equipment, user characteristics, scientific and military references, and basic human factors guidelines. The software also includes some analysis decision aides and HFE tools.
Users	Users include stakeholders with representation from all areas of the Soldier System requirements definition, development, acquisition and life cycle management process, both within and outside of DND. This includes requirements staff, researchers, engineering staff, designers and manufacturers, academia, test and evaluation staff, technical staff college, Department of Army Doctrine, and the CFB Gagetown Infantry School. The different users will use Soldier's Day to: • Support the development and acquisition process. • Support the development of Statements of Requirements. • Support the development of technical specifications. • Assist in the planning of research protocols. • Assist in the prioritization of research efforts. • Develop an understanding of missions, tasks and activities. • Develop an understanding of physical and informational demands. • Develop an understanding of user characteristics. • Develop an understanding of current clothing and equipment systems. • Develop an understanding of clothing and equipment compatibility issues. • Obtain Human Factors guidelines. • Obtain Human Factors related references. • Utilize a Battle Dress model including weights of items.
Military Environments	The information contained in the database is focused mainly on dismounted infantry. Some information is included that addresses mounted operations. The contents of Soldier's Day currently focuses on the Land Forces, but the system can be configured for any type of military environment.
Features	Soldier's Day allows the user to view high-resolution photographs, listen to soldier commentary and audio clips, observe information presented in tables, graphs and schematics and view videos of soldiers in action. Key features typically used by the users of the tool include the following: 1. Browse: One method of stepping through and discovering the data includes the use of *Browse Screens.* The browse screen is a common format across all database categories for presenting information and detailing associated data. The browse screen has a number of windows, icons and buttons that can be used to supply information and facilitate navigation. Browse screens let the user view equipment, soldiers, activities, and references related to each item. Icons also indicate the types of associations other items have to the current item (i.e. compatibility, component, etc.). *Tree Views* may also be used to provide a hierarchical and /or alphabetical view of all the items contained in a category and indicate how the items are associated. A *History* feature enables the user to keep track of the locations visited during a session and enables them to quickly return to any previous location. 2. Search for Keywords: The *Keyword Search* function helps the user find keywords in any section of the database. Search results with data files are displayed for the user to view. 3. View Mission Scenarios: Multimedia slide shows and task flowcharts are provided with information regarding Attack, Defence and Patrol scenarios. Task function flows decompose the mission scenarios into their component tasks and decisions. 4. Use Help: On-line Help describing the buttons, screens, features and functionality may be obtained by using *Point and Click Help* or by using *Help Menus*. 5. Search for References: The *Reference Search* function helps the user identify and view references that satisfy specific search criteria for scientific and military papers and military publications on a topic. 6. Create a Load List: The *Load List* allows the user to create a list of clothing and equipment and

	compute the overall weights carried or worn by dismounted infantry personnel. 7. Notepad: *Notepad* acts as a bookmark feature. It enables the user to select items and data and retain the list of items and data in a bookmark file for future reference. Once selected, the user may move forward or backward among the items and data selected and record notes or comments. Users might create such files to compile a listing of items and data corresponding to a particular topic or area of interest, to improve access to frequently visited locations, or to provide other users with a pre-determined route through the database. Generate a Document: The user may copy text and graphics from the database. These copies can then be pasted (inserted) into any Windows compatible word-processor program. This feature helps the user to take information and pictures directly from the database and place them quickly and easily into a document or report.
Hardware and Software Environment	Soldier's Day requires a PC with a 486 processor or higher, with at least 8 Megabytes of RAM, 10 Megabytes of free hard drive space, a double speed (x2) CD-ROM drive, a 16-bit sound card with speakers, a monitor capable of displaying 256 colour at 640x480 resolution (SVGA, and a Microsoft Windows compatible mouse Photographs and videos display best if the PC has a video card with more than 256 colors). Soldier's Day is a CD-ROM that operates on Windows 3.1 or higher. One module, the Mission Scenarios and Task flows requires Windows '95 or later as the operating system.
State of Development	Soldier's Day is a fully operational software tool with a User Manual and an Author Manual for the maintenance of the information contained on the CD-ROM.
Future Expansion	The identification of the resources required to extend Soldier's Day to include mounted operations has been completed. Population of the database with mounted infantry information is pending. The development of an anthropometry module including the CF Land Force Anthropometry data. In the future, a number of extensions of the database have been planned but are not yet funded; (1) the integration of ACCESS results and findings, (2) expansion of the environment to include other arms and/or other military environments, (3) migration from a CD-based system to a web based system, and (4) expansion to support additional areas or HFE tools in the acquisition cycle.

SOLDIERS DAY

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan		●	
Scenario Development	a. Identify Key Operational & Support Scenarios	●		
	b. Describe Characteristics of Key Scenarios	●		
System Analysis	a. Mission Analysis	●		
	b. Function Analysis	●		
	c. Potential Operator Capability Analysis	●	●	●
	d. Potential Equipment Identification	●		
	e. Function Allocation	●		
Analysis of System & Maintainer Tasks	a. Timeline Analysis			
	b. Task Analysis		●	●
	c. Critical Task Analysis			●
	d. Decision Analysis	●		●
	e. Error Analysis			●
	f. Loading and Crew Composition Analysis			●
	g. Training Analysis (Knowledge, Skill, Ability)			
Preliminary System & Sub-system Design	a. Information Requirements Analysis			●
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis		●	
	d. Environmental Analysis		●	
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis			
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters		●	
	b. Test and Evaluation Plan		●	
	c. Conduct Usability & Performance Trials		●	
Equipment Detailed Design	a. Application of Human Engineering Standards		●	
	b. Procedures Development		●	
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

System Operator Loading Evaluation (SOLE) / Integrated Performance Modeling Environment (IPME)

Description	SOLE IPME is a software tool used to conduct mission/function/task analysis, to model human behaviour, and to predict human performance under future operational conditions. SOLE is tool developed by the Canadian DND through DRDC T, while IPME is a software product distributed by Microanalysis and Design in the United States (developed through funding from the Department of Defence in the United Kingdom and DRDC T). A series of projects are currently integrating historical SOLE features into the IPME commercial software products.
Users	The users of SOLE IPME require an understanding of the general theory behind the performance predication models embedded within SOLE IPME (Attentional Demand, Task Conflict, IP, POP, W/Index) solid computer literacy (SGI and Windows NT), familiarity with operation of the IPME software, and the theory and application of human factors engineering and processes. As SOLE features are integrated further with the IPME product the need for software programming skills will decline, so the user population will primarily consist of human factors and human performance modeling professionals.
Military Environments	SOLE IPME can be used for all military environments.
Features	SOLE IPME focuses on the simulation of human operators in their operational environments. IPME allows the user to construct component models that are tied together in a simulation environment. IPME has five component models, a measurement suite that can be used for blocked design of experiments to evaluate human performance or the effects of system changes on human performance, and a number of operator workload measurement methods. The five component models of IPME include: 1. The Task Network. The task network model is used as the framework for systematic decomposition of the system, from the mission, to functions, to tasks. This model development and the associated analysis processes provide the data to allow the analyst to complete function analysis, function allocation, and high level task analysis. The user creates task networks either through forms on their display, or graphically using a hierarchical flow charting tool. Once networks are created, they can be printed out as function flow diagrams or Operational Sequence Diagrams (OSDs) which facilitate review with the operator community for validation. 2. The Operator Model. The operator model is created by the analyst to describe the characteristics of each operator in the crew which will be involved in the scenario. IPME comes with some default characteristics, with many alterable variables. Once operators are created they are then assigned functions and task to perform in the task network. Configuration of the operator allows the analyst to define which types of task elements will have priority over others, such that when the operator starts to get overloaded the lower priority tasks will be dropped, or passed to another member of the crew. The resulting simulation allows the analyst to evaluate how well the system will perform with the operator in the loop, and also allow functions and tasks to be re-assigned to different crew members to evaluate the impact of organizational changes on system performance and crew member workload. 3. The Environment Model. The environment model is used to define the environment within which the scenarios being simulated are executed. This allows the analyst to define variables such as temperature and vibration and have them influence the operators' behaviour for the tasks they are assigned to perform in the model. In addition, the environment model can be used to initiate external events to which the operator/crew should respond in their task sequence (e.g. present a target to be detected and engaged) according to a time schedule. 4. The Performance Shaping Model. The performance shaping model allows the analyst to introduce various performance stressors to the operator model (e.g. fatigue, or wearing NBC protective clothing). These stressors then apply the appropriate shaping factors (e.g. decrease in performance after being awake for 36 hours) to the operator model when interacting within the task flow assigned. These shaping factors allow the analyst to predict system performance under both normal and stressed or degraded modes of operation. 5. External Models. In addition the four internal models, IPME has been created within a common interface for interacting with one or more external simulations or software programs. This allows

	the representation of the human and their task flow to be linked to a system or equipment simulation, or an external simulation to present events to the human model through the environmental model. The SOLE IPME simulations allow the analyst to gain a wide range of data about human performance including a range of workload metrics, task conflict, attentional demands, time occupied, number of concurrent tasks, etc. In combination, SOLE IPME provides powerful “what – if” analysis capabilities to cost effectively evaluate alternate system configurations and their associated impact on human performance, in addition to the base analytical framework which provides structured tools for the analysis of missions/functions/tasks.
Hardware and Software Environment	IPME can be purchased to operate on a Silicon Graphics workstation (using IRIX 6.2 operating system) or on a PC using the LINUX operating system. SOLE operates on a Silicon Graphics workstation (using IRIX 5.2 operating system) with a PC running Windows NT for the graphical user interface.
State of Development	The IPME software is a commercial software product, with manuals and training programs being used within DND and in other militaries and in industrial environments. SOLE is an operational prototype, which is gradually being integrated into the IPME project by the IPME developer, which will result in a future COTS version of IPME enhanced with features of SOLE.
Future Expansion	The extension of IPME is an ongoing process as the tool developer receives feedback and enhancement requests from defence industry users in Canada, the United Kingdom, and the United States. From the Canadian perspective a number of enhancements are being planned: (a) the IPME environment will be upgraded to encompass the database requirements currently defined within SOLE, (b) consideration is being given to providing access to the SOLE IPME facility through a controlled Internet interface. Providing improvements to the data import facility are implemented, it will be possible for users to utilize the SOLE IPME algorithms through a standard Internet Service Provider, and (c) the algorithms embedded within SOLE IPME will continue to be enhanced and augmented to improve the quality of the data generated by these analyses.

System Operator Loading Evaluation (SOLE)
Integrated Performance Modeling Environment (IPME)

Project Stages	HSI Activities	Data Provided	Activity Supported	Planned for Future
Pre Acquisition	a. Identify Operational Deficiency			
	b. Determine High Level Requirements			
	c. Identify Solution Options			
Plan	a. Negotiate Human Engineering Plan			
Scenario Development	a. Identify Key Operational & Support Scenarios			
	b. Describe Characteristics of Key Scenarios		●	
System Analysis	a. Mission Analysis		●	
	b. Function Analysis		●	
	c. Potential Operator Capability Analysis			
	d. Potential Equipment Identification			
	e. Function Allocation		●	
Analysis of System & Maintainer Tasks	a. Timeline Analysis		●	
	b. Task Analysis		●	
	c. Critical Task Analysis		●	
	d. Decision Analysis		●	
	e. Error Analysis			
	f. Loading and Crew Composition Analysis		●	
	g. Training Analysis (Knowledge, Skill, Ability)		●	
Preliminary System & Sub-system Design	a. Information Requirements Analysis		●	
	b. Control Requirements Analysis		●	
	c. Workspace Requirements Analysis			
	d. Environmental Analysis			
	e. Safety and Hazard Analysis			
	f. Personnel and Staffing Analysis		●	
Project Research	a. Studies, Experiments & Laboratory Tests		●	
	b. Dynamic Simulation & Rapid Prototyping		●	
Test & Evaluation	a. Identification of T&E Parameters			
	b. Test and Evaluation Plan			
	c. Conduct Usability & Performance Trials			
Equipment Detailed Design	a. Application of Human Engineering Standards			
	b. Procedures Development			
	c. Staffing Concept and Organizational Structure			
	d. Training Development			
	e. Rapid Prototypes, Mockups, and Models		●	
Post Acquisition	a. Monitor Operational Effectiveness			
	b. Identify New Design/Manufacturing Deficiencies			

Annex H: Generic HSI Statement of Work and Data Item Description Templates

This document is intended to provide guidance to those responsible for creating a Human Systems Integration (HSI) Program within a Statement of Work for a Materiel Acquisition. This document presents a complete example program for a Major Acquisition. This document should be used as general guidance and be tailored for specific project requirements, ensuring that the tailoring process still maintains HSI principles and goals.

Annex H: Generic Human Systems Integration (HSI) Statement of Work and Data Item Descriptions

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Statement of Work

Data Item Descriptions

1 Introduction

This document is intended to provide guidance to those responsible for creating a Human Systems Integration (HSI) Program within a Statement of Work (SOW) for a materiel acquisition. This document presents a complete example program for a major acquisition. This document should be used as general guidance and be tailored for specific project requirements; ensuring that the tailoring process still maintains HSI principles and goals. This includes the goal to re-use existing analyses where applicable (i.e. all analyses from design to user evaluations) and to share the analyses across sub-domains in order to reduce analysis costs and ensure a common understanding of the concept/design/prototype/system across both the domains and the various groups within the project management office.

While the text is written in a general typical statement of work format, there are some points to note while making use of this material:

- A Data Item Description (DID) refers to the format and content of deliverables associated with work items of the SOW;
- Example DIDs are provided for most, but not all, of the DIDs referenced within the SOW, and there are some additional DIDs that may be used for specific needs, but are not referenced within the example SOW;
- The Contracts Data Requirements List (CDRL) is a consolidated list of DIDs detailing administrative information including delivery time and frequency, approval requirements, etc. The group of example HSI DIDs provided constitutes the HSI portion of the complete project CDRL, but without specific reference to actual administration;
- Direct work statements associated with a CDRL item are not included for brevity (i.e. it is assumed that if a plan is to be developed and submitted, the contractor is obligated to do the work). Statements directing the contractor to perform the work should be added.
- Some statements are more explanatory in nature, rather than obligatory to the contractor, and it may be necessary to remove these from the final statement of work;
- Project and program management items are not included for brevity (e.g. progress reporting, working groups).

2 Human Systems Integration Statement of Work

2.1 Human Systems Integration Definition

Human Systems Integration is the integration of Human Factors Engineering (HFE), System Safety, Health Hazards, Personnel and Manpower, and Training in the acquisition or development of materiel.

2.2 Human System Integration Approach

The HSI approach links the domains of HFE, System Safety, Health Hazards, Personnel and Manpower and Training throughout the project in order to:

- Share and re-use analyses;
- Ensure that a common analysis is used for the design, deployment, and training of the system(s); and
- Integrate and re-use modeling and simulation opportunities for both design and evaluation.

The Contractor shall implement a Human Systems Integration approach, as defined in this SOW, to the design, development, test, and production of the system.

The HSI program requirements in the Contract ensure that HFE, Training and System Safety processes are followed, and that there is a traceable link between the sub-domains.

The HFE Program is intended to ensure that:

- The system is based on an appropriate mission/function/task analysis;
- Operator workspace and interface design are based on task analysis;
- Task performance measures for evaluations are based on task analysis; and
- Human performance and workload are evaluated for critical tasks.

2.2.1 Contractor HSI Capability & Organization

The Contractor shall implement a HSI organization with qualified HSI personnel demonstrating integrated communication across the HSI sub-domains.

2.2.2 Human Systems Integration Process

The Contractor shall establish and maintain a process to ensure an appropriate level of integration between the sub-domains, including the following minimum elements:

- A common Target Audience Description (TAD) shared between the HSI domains, traceable to the description of the operational and support personnel;
- A Mission, Function, and Task Analysis (MFTA) that is common, at least at the critical task level, across the domains. The task analysis will demonstrate common user behaviour in HFE task analysis, System Safety analysis, Health Hazard (HH) analysis, training requirements analysis, and any workload/manpower/personnel assessments. The MFTA will be traceable back to the full range of operational scenarios outlined in the Statement of Operating Intent (SOI) or Statement of Operational Requirements (SOR);
- Integrated risks and requirements, such that there is a HSI section in the project approach to risk management where risks from all the domains are integrated as well as a HSI section in all project requirements and specification documents; and
- Common interface design and workstation layout concepts that are reviewed by all HSI domains; and
- Shared user evaluations, where design concepts, prototypes, simulations and final product evaluations/acceptance trials include an integrated suite of measures and evaluation criteria across the sub-domains.

2.3 HSI Program Plan

The Contractor shall prepare and submit a HSI Program Plan in accordance with the CDRL.

2.4 Human Factors Engineering Program Plan

The Contractor shall prepare and submit a HFE Program Plan meeting the general requirements of MIL-HDBK46855A: Human Engineering Program Process and Procedures, or a demonstrated equivalent in accordance with the CDRL.

2.5 HFE Regulation/Certification Plan

The Contractor shall prepare and submit a HFE Regulation/Certification Plan in accordance with the CDRL. (This applies to aviation, nuclear and possibly marine systems).

2.6 Target Audience Description

The Contractor shall prepare and submit a Target Audience Description (TAD) in accordance with the CDRL.

The Contractor shall utilize the user population definition parameters of the TAD as the foundation for subsequent HSI analyses.

2.7 System Safety Program Plan

The Contractor shall develop and submit a System Safety Program (SSP) in accordance with MIL-STD-882D: Standard Practice for System Safety, or a demonstrated equivalent.

The Contractor shall implement a SSP to identify, analyze and mitigate hazards to the operational and maintenance personnel, the system and environment.

The Contractor shall utilize the SSP to generate derived safety requirements that are flowed into specifications for the system.

The Contractor shall use safety requirements as an input into forming the basis for establishing the system architecture and hardware-software interfaces.

The Contractor shall use the following order of precedence for satisfying system safety requirements and resolving identified hazards:

- Design for minimum risk;
- Incorporate safety devices;
- Provide warning devices; and
- Develop procedures and training.

2.8 HFE Work Tasks

The Contractor shall complete a HFE System Analysis, that includes mission analysis, function analysis and function allocation for operational and maintenance functions. The HFE System Analysis should be traceable to the full range of operational scenarios in the SOI/SOR.

The Contractor shall prepare and submit a Human Engineering Systems Analysis Report (HESAR) in accordance with the CDRL.

2.8.1 HFE Task Analyses

The Contractor shall conduct task analyses with tasks that are traceable from the function allocations defined in the system HESAR.

The Contractor shall identify and describe the full range of operational and maintenance tasks in the task analyses including normal and degrade operation modes and integrate the results with HSI sub-domains.

2.8.1.1 HFE Critical Task Analysis

The Contractor shall ensure that critical tasks are identified in the task analyses, and undergo Critical Task Analysis (CTA) as defined in MIL-HDBK46855A.

The Contractor shall identify Measures Of Performance (MOPs) and Measures Of Effectiveness (MOEs) for critical tasks.

The Contractor shall prepare and submit an analysis of critical operational tasks in a Critical Task Analysis Report (CTAR) in accordance with the CDRL.

2.8.1.2 Workload Analysis

The Contractor shall prepare and submit a Workload Analysis Plan in accordance with the CDRL.

The Contractor shall perform predictive workload analysis, using constructive simulation to evaluate functionality and integration of the systems. This analysis should include task sequences and task assignment to ensure the operators are able to maintain the system at a level that: does not exceed manageable levels of operator workload; does not result in critical task shedding, and; does not result in critical task failure.

The Contractor shall prepare and submit a Workload Analysis Network Data in accordance with the CDRL.

2.8.1.3 Workspace Layout Analysis

The Contractor shall conduct a human-form mannequin analysis of the workspace layout to determine the compatibility with operator and maintainer characteristics, the task requirements, and the environment (including clothing and equipment).

2.8.1.4 Operator Machine Interface Design Process

The Contractor shall ensure that the design of all Operator Machine Interfaces (OMIs) are traceable to the control, display, and layout requirements identified in the task analysis for both operator and maintainer tasks.

The Contractor shall ensure that the design and layout of workstations, workspaces, and maintenance areas in the system are traceable to the control, display, and layout requirements identified in the task analyses.

The Contractor shall prepare a description of the design of each major defined system OMI, workstation and workspace in an associated Human Engineering Design Approach Document-Operator (HEDAD-O) from an operational perspective in accordance with the CDRL.

2.8.1.5 Maintainer Interface Design

The Contractor shall prepare and submit a description of the design of each major maintenance interface defined for the system in an associated Human Engineering Design Approach Document-Maintainer (HEDAD-M) document, in accordance with the CDRL.

2.9 Human Systems Integration User Evaluations

2.9.1 User Evaluations Process & Reporting

The Contractor shall plan and conduct all user-centered evaluations using the Technical Authority provided Subject Matter Experts (SMEs) from the user community.

The Contractor shall prepare and submit an overall Human Factors Engineering Simulation and Test Plan in accordance with the CDRL that demonstrates an iterative process beginning as early as possible using early desk-top concepts through to mock-ups through to prototypes, part-task devices and actual systems.

The Contractor shall prepare and submit a Human Factors Engineering Test Plan for each of the user evaluations of this SOW in accordance with the CDRL.

The Contractor shall prepare and submit a Human Factors Engineering Test Report for each user evaluation of this SOW in accordance with the CDRL.

The Contractor shall ensure that the user evaluations include an evaluation of the full range of related critical tasks, as defined in the critical task analysis, within the context of the missions outlined in the HESAR.

The Contractor shall include the HSI evaluation criteria from the user evaluations of concepts, prototypes and mock-ups in any final acceptance tests.

2.9.1.1 Workspace Configuration User Evaluations

The Contractor shall conduct operator/maintainer workspace configuration evaluations to assess the gross physical aspects of the system interior with respect to safety, and task performance, according to a HFE Test Plan that addresses the following design factors:

- Critical task MOEs/MOPs;
- Compatibility with user characteristics included in the TAD (including anthropometric accommodation, reach distances, lines of sight, and compatibility with clothing and life support equipment);

- Internal and external vision requirements as defined by the task analysis;
- Communication requirements, as derived from the task analysis;
- Hazard identification and evaluation;
- Training requirement identification and evaluation; and
- Operator and maintainer task flow requirements.

2.9.1.2 Operator Machine Interface (OMI) User Evaluations

The Contractor shall conduct OMI user evaluations to assess the operator machine interface aspects of the system with respect to safety and task performance, according to a HFE Test Plan, that addresses the following design factors:

- Critical task MOEs/MOPs;
- Control and display requirements, for normal and degraded modes, as derived from the task analysis;
- Screen design and layout logic as defined by the task analysis;
- Display resolution, refresh rate, and data update rates;
- Display visibility in all anticipated operational lighting conditions;
- Usability;
- Workload and situational awareness;
- Operator and maintainer task flow requirements;
- Communications requirements; and
- Training requirement identification and evaluation.

2.9.1.3 Maintenance Tasks User Evaluations

The Contractor shall conduct a series of maintenance task performance user evaluations, according to a HFE Test Plan, that addresses the following design criteria:

- Critical task MOEs/MOPs;
- Control and display requirements as derived from the task analysis;
- Human computer interface design, if applicable;
- Layout logic, as defined by the task analysis;
- Usability;
- Maintainer task flow requirements;
- Maintainer physical workload;
- Compatibility with maintenance staff characteristics as defined in the TAD (including anthropometric accommodation, reach distances, vision, lines of sight, and compatibility with clothing and equipment);
- Communication requirements;
- Hazard identification and evaluation; and
- Training requirements identification and evaluation.

2.10 System Safety Work Tasks

2.10.1 Preliminary Hazard List (PHL)

The Contractor shall identify the preliminary list of hazards that may require special safety design emphasis or identify the preliminary list of hazardous areas where in-depth analyses are required.

The Contractor shall prepare and submit a PHL in accordance with the CDRL.

2.10.2 Preliminary Hazard Analysis (PHA)

The Contractor shall conduct a PHA to identify safety-critical areas, provide an initial assessment of hazards, and identify requisite hazard controls and follow-on actions.

The Contractor shall prepare and submit a PHA in accordance with the CDRL.

2.10.3 Hazard Tracking

The Contractor shall perform hazard tracking commencing when hazards are identified and continuing for the duration of the Contract.

2.10.4 Functional Hazard Assessment

The Contractor shall conduct a Functional Hazard Assessment (FHA) consisting of a systematic and comprehensive examination of system functions to identify and classify failure conditions of system functions according to their severity.

The Contractor shall prepare and submit an FHA in accordance with the CDRL.

2.10.5 Preliminary System Safety Assessment

The Contractor shall conduct a Preliminary System Safety Assessment (PSSA) in order to complete the failure conditions list, defined by the FHA, and the safety requirements associated with these failure conditions.

The Contractor shall prepare and submit a PSSA in accordance with the CDRL.

2.10.6 System Safety Assessment

The Contractor shall conduct a System Safety Assessment (SSA) consisting of a systematic and comprehensive evaluation of the implemented system to ensure that qualitative and quantitative safety requirements, as defined in the FHA and PSSA, are met.

The Contractor shall prepare and submit an SSA in accordance with the CDRL.

2.10.7 Common Cause Analysis (CCA)

The Contractor shall conduct a CCA, as an inherent element of the FHA, PSSA, and SSA, to establish and validate physical and functional separation and isolation requirements between subsystems and verify that the safety requirements have been met.

2.10.8 System Safety Case

The System Safety Case provides a reasoned argument, supported by identified evidence that confirms the system as safe and fit for purpose. The System Safety Case shall contain reports of all System Safety assessments and analyses, conducted throughout the SSP.

The Contractor shall accumulate System Safety evidence, produced by the SSP, which demonstrates that all safety requirements, both contractual and derived, including qualitative and quantitative targets, have been achieved.

The Contractor shall prepare and submit a System Safety Case in accordance with the CDRL.

2.11 Health Hazard Assessment Work Tasks

The Contractor shall carry out an assessment to identify and evaluate health hazards, evaluate proposed hazardous materials, and propose measures to eliminate or control these hazards.

The Contractor shall prepare and submit a Health Hazard Assessment (HHA) in accordance with the CDRL.

The Contractor shall carry out an analysis of the hazards that can be caused by operating and support personnel and, conversely, the hazards to which operating and support personnel can be exposed.

The Contractor shall prepare and submit an Operating and Support Hazard Analysis (O&SHA) in accordance with the CDRL. Information available through the completion of the HESAR and associated task analysis should be used to support this analysis.

2.12 Training

The Contractor shall prepare and submit a Training Plan (TP) that will detail the Contractor's approach to the conduct of timely and effective training for operators and maintainers of the system in accordance with the CDRL.

The Contractor shall provide Initial Cadre Training (ICT) to all personnel required to operate or maintain the system prior to final acceptance system by the Department of National Defence (DND) personnel.

The ICT training program shall be consistent with the Canadian Forces Individual Training and Education System (CFITES) principles and processes described in the following documents:

- A-P9-000-001/PT-000, Introduction/Description;
- A-P9-000-002/PT-000, Needs Assessment;
- A-P9-050-000/PT-003, Analysis of Instructional Requirements;
- A-P9-050-000/PT-004, Design of Instructional Programs;
- A-P9-050-000/PT-005, Development of Instructional Programs;
- A-P9-050-000/PT-006, Conduct of Instructional Programs; and
- A-P9-050-000/PT-007, Evaluation of Learners.

The Contractor shall re-use existing training materials as the basis for the development of the system training.

The scope of the Contractor's ICT Program for the system shall include:

- Management of training;
- Analysis of the training requirement;
- Design of the training program;
- Development of training materials; and,
- Delivery of training to all DND personnel.

The Contractor shall identify all operator and maintenance tasks for each system and sub-system and assign these tasks to one or more of the system personnel identified by DND, thereby creating a task list for each position. This information should be available through the completion of the HESAR and associated task analysis.

The Contractor shall conduct a Knowledge, Skills and Ability requirements analysis for all the task lists. This information should be available through the completion of the HESAR and associated task analysis.

For each task list, the Contractor shall create:

- Performance Objective (PO) scalars;
- POs based on the PO scalars, task data and technical publications; and
- A copy of each technical publication cited in any PO condition or standard.

For each PO, the Contractor shall create and submit a Performance Check Guide (PCG) and include a list of its rating criteria.

For each PO, the Contractor shall determine the skills and knowledge that require training for each position that will operate or maintain the system in order to generate the following:

- Enabling Objective (EO) scalars;
- EOs; and
- EO teaching points, including any references to the technical publications.

For each EO, the Contractor shall create an "Enabling Check" and include a list of its rating criteria.

2.13 Personnel Impact Assessment

The contractor shall conduct a Personnel Impact Assessment to include input from HSI domains to document any potential affects of the system on the planned operational and maintenance personnel in terms of recruiting, selection, training, career path and retention.

The Contractor shall prepare and submit a Personnel Impact Assessment Report (PIAR) in accordance with the CDRL.

Human Systems Integration Data Item Descriptions

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Systems Integration (HSI) Program Plan	HSI-000

DESCRIPTION

The HSI Program Plan describes the integration of human factors engineering, system safety, health hazard assessment, manpower, personnel, and training in the acquisition or management of a materiel system. The plan also describes activities to be performed in conjunction with System Engineering to provide timely input to influence the system design and identifies how and where the sub-domains of HSI will be applied, and where analysis, tools, and techniques will be shared across the domains.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering (HFE) Program Plan
DID HSI-SAF-000: System Safety Program Plan

PREPARATION INSTRUCTIONS

1 Format: The Human Systems Integration Program Plan shall be prepared in Contractor's format.

2 Content: The Human Systems Integration Program Plan shall contain, but not be limited to, the following:

a. **Overview of HSI:** This section shall provide an outline of HSI, including the sub-domains, and the rationale for the HSI program.

b. **Organisation:** This section shall identify and describe:

   i. The organizational structure of the personnel responsible for each of the sub-domains of HSI;

   ii. The individual designated as the HSI manager who is responsible for coordination of activities across the HSI domains (this individual must have direct access to project management at the systems engineering manager level or higher); and

   iii. The links between HSI personnel and the contractor's organization.

   The total description of the organization shall include the:

   i. Number of proposed personnel;

   ii. Position titles;

   iii. Position qualifications;

   iv. Position responsibilities;

   v. HSI capability in subcontractor organizations; and

vi. Role of any specialist HSI subcontractors within the team.

c. **Organisational Maturity:** This section shall summarize the contractor's overall program for HSI and demonstrate a Level 3 capability maturity level based on the levels in Table 1 of this DID;

d. **Integration of HSI Domains:** This section shall summarize at a high level the analysis processes to be used in each sub-domain, including human factors, system safety, health hazard, assessment, manpower, personnel, and training. The areas where these domains will be integrated through shared analysis, analysis re-use, or common tools and techniques shall also be identified. This integration shall include, as a minimum, the sharing of a common Target Audience Description (DID HSI-HFE-005), common mission/function/task analysis, integrated risks and requirements, common use of workspace or system designs/mockups/simulations, and shared user evaluations;

e. **Communication:** This section shall detail a communication strategy that demonstrates how communication within and across the HSI domains will be managed. It should clearly define the communication links between the HSI community and other technical groups and disciplines in the contractor's project team. The communication strategy shall illustrate the major inputs to each of the HSI domains and the major outputs from the HSI domains to other organizations.

Table 1

Level 1: Initial **General** - Incomplete formal procedures, cost estimates, project plans. - Incomplete management mechanism to ensure procedures are followed. - Tools not well integrated; change control is lax. - Senior management does not understand key issues. **Processes/Management** -No formal processes or management structure established
Level 2: Repeatable **General** - Process dependent on individuals. - Basic project controls established. - Strength in doing similar work, but new challenges present major risk. - Orderly framework for improvement lacking. **Planning** - Ensure HSI planning is included in project documents. - HSI activities and commitments are planned and documented. - Affected groups and individuals understand and agree to their HSI roles and commitments. **Processes** - An established framework is in place to identify and understand HSI requirements. - The Organization has a process to identify and understand HSI requirements. - HSI requirements and constraints are clearly identified in project documents. - HSI plans, products, and activities are kept consistent with identified HSI

requirements.

Management
- Management has adequate visibility into actual progress in order to be able to take effective actions when HSI performance deviates significantly from HSI plans.
- Actual results and performances are tracked against HSI plans.
- Corrective actions for deviations from planned HSI activities are assigned, managed and tracked.
- Changes to HSI commitments are agreed to by the affected groups and individuals.

Level 3: Defined

General
- Process defined and demonstrated.

Planning
- All HSI activities, roles, responsibilities, issues, and concerns are incorporated into a coordinated and comprehensive plan.
- Integrated HSI planning is accomplished in the Organization for each Program.
- HSI planning is coordinated across the entire Program.

Processes

(a) The organization has and maintains a usable set of HSI processes and assets for a specific project.
- The Organization has HSI direction and guidance on standard HSI processes.
- The Organization tailors the HSI process to specific Program requirements.

(b) The organization has established "working" mechanisms to accomplish HSI activities.
- HSI functional Elements are empowered to resolve technical issues.
- The Organization has a standard process to resolve issues and elevate issues that cannot be resolved.
- The Organization has a process to incorporate HSI work products with other Program elements.
- The Organization has a process to manage contracted HSI activities.

Management
- Management and technical personnel together manage and track HSI activities, issues and concerns.
- HSI technical and management activities are planned, managed, and tracked by a defined process.
- Tracking, co-ordination, and integration of HSI element activities are centrally managed.

Training
- The Organization has a HSI Education and Training Program. The Program Manager and Lead Engineer have an understanding of HSI principles.
- HSI training requirements are defined.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Factors Engineering (HFE) Program Plan	HSI-HFE-000

DESCRIPTION

The HFE Program Plan describes the Contractor's entire human factors engineering program, identifies its elements, and explains how the elements will be managed to provide timely input to influence the system design.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)
DID HSI-HFE-000: Human Engineering System Analysis Report (HESAR)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)
DID HSI-HFE-000: Human Engineering Design Analysis Document-Operator (HEDAD-O)
DID HSI-HFE-000: Human Engineering Design Analysis Document-Maintainer (HEDAD-M)
DID HSI-HFE-000: Workload Analysis Report
DID HSI-HFE-000: Human Engineering Simulation and Test Plan
DID HSI-HFE-000: Human Engineering Test Plan
DID HSI-HFE-000: Human Engineering Test Report

PREPARATION INSTRUCTIONS

1 Format: The Human Factors Engineering Program Plan shall be prepared in Contractor format.

2 Content: The Human Factors Engineering Program Plan shall contain, but not be limited to, the following:

a. **Existing Analysis:** Where the Contractor has previously conducted, or has access to, analyses within this program that meets the Contract requirements, these analyses shall be described in the appropriate sections;

b. **Organization:** This section shall identify and describe the organizational structure of the HFE personnel working on this project. The functions and structure of all personnel shall be identified, as well as a description of the numbers, types, and qualifications of all personnel. Senior human factors personnel listed in the organization shall be described in terms of the necessary experience and education to render them eligible for certification as human factors professionals with the Canadian College for the Certification of Professional Ergonomists or the Board of Certification in Professional Ergonomics (USA) or demonstrated equivalent. Junior human factors personnel listed in the organization shall be described in terms of the necessary experience and education to render them eligible to be members of a human factors and/or ergonomics professional association;

c. **Human Engineering in Systems Analysis:** This section shall identify those efforts in systems analysis as described in MIL-HDBK-46855, which will be conducted and the organizational elements responsible for their completion. Human engineering participation in system analysis, determination of system functional requirements, allocation of system functional requirements to human/hardware/software, development of system functional flows, and performance of systems effectiveness studies shall be fully described. Data Items (DI) generated from this process shall be identified and described;

d. **Human Engineering in Detailed Equipment Detailed Design:** This section shall describe the human engineering effort in equipment detailed design to ensure compliance with the applicable human engineering design standard(s). Human engineering participation in studies, tests, mock-up evaluations, dynamic simulation, detailed drawing reviews, systems design reviews and system/equipment/component design and performance specification preparation and reviews shall be fully described;

e. **Human Engineering in Equipment Procedure Development:** This section shall describe the human engineering effort in equipment procedure development to ensure compliance with MIL-HDBK-46855. The methods shall be stated to ensure that:

   i. Operator and maintainer functions and tasks are allocated, organized, and sequenced for efficiency, safety, and reliability; and

   ii. The results of this effort are reflected in operational, technical and training publications, and in training system design. This section shall provide evidence that human engineering analyses are linked with training requirements analyses;

f. **Derivation of Personnel and Training Requirements:** This section shall describe the methods by which the Contractor shall ensure that operator and maintainer personnel and training requirements are based upon human performance requirements generated from the HFE program. This section shall provide evidence that human engineering analyses are linked with personnel and training analyses;

g. **Workload Management:** This section shall describe human engineering methods to be used to predict, measure, and monitor the level of personnel workload resulting from the system;

h. **Human Engineering in Test and Evaluation:** This section shall provide a high level description with links to relevant DIDs, and human engineering test and evaluation activities as an integrated effort within the Contractor's overall test and evaluation program, and shall indicate how and when the Contractor will follow human engineering test and evaluation guidance of MIL-HDBK-46855. This section shall identify any facilities that will be used to conduct human engineering test and evaluations;

i. **Human Engineering Deliverable Data Products:** This section shall identify and briefly describe each human engineering deliverable proposed in the plan, and include each full DID for these documents in an Annex; and

j. **Schedule:** This section shall include schedule information covering the Work described in this plan by identifying the relevant milestones, activities and logic.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Factors Engineering (HFE) Simulation and Test Plan	HSI-HFE-000

DESCRIPTION

The HFE Simulation and Test Plan outlines the overall sequence of HFE evaluations throughout the project. This plan should detail how various test equipment including prototypes, mockups, simulations, and live system testing will be used through the HFE evaluation process.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Workload Analysis Report
DID HSI-HFE-000: Human Factors Engineering Test Plan

PREPARATION INSTRUCTIONS

1 Format: The HFE Simulation and Test Plan shall be prepared in Contractor format.

2 Content: The HFE Simulation and Test Plan shall outline the overall sequence of HFE evaluations that will be conducted throughout the project. The plan should detail how various test equipment including prototypes, mockups, simulations, and live system testing will be used through the HFE evaluation process. This plan shall include, but not be limited to:

a. **Test Sequence:** An overview of the overall sequence of evaluations related to human factors, workload, and human performance criteria;

b. **Test Equipment:** A brief overview of each HFE evaluation, and the primary equipment that will be used to support each evaluation, such as concept drawings, prototypes, mockups, simulations, and final systems or others as applicable; and

c. **Measurement:** In cases where data collection will be repeated across a number of test equipment levels (e.g. prototype, simulation, final system) a description shall be provided indicating the efforts required to ensure that the comparison of the collected data will be scientifically valid.

DATA ITEM DESCRIPTION

TITLE Target Audience Description (TAD)	IDENTIFICATION NUMBER HSI-HFE-000

DESCRIPTION

The TAD describes the characteristics, capabilities, and limitations of the operational and maintenance personnel of a system. The information is necessary input into Human Systems Integration analysis in order to ensure that the system is designed to accommodate the characteristics of the defined population.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan

PREPARATION INSTRUCTIONS

1 Format: The TAD shall be prepared in Contractor format.

2 Content: The TAD shall contain characteristics of the system's operational and maintenance personnel including, but not limited to, the following:

a. Physical Characteristics including gender, age range, body size;

b. Sensory Characteristics including visual acuity, colour perception, hearing capability;

c. Psychological Characteristics including reasoning, decision making;

d. Skills and qualifications;

e. Training and experience;

f. Tasks and responsibilities; and

g. Operational environment considerations.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Engineering System Analysis Report (HESAR)	HSI-HFE-000

DESCRIPTION

The HESAR describes the human engineering efforts conducted as part of system analysis and presents the results. The data are used to evaluate the appropriateness and feasibility of system functions and roles allocated to operators and maintainers.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Critical Task Analysis Report (CTAR)

PREPARATION INSTRUCTIONS

1 Format: The HESAR shall be prepared in Contractor format.

2 Content: The HESAR shall contain, but not be limited to, the following:

a. **System Objectives:** Description of the system objectives. Where objective(s) are to be met by the system operating in conjunction with other systems, the following shall also be described:
   - i. The overall (or higher level) objective(s) to be met through combined operation of systems;
   - ii. The sub-objective(s) to be met by the system being developed; and
   - iii. Interactions required between systems to meet the objective(s).

b. **System Operational Modes:** The systems operational modes shall be described if applicable. The descriptions shall describe the context(s) within which the system will meet its objective(s).

c. **System Functions:** Description of the systems functions (which must be performed to meet the system objective(s) within a specific context).

d. **Allocation of System Functions:** Operator allocation of system functions shall be described. The following analyses and the results of these analyses shall be presented:
   - i. Information flow and processing;
   - ii. Estimates of potential operator/maintainer processing capabilities; and
   - iii. Allocation of functions.

e. **Equipment Identification:** Description of the selected equipment and design configuration.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Critical Task Analysis Report (CTAR)	HSI-HFE-000

DESCRIPTION

The CTAR describes the results of critical task(s) analyses performed by the Contractor to provide a basis for evaluating the design of the system, equipment, or facility. The evaluation will verify that human engineering technical risks have been minimized and solutions have been proposed.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Engineering Systems Analysis Report (HESAR)
DID HSI-HH-000: Operating and Support Hazard Analysis

PREPARATION INSTRUCTIONS

1 Format: The Critical Task Analysis Report shall be prepared in Contractor format.

2 Content: The Critical Task Analysis Report shall contain, but is not limited to, the following information:

a. **General:** The CTAR shall describe and analyze each critical task according to the following information:

i. Information required by and available to personnel which is relevant to the critical task assigned to them;

ii. Actions which each performer shall complete to accomplish the critical task, including responses to specific information, responses to combinations of information, and self-initiated responses;

iii. The functional consequences of each operator or maintainer critical task with respect to the effects upon both the immediate subsystem functions and the overall system mission; and

iv. All affected missions and phases including degraded modes of operation. Information on each critical task shall be provided to a level sufficient to identify operator and maintainer problem areas (i.e. potential error sources and consequences) that can adversely affect mission accomplishment and to evaluate proposed corrective action.

b. List: For each critical task analyzed, the following shall be listed:

i. Information required by operator/maintainer, including cues for task initiation;

ii. Information available to operator/maintainer;

iii. Evaluation process;

iv. Decision reached after evaluation;

v. Action taken, including: body movements required by the action taken, and workspace envelope required by the action taken;

vi. Frequency and tolerances of action;

vii. Accuracy of action required;

viii. Feedback informing operator/maintainer of the adequacy of actions taken;

ix. Time base required;

x. Workspace available;

xi. Location and condition of the work environment;

xii. Error sources and consequences;

xiii. Tools and equipment required;

xiv. Number of personnel required, their specialties, and experience;

xv. Job aids, training, or references required;

xvi. Communications required, including type of communication;

xvii. Hazards involved, including personnel exposure to hazards or hazards caused by personnel;

xviii. Operator interaction where more than one individual is involved;

xix. Performance limits of personnel; and

xx. Operational limits of machine and software.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Engineering Design Approach Document – Operator (HEDAD-O)	HSI-HFE-000

DESCRIPTION

The HEDAD-O describes the equipment that interfaces with operators. This document structure will be applied to all human machine interfaces. Each variant of the HEDAD-O is a source of data to evaluate the extent to which equipment having an interface with operators meets human performance requirements and human engineering criteria.

The HEDAD-O describes the layout, detail design, and arrangement of equipment having an operator interface. It also describes operator tasks associated with equipment. The HEDAD-O describes the extent to which human performance requirements and relevant human engineering design criteria have been incorporated into the layout, design, and arrangement of equipment having an operator interface. Findings from analysis of operator tasks are presented as part of the rationale supporting the layout, design, and integration of equipment.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Human Engineering System Analysis Report (HESAR)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)

PREPARATION INSTRUCTIONS

1 Format: The HEDAD-O shall be prepared in Contractor format.

2 Content: The HEDAD-O shall include if applicable:

a. **Equipment List:** List of each piece of equipment that has an operator interface, including a brief statement outlining the purpose of each piece of equipment.

b. **Specification and Drawing List:** For each piece of equipment, a list of approved specifications and drawings, or specifications and drawings planned for approval.

c. **Description:** Description(s) of the system's equipment emphasizing human engineering design features including, if applicable:

i. Layout and Arrangement: A drawing or photograph depicting the piece of equipment, containing an operator and equipment related reference point (i.e. operator eye position for a crew station), and scale.

ii. Controls and Displays: The layout and detail design of each control/display panel (or controls/display areas independent of panels) shall be described (e.g. colour coding, resolution, range characteristics, contrast). Display symbology, display formats, and control/display operation logic shall be described with regard to the intended us of the equipment by the operator(s).

iii. Operator Vision: Operator vision to the equipment shall be described and represented visually using a realistic and representative range of operator's eye position(s) relative to the design eye line.

iv. Environmental Factors: Operator life support systems, protective clothing and equipment, noise, vibration, radiation, temperature, ambient illumination, climatic effects, and other relevant environmental parameters.

v. Lighting: Lighting characteristics shall be described.

vi. Signals: Signals inherent in the equipment, such as warning, caution, advisory signals, shall be described with regard to signal characteristics, signal meaning, signal consequences, operator procedures, cause of signal activation, and control over signal characteristics.

vii. Operator Posture Control: Operator posture control including seating, restraint systems, and other postural control techniques.

viii. Communication Systems: Communication systems and communication systems control shall be described.

ix. Special Design: Special design, layout, or arrangement feature shall be described if required.

x. Multiple Operator Stations: Multiple operator station design shall be described to include rationale for: number of operators, arrangement of operators, and allocation of functions to the operators.

d. **Human Engineering Design Rationale:** Rationale for human engineering design, layout, and arrangement of each piece of equipment having an operator interface shall be described. The specific considerations are system function, equipment operation, operator selection, training, and skill requirements, operator task performance requirements, and limitations. The basis for reaching specific design, layout, and arrangement decisions shall be presented (e.g. human factors design standard criteria, human engineering requirements, system engineering analyses, systems analyses, human engineering studies, trade-off analyses, mock-up results, simulation results, and human engineering results).

e. **Analysis of Operator Tasks:** Results from analysis of operator tasks shall be presented as part of the rationale for equipment design, integration, and layout. The following shall also be described:

i. Methodology used to generate task analysis results (e.g. paper and pencil, computer-based simulation, dynamic simulation);

ii. System-mission(s), function(s), or other exogenous information used to "drive" the task analysis; human performance data (e.g. time and error) against which task analysis results are compared; and

iii. Operator assumptions (e.g. level of skill, training).

f. Alternative to Baseline Design: A drawing or photograph of each piece of equipment considered as alternatives or changes to the selected (baseline) equipment design.

g. Design Changes: Design, arrangement, or layout changes made since the last HEDAD-O preparation.

DATA ITEM DESCRIPTION

TITLE Human Engineering Design Approach Document – Maintainer (HEDAD-M)	IDENTIFICATION NUMBER HSI-HFE-000

DESCRIPTION

The HEDAD-M describes the system's equipment that interfaces with system's maintenance personnel. This document provides data that can be used to evaluate whether the equipment meets human performance requirements and human engineering criteria.

The HEDAD-M describes the characteristics, layout, and installation of all equipment having an interface with maintenance personnel, and identifies the extent to which the requirements and relevant human engineering design criteria have been incorporated into the design, layout, and installation of the equipment. The HEDAD-M also describes the maintenance personnel's tasks associated with the equipment.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Human Engineering System Analysis Report (HESAR)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)

PREPARATION INSTRUCTIONS

1 Format: The HEDAD-M shall be prepared in Contractor format.

2 Content: The HEDAD-M shall include, but is not limited to, the following:

a. **Equipment List:** List of each piece of equipment that has a maintainer interface. A brief statement should be included outlining the purpose of each piece of equipment, and the type of maintenance required on each piece of equipment (e.g. inspect, test, and repair).

b. **Specification and Drawing List:** For each piece of equipment, a list of approved specifications and drawings, or specifications and drawings planned for approval.

c. **System Equipment Description:** Description(s) of system equipment emphasizing human engineering design features including:

   i. Layout and Arrangement: Visual representation of the layout of all system equipment requiring maintenance with emphasis on human engineering features which facilitate maintenance.

   ii. Design of Equipment: The design of all system equipment with emphasis on human engineering features which facilitate maintenance, such as self test capability, labeling, handles.

   iii. Installation of Equipment: The installation of each item of equipment with emphasis on human engineering features which facilitate maintenance such as clearances, relationship between accessibility and failure rate.

d. Rationale: The consideration of equipment maintenance requirements (i.e. frequency, criticality, equipment failure rate), maintainer requirements (e.g. personnel selection, training, and skills), maintainer task requirements, environmental considerations, safety, and limitations. The basis for specific design, layout, and installation decisions should be provided (e.g. design criteria, guidelines, analyses).

e. Special Tools, Support Equipment, and Aids: List of special tools, support equipment, and job aids required for maintenance of each piece of equipment.

f. Analysis of Maintainer Tasks: Results from analysis of maintainer tasks shall be presented as part of the rationale supporting the layout, design, and installation of equipment. The analysis of the maintainer tasks shall include:

i. Task title and number if applicable;

ii. Task frequency for scheduled maintenance actions, or estimated task frequency for unscheduled maintenance actions (e.g. maintenance due to equipment failure);

iii. Data source used such as drawing number, hardware, actual production equipment;

iv. Support equipment required;

v. Tools required;

vi. Job aids required;

vii. Estimated task time;

viii. Estimated personnel requirements, such as number of personnel required, skills, and knowledge required;

ix. Human engineering considerations which reflect human engineering requirements incorporated into the design, such as maintainer fatigue, safety equipment, potential hazards, access problems; and

x. If applicable, the following maintainer tasks shall be addressed: troubleshooting, repair, adjustments, inspections, servicing and testing.

g. Maintainer Interface Depictions: A drawing or photograph of each piece of equipment having a maintainer interface. Each item shall be depicted:

i. By itself, from the top, front, and side; and

ii. As the maintainer would normally view it while performing maintenance tasks (equipment installed).

h. Alternative Installations or Layouts: A drawing or photograph of each piece of equipment being considered as an alternative to the selected, or baseline design. A drawing or photograph of suggested alternative equipment installations or layouts.

i. Design Changes: Design, installation, or layout changes, which have been made since the last HEDAD-M.

DATA ITEM DESECRIPTION

TITLE Workload Analysis Plan	**IDENTIFICATION NUMBER** HSI-HFE-000

DESCRIPTION

The Workload Analysis Plan describes the analysis that will be completed to predict and measure personnel workload. Workload analysis shall be performed across the range of system operational scenarios.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Target Audience Description (TAD)
DID HSI-HFE-000: Human Engineering Systems Analysis Report (HESAR)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)
DID HSI-HFE-000: Human Engineering Design Approach Document-Operator (HEDAD-O)
DID HSI-HFE-000: Human Engineering Simulation and Test Plan
DID HSI-HFE-000: Human Factors Engineering Test Plan

PREPARATION INSTRUCTIONS

1 Format: The Workload Analysis Plan shall be in Contractor Format.

2 Content: The Workload Analysis Plan shall contain, but is not limited to the following information:

a. **Introduction and Objectives:** Outline overall objectives of workload prediction and measurement, and user testing identifying any links to human factors engineering analyses including system safety analyses;

b. **Workload Measures:** Outline the workload methods, measures, and techniques, and associated workload evaluation criteria to be used throughout the project. Any differences in evaluation for the purpose of the safety analysis, or performance analysis, shall be clearly identified;

c. **Predictive Workload Analysis:** Describe the methods and results of the predictive workload analysis across the full range of operational scenarios if applicable. In the method section, include and describe the workload models, preferably in Integrated Performance Modelling Environment (IPME) format. In the results section, describe the results of the analysis and identify and include a detailed interpretation of any high workload areas;

d. **Workload Measurement:** Include the following information:

   i. Outline of methods and results of workload measurement during user evaluations with actual personnel;

   ii. Update this section each time a workload measurement has been completed, whether with simulators or during field evaluations of the final system; and

iii. Assessment of the ability of the defined personnel to maintain manageable levels of workload.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Workload Analysis Network Data	HSI-HFE-000

DESCRIPTION

The workload analysis network database is a computer database file that is used to store all task information required to perform a predictive workload analysis of a system. The database is required to support further analysis of system tasks as part of future system development.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Human Engineering Systems Analysis Report (HESAR)

PREPARATION INSTRUCTIONS

1 Format: There are two alternative forms of delivery of the workload analysis network data including:

a. The contractor shall submit an Integrated Performance Modelling Environment (latest version required);

b. The network database workload model of an alternative workload analysis tool shall be submitted with the workload analysis tool and associated workstation.

2 Content: The Workload Network Analysis Database shall contain:

a. **Model Description:** General description of the workload model including various operational scenarios of the system (if applicable), and linkages to critical tasks sequences identified in DID HSI-HFE-007, HESAR.

b. **Task Title:** Provide succinct titles which uniquely identify each task;

c. **Task Identifier:** Number that identifies each task uniquely;

d. **Task Description:** Provide a text description of the task;

e. **Operator Assignment:** Identify operator assignment of all tasks;

f. **Task Demands:** Include metrics that systematically define the mental and physical demands imposed on the operators when performing the task. The contractor may choose between a number of alternative qualified and generally accepted metrics (e.g. VACP, Windex, IP/PCT, POP etc) of task workload demands.

g. **Task Timing Information:** This shall include, but is not limited to:

i. Task duration;

ii. Task duration standard deviation.

h. **Task Interrelationship Information:** Provide information on the relative sequencing and relationships between tasks.

DATA ITEM DESECRIPTION

TITLE Workload Analysis Report	IDENTIFICATION NUMBER HSI-HFE-000

DESCRIPTION

The Workload Analysis Report describes the analysis that will be completed to predict and measure personnel workload. Workload analysis shall be performed across all the systems operational scenarios.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Target Audience Description (TAD)
DID HSI-HFE-000: Human Engineering Systems Analysis Report (HESAR)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)
DID HSI-HFE-000: Human Engineering Design Approach Document-Operator (HEDAD-O)
DID HSI-HFE-000: Human Engineering Simulation and Test Plan
DID HSI-HFE-000: Human Factors Engineering Test Plan

PREPARATION INSTRUCTIONS

1 Format: The Workload Analysis Report shall be in Contractor Format.

2 Content: The Workload Analysis Report shall contain, but is not limited to the following information:

a. **Introduction and Objectives:** Outline overall objectives of workload prediction and measurement, identifying any links to human factors engineering analyses including system safety analyses;

b. **Workload Measures:** Outline the workload methods, measures, and techniques, and associated workload evaluation criteria to be used throughout the project. Any differences in evaluation for the purpose of the safety analysis, or performance analysis shall be clearly identified;

c. **Predictive Workload Analysis:** Describe the methods and results of the predictive workload analysis across the full range of operational scenarios if applicable. In the method section, include and describe the workload models (preferably in IPME format). In the results section, describe the results of the analysis and identify and include a detailed interpretation of any high workload areas;

d. **Workload Measurement:** Include the following information:

   i. Outline of methods and results of workload measurement during user evaluations with actual personnel

   ii. Update this section each time a workload measurement has been completed, whether with simulators or during field evaluations of the final system; and

   iii. Assessment of the ability of the defined personnel to maintain manageable levels of workload.

DATA ITEM DESECRIPTION

TITLE Human Factors Engineering (HFE) Test Plan	IDENTIFICATION NUMBER HSI-HFE-000

DESCRIPTION

The HFE Test Plan details the proposed testing to demonstrate that the personnel-equipment/software combination can effectively accomplish the intended operation and maintenance functions in accordance with system specifications. This plan identifies the principal means of planning for validating human performance requirements, accuracy of personnel selection criteria, adequacy of training, and usability and acceptability of design of the personnel-equipment/software interface.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Target Audience Description (TAD)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)
DID HSI-HFE-000: Human Factors Engineering Simulation and Test Plan
DID HSI-HFE-000: Human Factors Engineering Test Report

PREPARATION INSTRUCTIONS

1 General

a. Purpose: The HFE Test Plan shall detail the Contractor's plan for gathering and analyzing data to show that the system, when fielded will satisfy four criteria:

i. All human performance requirements for operations and maintenance can be performed to an acceptable level or standard under conditions of expected use;
ii. The human performance requirements for operations and maintenance can be performed reliably by personnel reasonably representative of the military personnel who will ultimately perform them;
iii. An assessment of training impact based on the resources required for training users for the conduct of user evaluations, and some measure of prospective effectiveness of the proposed training program for operations and maintenance (based on human performance time and error data);
iv. The design of system Hardware and Software facilitates efficient, safe, useable and accurate human performance.

b. Format: The HFE Test Plan shall be in Contractor Format.

2 Content: The HFE Test plan shall contain, but is not limited to, the following:

a. Introductory Information: Introductory information shall include the following:

i. A descriptive title of each test to be conducted;
ii. Identification of equipment (or concept) being tested;
iii. Identification of the high-level operator and/or maintainer tasks being evaluated and general description of task assignment to personnel;
iv. Purpose of test(s); and
v. Objective of test(s) (if different from test purpose above).

b. Test Design: Test Design shall include the following:

i. Identification of test conditions;
ii. Outline of performance measures;
iii. List of the detailed operator and/or maintainer tasks being evaluated, and the relationship to DID HSI-HFE-006, Critical Tasks Analysis Report;
iv. Sample sizes; and
v. Sequence of test events.

c. Test Methods and Controls: Test Methods and Controls shall include a description of procedures to be followed in conducting each test. Also, an explanation of how environmental variables and other factors which could affect the performance measures will be controlled or described, including where relevant:

i. Noise;
ii. Illumination level;
iii. Shock and vibration;
iv. Air temperature and humidity;
v. Ventilation; and
vi. Exposure to toxic or hazardous substances.

d. Test Participants: Test Participants shall include a general description of the personnel population from which the test participants will be selected and their relationship to DID HSI-HFE-005, Target Audience Description. Identification and justification of numbers of test participants required and the selection criteria. Identification of methods by which data describing actual test participants will be gathered, including where relevant:

i. Age;
ii. Weight;
iii. Gender;
iv. Anthropometry;
v. Visual acuity;
vi. Hearing level;
vii. Existence of physical disabilities;
viii. Educational and work experience; and
ix. Prior experience relevant to performance tasks.

e. Training of Test Participants: Training of Test Participants shall outline:

i. Type and amount (in hours) of system-specific pre-test training planned for test participants; and
ii. Identification and outline of any end-of-training comprehension test administered to test participants prior to data collection.

f. Equipment Involved: Equipment involved shall outline:

i. Description of mock-up or equipment on which tests will be conducted including material to be used and type of fabrication, dimensions, and cross-referenced to drawings or sketches; and
ii. Identification of other, non-system equipment involved in tests, including all equipment to be worn, or carried or otherwise borne on the body of test participants such as weapons, communications equipment, headgear, life support equipment, and night vision equipment.

g. Data Collection: Data collection shall outline:

i. Identification and description of the instrumentation or other means which will be used to obtain raw data on each of the performance measures; and
ii. Identification of any forms that will be used for data recording. Description of frequency of distribution of forms. Description of the frequency and means by which data on environmental variables and other extraneous factors will be collected.

h. Data Reduction: Data reduction shall outline:

i. Description of techniques to be used for transformation and combination of raw data, statistical techniques to be employed and assumptions pertaining to the use of each (e.g. normally distributed), and confidence levels selected.

i. Data Analysis: Data Analysis shall explain how the data collected will be used in:

i. Human performance error analysis (e.g. calculating operator error rate for critical tasks);
ii. Identifying incompatibilities among human performance and equipment);
iii. System safety analysis;
iv. Logistics and maintainability assessment(s); and
v. Calculating system reliability, availability, and effectiveness.

j. Test Reporting: Test Reporting shall outline:

i. Identification of tests for which a “Human Engineering Test Report”, #, is planned and tentative date(s) for draft and final submission. Identification of tentative presentation date if applicable.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Human Engineering Progress Report	HSI-HFE-000

DESCRIPTION

The Human Engineering Progress Report describes the status of the contractor's human engineering program and reports progress, problems, and plans for each succeeding reporting period. These reports provide evidence that human engineering considerations are reflected in system design and development and indicate compliance with contractual requirements for human engineering.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HFE-000: Target Audience Description (TAD)
DID HSI-HFE-000: Critical Task Analysis Report (CTAR)
DID HSI-HFE-000: Human Factors Engineering Simulation and Test Plan
DID HSI-HFE-000: Human Factors Engineering Test Report

PREPARATION INSTRUCTIONS

1 General:

The Human Engineering Progress Report shall describe progress and activity in sufficient detail to demonstrate that human engineering considerations are reflected in systems analyses (or systems engineering analyses where required), system design and development, and system test and evaluation. Progress reports shall be concise and shall not unnecessarily repeat previously reported material. Changes may be indicated by reference to past reports rather than by duplication of an entire set of data, information, or plans. Where detailed data are furnished by other reporting media, they shall be referenced by, rather than included in the progress report; however, general summary information, reflecting results of efforts germane to reported progress shall be included.

2 Format: The Human Engineering Progress Report shall include the following sections:

a. **Work Accomplished this Reporting Period:** Indication of tasks that have begun, are completed, or are in progress. Indication of significant results of completed tasks, end item projects completed and available for review, and any unusual conclusions that may cause modification to future activities.
b. **Work Planned for Next Reporting Period:** Indication of tasks that shall be started, or completed, during the next reporting period.
c. **Problems:** Indication of specific problems that occurred during the reporting period or are anticipated to occur during the next reporting period. Indication of the effects of problems on other tasks, schedules, costs or program scope. Proposed solutions shall be presented.
d. **Actions Required of the Procuring Activity:** Identification of special considerations or problems requiring procuring activity assistance.
e. **Appendix:** Inclusion of reports, project notes, drawings, or other documentation required to ensure completeness of the progress report.

3 Content: The Human Engineering Progress Report shall contain the following:

i. Summary and current status of human engineering activity;

ii. Summary and status of significant human engineering design recommendations and action teams;

iii. Summary of human engineering participation in major technical/subsystem reviews, other design reviews, and program reviews;

iv. Summary results of human engineering analyses, studies, experiments, mock-up evaluations, simulation activities, tests, and demonstrations;

v. Results of projects which involved human engineering participation; and

vi. Other documentation reflecting changes to system design which affect human system interface.

DATA ITEM DESECRIPTION

TITLE System Safety Program Plan (SSPP)	**IDENTIFICATION NUMBER** HSI-SAF-000

DESCRIPTION

The SSPP describes in detail the tasks and activities of system safety management and system safety engineering required to identify, analyze, and mitigate hazards by reducing their associated risks to a level acceptable to the Technical Authority throughout the system life cycle. The approved SSPP provides a formal basis of understanding between the Contractor and the Technical Authority to ensure that adequate consideration is given to safety during all life cycle phases of the program and to establish a formal, disciplined program to achieve the system safety objectives.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan
DID HSI-HH-000: Preliminary Hazard List
DID HSI-HH-000: Preliminary Hazard Analysis
DID HSI-HH-000: Functional Hazard Analysis
DID HSI-SAF-000: Preliminary System Safety Assessment (PSSA)
DID HSI-HH-000: Operating & Support Hazard Analysis (O&SHA)
DID HSI-HH-000: Health Hazard Assessment
DID HSI-SAF-000: System Safety Case

PREPARATION INSTRUCTIONS

1 Format: The System Safety Program Plan shall be prepared in Contractor format.

2 General: The System Safety Program Plan shall:

a. Describe the scope of the overall program and the related System Safety Program (SSP);

b. Describe the tasks and activities of system safety management and engineering; and the interrelationship between system safety and other functional elements of the program;

c. List the Contractor and Technical Authority documents which will be applied either as directives or guidance in the conduct of the SSP; and

d. Account for all contractually required system safety requirements, tasks, and responsibilities on an item-by-item basis.

3 Content: The System Safety Program Plan shall include, but is not limited to, the following information:

System Safety Organization: The SSPP shall describe:

i. The system safety organization or function within the organization of the total program using charts to show the organizational and functional relationships, and lines of communication;

ii. The responsibility, authority, and accountability of system safety personnel, other Contractor organizational elements involved in the system safety effort, Subcontractors, and system safety groups. Identify the organizational unit responsible for executing each task. Identify the authority in regard to resolution of all identified hazards. Include the name, address, and telephone number of the System Safety Manager;

iii. The methods by which system safety personnel may raise issues of concern directly to the Contractor’s program manager or the program manager's supervisor;

iv. The staffing of the system safety organization for the duration of the contract and the qualifications and experience of assigned key personnel. Demonstrate that the System Safety Manager and subordinate system safety staff each have the requisite level of education and experience in the field of system safety to ensure the successful implementation of the system safety requirements identified in the SOW;

v. The procedures by which the Contractor will integrate and coordinate the system safety efforts including dissemination of the system safety requirements to action organizations and Subcontractors, coordination of Subcontractor's SSPs, integration of hazard analyses, program and design reviews, program status reporting, and system safety groups; and

vi. The process through which Contractor management decisions will be made to include notification of catastrophic and hazardous/severe major hazards, as defined in Annex A of this DID, corrective action taken, accidents/incidents or malfunctions, waivers to safety requirements, and program deviations.

SSP Milestones: The SSPP shall:

i. Identify safety milestones so that evaluations of the effectiveness of the system safety effort can be made at critical safety check points, such as Preliminary Design Reviews, Critical Design Reviews, etc.;

ii. Include schedule information, covering the Work described in the SSPP, by identifying the relevant milestones, activities, and logic via an extract from or reference to the Project Schedule; and

iii. Identify integrated system activities, including, but not limited to, design analyses, tests, and demonstrations, applicable to the SSP but specified in other engineering studies to preclude duplication.

System Safety Requirements: The SSPP shall:

i. Describe or reference the methods that will be used to identify and apply safety/hazard control requirements and criteria for design of equipment, software and facilities, and for procedures, for all phases of acquisition specified by the SOW;

ii. List the safety standards and system specifications, which are the sources of safety requirements with which the Contractor is required to comply and any others the Contractor intends to use. Include titles, dates, and, where applicable, paragraph numbers;

iii. Clearly state unacceptable system safety conditions including, but not limited to, single component failure, common mode failure, dormant failures, or design features which could cause an accident of catastrophic or hazardous/severe major severity as defined in Annex A of this DID;

iv. Clearly state acceptable system safety conditions including, but not limited to, system designs which positively prevent damage propagation from one component to another or prevent sufficient energy propagation to cause an accident; use of interlocks, redundancy, fail-safe design, fire suppression, and protective clothing;

v. State that, in addition to mitigating hazards, the severity of personnel injury or damage to equipment in the event of an accident is to be minimized;

vi. Describe the risk assessment procedures. Risk severity categories, risk probability classifications, risk indices, and acceptable levels of risk shall be in accordance with the definitions in Annex A of this DID. Define the method for the formal acceptance and documenting of residual risks and associated hazards; and

vii. Describe the management controls that shall be used to ensure compliance or justify waivers/deviations with general design and operation safety criteria, and the closed-loop procedures to ensure hazard resolution.

Software Safety Requirements: The SSPP shall describe:

i. The tasks and activities of software engineering required to identify, evaluate, and mitigate software hazards throughout the system life cycle;

ii. The process by which the system hazards are to be traced down to the software-hardware interface by the system hazard analyses thus identifying the software hazards; and

iii. How the identified software hazards will be translated into constraints on software behaviour, into software requirements, and into software levels.

Hazard Analyses: The SSPP shall describe:

i. The hazard analyses to be performed. This shall include Preliminary Hazard Analysis, Operating and Support Hazard Analysis, System and Subsystem Hazard Analyses;

ii. The analysis techniques (e.g. Fault Tree Analysis, failure mode, effects and criticality analysis) and formats that will be used in qualitative and quantitative analyses to identify hazards, their causes and effects, and recommended corrective actions;

iii. The depth within the system to which each analysis technique will be used including hazard identification associated with the system, subsystem, components, personnel, government furnished equipment, facilities, and their interrelationship in the logistic support, training, maintenance, transportability, and operational environments;

iv. The integration of Subcontractor hazard analyses and techniques with overall system hazard analyses; and

v. The technique for establishing a single closed-loop hazard tracking system.

System Safety Data: The SSPP shall describe:

i. Describe the approach for researching, disseminating, and analyzing pertinent historical hazard or accident/incident data;

ii. Identify deliverable data; and

iii. Identify safety-related non-deliverable data and describe the procedures for accessibility by the Technical Authority and retention of data of historical value.

Safety Verification: The SSPP shall describe:

i. The verification requirements for ensuring that safety is adequately demonstrated;

ii. Procedures for ensuring feedback of test information for review and analysis;

iii. The review procedures established by the Contractor's system safety organization to ensure safe conduct of all tests; and

iv. The procedures for ensuring that all identified hazards have been eliminated or controlled to an acceptable level of risk.

Training: The SSPP shall describe:

i. Techniques and procedures to be used by the Contractor to ensure that the objectives and requirements of the SSP are met in the safety training for engineers, technicians, operating and maintenance personnel.

Audit Program: The SSPP shall:

i. Describe the techniques and procedures to be employed by the Contractor to ensure that the objectives and requirements of the SSP are being accomplished at Contractor and Subcontractor levels; and

ii. Describe the method of documenting the results of these system safety audits and the frequency of these audits.

Accident/Incident Reporting and Investigation: The SSPP shall:

i. Describe the procedure for closed loop accident/incident reporting, collection, recording, analyzing (in order to determine cause), investigating, and timely corrective action; and

ii. Describe the procedure used to re-examine the system design or procedures, improve existing mitigations or introduce new mitigations, and update the hazard log based on accident/incident data, which has been logged.

System Safety Interfaces: The SSPP shall identify the interface between system safety and:

i Systems engineering, and all other support disciplines, such as maintainability, quality assurance, reliability, software development, human factors engineering, etc.

Annex A

Risk Assessment Matrix

	Risk Severity			
Risk Probability	Catastrophic (1)	Hazardous/ Severe-Major (2)	Major (3)	Minor (4)
Frequent (A)	1A	2A	3A	4A
Reasonably Probable (B)	1B	2B	3B	4B
Remote (C)	1C	2C	3C	4C
Extremely Remote (D)	1D	2D	3D	4D
Extremely Improbable (E)	1E	2E	3E	4E

Unacceptable	Acceptable

Risk Severities

Catastrophic – would result in:

- death or total loss of a bodily system, or
- system loss.

Hazardous/Severe-Major - would result in:

- major damage to a bodily system,
- severe occupational illness, or
- major system damage.

Major - would result in:

- minor damage to a bodily system,
- minor occupational illness, or
- minor system damage.

Minor - would result in:

- less than minor bodily system damage
- less than minor occupational illness, or
- less than minor system damage.

Risk Probabilities

Frequent - probability greater than 10^{-3}.

Reasonably Probable - probability of 10^{-3} or less, and greater than 10^{-5}.

Remote - probability of 10^{-5} or less, and greater than 10^{-7}.

Extremely Remote - probability of 10^{-7} or less, and greater than 10^{-9}.

Extremely Improbable - probability of 10^{-9} or less.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Preliminary Hazard List	HSI-HH-000

DESCRIPTION

The Preliminary Hazard List provides a list of hazards that may potentially require special safety design considerations, or provides a list of hazardous areas where in-depth hazard analyses are required. The PHL is compiled very early in the system acquisition life cycle to identify potentially hazardous areas that may require management emphasis.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan

PREPARATION INSTRUCTIONS

1 Format: The Preliminary Hazard List shall be prepared in Contractor format.

2 Content: The Preliminary Hazard List shall identify all potential hazards according to the following information:

- **a. System/Subsystem/Unit:** The particular part of the system that the hazard is inherent within;
- **b. System Event(s) Phase:** The configuration, or operational mode of the system, when the hazard will be encountered (e.g. during maintenance);
- **c. Hazard Description:** A description of the potential hazard (e.g. results from normal actions or equipment failure, results from hazardous materials);
- **d. Effect of Hazard**. The detrimental effects which could be inflicted on the subsystem, system, other equipment, facilities or personnel, resulting from the hazard. Possible upstream and downstream effects should also be described;
- **e. Risk Assessment**. A brief risk assessment for each potential hazard (classification of severity and probability of occurrence using the risk assessment matrix documented in the SSSP: DID HSI-SAF-001). This is the assessment of the risk prior to taking any action to eliminate or control the hazard;
- **f. Recommended Action**. The potential action(s) required to eliminate or control the hazard. Sufficient technical detail is required in order to permit the design engineers and the customer to adequately develop and assess design criteria;
- **g. Effect of Recommended Action**. The effect of the recommended action(s) on the assigned risk assessment. This is the risk assessment after taking action to eliminate or control each hazard; and
- **h. Remarks:** Any additional information relating to the hazard.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Preliminary Hazard Analysis (PHA)	HSI-HH-000

DESCRIPTION

The PHA identifies safety-critical areas, provides an initial assessment of hazards, and identifies requisite hazard controls and follow-on actions. The PHA is used to obtain an initial risk assessment of the system based on the best available data, including accident/incident data, from similar systems and other lessons learned. Hazards associated with the proposed design or function is evaluated for hazard severity, hazard probability, and operational constraints. Safety provisions and alternatives, required to eliminate hazards or to reduce their associated risk to a level acceptable to the Technical Authority are included in the PHA.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)

PREPARATION INSTRUCTIONS

1 Format: The Preliminary Hazard Analysis shall be prepared in Contractor format.

2 Content: The Preliminary Hazard Analysis shall document all hazards according to the following information:

a. **System/Subsystem/Unit:** The particular part of the system that the hazard is inherent within;

b. **System Event(s) Phase:** The configuration, or operational mode of the system, when the hazard is encountered (e.g. during maintenance);

c. **Hazard Description:** A description of the potential/actual hazard (e.g. results from normal actions or equipment failure);

d. **Hazard Identification/Indication**. A description of indications including all means of identifying the hazard to operational/maintenance personnel;

e. **Effect of Hazard**. The detrimental effects which could be inflicted on the subsystem, system, other equipment, facilities or personnel, resulting from the hazard. Possible upstream and downstream effects should also be described;

f. **Risk Assessment**. A risk assessment for each hazard (classification of severity and probability of occurrence using the risk assessment matrix documented in the DID HSI-SAF-001, System Safety Program Plan). This is the assessment of the risk prior to taking any action to eliminate or control the hazard;

g. **Recommended Action**. The recommended action(s) required to eliminate or control the hazard. Sufficient technical detail is required in order to permit the design engineers and the customer to adequately develop and assess design criteria resulting from the analysis. Include alternative designs and life cycle cost impact where appropriate;

h. **Effect of Recommended Action**. The effect of the recommended action(s) on the assigned risk assessment. This is the risk assessment after taking action to eliminate or control each hazard; and

i. Remarks. Any additional information relating to the hazard (e.g. applicable documents, previous failure data on similar systems, or administrative directions).

DATA ITEM DESCRIPTION

TITLE Functional Hazard Assessment (FHA)	IDENTIFICATION NUMBER HSI-HH-000

DESCRIPTION

A Functional Hazard Assessment is a systematic, comprehensive examination of functions to identify and classify failure conditions of those functions according to their severity. An FHA is performed at two levels: system-level and subsystem-level. The system-level FHA is a high-level, qualitative assessment of the basic functions of the system as defined at the beginning of system development. This FHA identifies and classifies the failure conditions associated with the system-level functions. The classification of these failure conditions establishes the safety requirements that the system must meet. The subsystem-level FHA is also a qualitative assessment, which is iterative in nature and becomes more defined and fixed as the system evolves. This FHA considers a failure or combination of system failures that affect a system's function. The output of the system-level and/or subsystem-level FHAs is the starting point for the generation and allocation of safety requirements.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)

PREPARATION INSTRUCTIONS

1 Format: The Functional Hazard Assessment shall be prepared in Contractor format.

2 Content: The Functional Hazard Assessment shall include, but is not limited to, the following:

a. Summary of objectives and conclusions of the FHA;

b. Description of the analytical approach used to create the FHA;

c. Description of the system's functional capabilities and various modes of operation if applicable. Sufficient detail regarding the functions and systems interfaces shall be provided. Descriptions of the interfaces shall include warnings and indications, controls, settings, and input/output signals;

d. Reference to relevant technical drawings and documents (e.g. functional block diagrams);

e. Analyses including, but not limited to:

   i. System-level FHA;

   ii. System Fault Tree Analysis (FTA);

   iii. Subsystem-level FHAs; and

   iv. Common Cause Analyses.

f. Indication and discussion of the most serious failure conditions and methods that may be utilized during the design phases to meet the safety requirements;

g. Provide the following information relative to each system-level function and combination of system-level functions;

    i. Identification of related failure conditions;

    ii. identification of the effects of the failure conditions;

    iii. Classification of each failure conditions based on the identified effects (using the risk severity categories defined in DID HSI-SAF-001, Systems Safety Program Plan);

    iv. Identification of the required system development assurance levels; and

    v. Statement outlining what was considered and what assumptions were made when evaluating each failure condition; and

h. The FHA shall consider the effect of:

    i. Multiple failures and undetected failures;

    ii. Anticipated personnel errors after the occurrence of a failure or failure condition; and

    iii. Corrective action required, and the capability of detecting faults.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Preliminary System Safety Assessment (PSSA)	HSI-SAF-000

DESCRIPTION

The PSSA assures that requirements identified in the Functional Hazard Assessment (FHA) are satisfied. The PSSA is used to complete the "Failure Conditions List" and the corresponding safety requirements. It is also used to demonstrate how the system will meet the qualitative (system development assurance levels; hardware design assurance levels, and software levels) and quantitative (safety-related reliability targets) safety requirements for the various hazards identified. It identifies and captures all derived system safety requirements. The PSSA process identifies protective strategies, taking into account fail-safe concepts and architectural attributes which may be needed to meet the safety objectives.

PSSA outputs are used as inputs to the System Safety Assessment (SSA) and other documents, including, but not limited to, system requirements, hardware requirements and software requirements.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)
DID HSI-HH-000: Functional Hazard Assessment (FHA)

PREPARATION INSTRUCTIONS

1 Format: The Preliminary System Safety Assessment shall be prepared in Contractor format.

2 Content: The Preliminary System Safety Assessment shall include, but is not limited to, the following:

a. Summary of objectives and conclusions of the PSSA;

b. Description of the analytical approach used to create the PSSA (e.g. reliability predictions including sources for component failure rates, Failure Mode and Effects Analyses (FMEAs), Fault Tree Analysis, Fault Analysis, Markov Analysis, Common Cause Analysis);

c. References to relevant technical drawings and documents (e.g. functional block diagrams, schematics). Identify the following if applicable:

   i. Modes of operation;

   ii. Indicators or warning devices;

   iii. Control settings;

   iv. How system interfaces with other systems;

v. Functional relationships between systems;

vi. Environmental limits (temperature, pressure, altitude); and

vii. Physical location of the system.

d. Succinct overview of the philosophy used to achieve safety requirements identified by the FHA. Discuss methods for achieving desired criticalities (e.g. dissimilarity, monitoring, cross talk, segregation, comparison, redundancy). Cover the precautions taken for common cause faults.

e. List failure conditions identifying for each item, the class of failure mode, safety objective, probability of occurrence, and requirement. For each failure condition, discuss anything novel or unusual in the approach of addressing that failure condition. As a result of the various analyses, discuss any operating limits and associated procedures.

f. Description of analyses including, but not limited to:

i. Fault Tree Analyses;

ii. FMEAs;

iii. Common Cause Analyses; and

iv. Safety maintenance tasks/intervals.

g. List of possible immediate and subsequent effects of incorrect action on the system.

DATA ITEM DESECRIPTION

TITLE	IDENTIFICATION NUMBER
Safety Compliance Assessment Report	HSI-SAF-000

DESCRIPTION

The Safety Compliance Assessment Report provides evidence that the system is safe for its intended operation. The report identifies that all safety requirements, both contractual and derived, and qualitative and quantitative have been achieved. The report provides design safety assurance and operational and maintenance safety assurance to the Technical Authority.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)
DID HSI-HH-000: Preliminary Hazard Analysis
DID HSI-HH-000: Operating and Support Hazard Analysis (O&SHA)
DID HSI-HH-000: Health Hazard Assessment (HHA)

PREPARATION INSTRUCTIONS

1 Format: The Safety Compliance Assessment Report shall be prepared in Contractor format.

2 Content: The Human Factors Engineering Test Report shall contain, but is not limited to, the following:

a. Technical description of the physical and functional elements of the system including interfaces;

b. Reference to all applicable safety assessments, including assessment summaries;

c. Reference to all non-deliverable safety assessments and analyses, including assessment summaries;

d. Evidence of compliance with all safety-related contractual requirements;

e. Evidence of compliance with all derived safety requirements including mitigations of system hazards and mitigations of failure conditions contributing to system hazards;

f. Identification of closure of all safety-related action items;

g. List of testing activities used to verify system integrity;

h. Summary of all system operating limitations; and

i. Identification of compliance with all safety regulations.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
System Safety Case	HSI-SAF-000

DESCRIPTION

The System Safety Case provides evidence that justifies that the system modifications are safe for the system's intended purpose. The System Safety Case demonstrates that overall safety requirements, both contractual and derived, including qualitative (system development assurance levels, item development assurance levels, hardware design assurance levels, and software levels) and quantitative (safety-related reliability) targets, have been achieved. It provides both design safety, health hazard, and operational and maintenance safety assurance to the Technical Authority.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)
DID HSI-HH-000: Preliminary Hazard Analysis (PHA)
DID HSI-HH-000: Operating and Support Hazard Analysis (O&SHA)
DID HSI-HH-000: Health Hazard Assessment

PREPARATION INSTRUCTIONS

1 Format: The System Safety Case shall be prepared in Contractor format.

2 Content: The System Safety Case shall provide, but is not limited to, the following information:

a. Technical description of the physical and functional elements of the system including interfaces;

b. Summary and reference to all applicable safety assessments and analyses conducted in accordance with DID HSI-SAF-001: System Safety Program Plan (SSPP);

c. Summary of all non-deliverable safety assessments and analyses;

d. Evidence of compliance with all safety-related contractual requirements;

e. Evidence of compliance with all derived safety requirements including mitigations of system hazards and mitigations of failure conditions contributing to system hazards;

f. Demonstration of closure of all safety-related action items;

g. List of all testing activities performed to verify system integrity;

h. Summary of all system operating limitations; and

i. List of all safety regulations complied with by the design.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Health Hazard Assessment	HSI-HH-000

DESCRIPTION

The Health Hazard Assessment is used to systematically identify and evaluate health hazards and to evaluate proposed hazardous materials. The HHA also proposes measures to eliminate or control the hazards identified through engineering design changes or protective measures to reduce the risk to a level acceptable to the Technical Authority.

The HHA evaluation determines the quantities of potentially hazardous materials or physical agents (e.g. noise, radiation, heat stress, cold stress) involved with the system, analyzes how these materials or physical agents are used in the system, estimates where and how personnel exposures may occur, and if possible identifies the degree or frequency of the exposure involved. Materials are evaluated if, because of their physical, chemical, or biological characteristics, quantity, or concentrations, they cause or contribute to adverse effects in organisms or off-spring, pose a substantial present or future danger to the environment, or result in damage to or loss of equipment or property during the system's life cycle.

APPLICATION/INTERRELATIONSHIP

DID HSI-SAF-000: System Safety Program Plan (SSPP)

DID HSI-HFE-000: Target Audience Description (TAD)

DID HSI-HFE-000: Human Engineering Systems Analysis Report (HESAR)

PREPARATION INSTRUCTIONS

1 Format: The Health Hazard Assessment shall be prepared in Contractor format.

2 General: The health hazards that should be considered include, but are not limited to, the following:

a. Chemical hazards (e.g. hazardous materials that are flammable, corrosive, toxic, carcinogens or suspected carcinogens, systemic poisons, asphyxiants, including oxygen deficiencies; respiratory irritants);

b. Physical hazards (e.g. acoustical energy such as steady-state noise, impulse noise and blast over-pressure, vibration, heat or cold stress, shock, trauma, ionizing and non-ionizing radiation); and

c. Biological hazards (e.g. pathogenic micro-organisms).

<u>3 Content:</u> The Health Hazard Assessment shall contain, but is not limited to, the following information:

a. Summary: Include a summary of the significant heath hazard issues that are identified in Section C, and the primary recommendations outlined from Section E.

b. Background: Includes, but is not limited to, the following:

i. Description of the system and its intended operation including pertinent components or subsystems which contribute most to a health hazard;

ii. Identification of the intended operational and support personnel, and protective clothing and equipment; and

iii. Summary of prior evaluations or assessments performed on system prototypes or developmental models.

c. Health Hazard Issue Identification: Description of each potential or actual health hazard issue of concern for each subsystem or component. Sufficient details should be provided to define the specific problem, issues involved, and reasoning behind the analyses. For each potential issue, or any proposed alternatives, the following should be outlined:

i. Material Identification: Include material identity, common or trade name, chemical name, Chemical Abstract Service (CAS) number, National Stock Code for Manufacturers (NSCM), or Local Stock Number (LSN), physical form (solid, liquid, gas), NATO Stock Number (NSN), and manufacturers and suppliers;

ii. Material Use and Quantity: Include component name, description, and code, and/or operational details for the material. Total system and program life-cycle quantities to be used. For mixtures of materials, concentrations of each ingredient is required;

iii. Hazard Identification: Identify the detrimental effects of the material on the system, personnel, environment, or facilities; and

iv. Toxicity Assessment: Describe the expected frequency, duration, and amount of exposure. Include the reference documentation and methods used to determine potency/toxicity assessment factors and calculations.

d. Health Hazard Assessment: The assessment involves, but is not limited to, the following:

i. An analysis of data, observations, findings, reports, and other sources of information against health standards and criteria;

ii. A risk assessment for each hazard (classification of severity and probability of occurrence using the risk assessment matrix documented in System Safety Program Plan DID HSI-SAF-001);

iii. Discussion of uncertainties in data or calculations, or missing information;

iv. Identification of when hazards may be expected, such as under normal or unusual operating or maintenance conditions.

e. Recommendations: Description of the recommended actions that should be taken to eliminate, reduce or control each actual or potential health hazard described. Include the effect that each action may have on the risk of the health hazard(s), such as hazard severity and probability.

f. References: List of source materials used in preparing the assessment, such as government and contractor reports, standards, criteria, technical manual, and specifications.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Operating and Support Hazard Analysis (O&SHA)	HSI-HH-000

DESCRIPTION

The Operating and Support Hazard Analysis is used to document, analyze, and mitigate the hazards that can be caused by operating and support personnel or, conversely, the hazards to which operating and support personnel can be exposed. The human is to be considered as an element of the total system, receiving both inputs and initiating outputs during the conduct of this analysis, thus creating an effective link between Human Factors Engineering (HFE) analyses and system safety. This hazard analysis typically requires the following elements to be available:

a. engineering descriptions of the proposed system, support equipment and facilities;
b. draft procedures and preliminary operating manuals;
c. various hazard analysis reports;
d. related requirements, constraint requirements, and personnel capabilities;
e. HFE data and reports; and
f. lessons learned, including a history of accidents caused by human error.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan. (HFEPP)

DID HSI-SAF-000: System Safety Program Plan (SSPP)

DID HSI HFE-000: Human Engineering Systems Analysis Report (HESAR)

PREPARATION INSTRUCTIONS

1 Format: The Operating and Support Hazard Analysis shall be prepared in Contractor Format.

2 Content: The Operating and Support Hazard Analysis shall identify hazards and include, but not be limited to, the following information:

a. System/Subsystem/Unit: Outline the part of the system with which the analysis is concerned;

b. Task Description: Decompose each job into tasks (versus individual steps) and provide a description. The tasks shall include, but not be limited to, those identified in the DID HSI-HFE-007: HESAR;

c. Hazard Description: Describe the potential/actual hazard;

d. Effect of Hazard: Describe the detrimental effects which could be inflicted on the system, subsystem, other equipment, facilities or personnel, resulting from the hazard. Possible upstream and downstream effects shall also be described;

e. Risk Assessment: Perform a risk assessment for each hazard (classification of severity and probability of occurrence using the risk assessment matrix documented in DID HSI-SAF-001, System Safety Program Plan). This is the assessment of the risk prior to taking any action to eliminate or control the hazard;

f. Mitigation: The mitigation(s) required to eliminate or control the hazard (e.g. a complete list of warnings, cautions, and procedures required in operating and maintenance manuals and for training courses);

g. Effect of Mitigation: The effect of the mitigation(s) on the assigned risk assessment. This is the risk assessment after taking action to eliminate or control each hazard;

h. Remarks: Identify any information relating to the hazard not covered in other blocks;

i. Mitigation Verification: Reference the drawing(s), specification(s), procedure(s), test result(s), etc. that support closure of the hazard (i.e. demonstrate the effectiveness of the mitigation[s]); and

j. Status: Describe the status of actions to implement and verify the hazard mitigation. The status shall indicate "open" or "closed". Additional status indications may be useful in order for both Contractor and Technical Authority to track progression towards hazard closure and identify impediments to closure.

DATA ITEM DESCRIPTION

TITLE	IDENTIFICATION NUMBER
Personnel Impact Assessment Report	HSI-HH-000

DESCRIPTION

The Personnel Impact Assessment Report documents the impact of the system design on the personnel who will operate and maintain the system (i.e. the users). The assessment draws substantially from HSI domains including HFE, Training and Personnel. The intent of the assessment is to provide system designers, procurement officers and users with an up-to-date assessment of the operations and maintenance personnel concept in relation to the personnel demands of the system and the projected personnel that are envisioned to be available for the system. This is an iterative assessment that integrates information and analysis derived throughout the definition, design, development and testing phases. The potential impacts can be extremely significant lifecycle cost drivers as a result of the introduction of new technologies, tactics, techniques, procedures, training and doctrine. They can impact at all levels including the ability to recruit and select future users, initial and continuation training, new military occupational categories and career progression changes. This integrated approach to analyzing the impact on personnel allows trade offs to be weighed and implemented to reduce unforeseen negative impacts on the total system cost and performance.

APPLICATION/INTERRELATIONSHIP

DID HSI-HFE-000: Human Factors Engineering Program Plan. (HFEPP)

DID HSI-HFE-000: Target Audience Description (TAD)

DID HSI HFE-000: Human Engineering Systems Analysis Report (HESAR)

A-P9-000-002/PT-000, Needs Assessment

PREPARATION INSTRUCTIONS

1 Format: The Personnel Impact Assessment Report shall be prepared in Contractor Format.

2 Content: The Personnel Impact Assessment Report shall include, but not be limited to, the following information:

a. Personnel Concept: This shall include a compete description of the crews who will operate and maintain the total system including operation, primary and secondly maintenance, sustaining strategy (i.e. watches and shifts, work-rest cycles, security, husbandry). Both the number and categories (Military Occupational Structure Identification [MOSID]) of personnel shall be identified. This information may be extracted directly from the DID HSI-HFE-000 Target Audience Description;

b. Personnel Impact: Differences between the available personnel (numbers and categories) and projected personnel shall be identified based on the characteristics identified in the DID HSI-HFE-000 Target Audience Description. This analysis shall be presented in graphical and text format to include the current personnel, MOCs and career path in comparison to the future system personnel, MOSIDs and career path;

c. Personnel Trade-offs: Describe and substantiate new personnel requirements including the analysis supporting trade-offs (e.g. constructive simulation of operational concept, human-in-the loop simulation, field exercises). These difference may results from increased technology associated with increased capability, changes in doctrine or tactics, more distributed command and control requiring increased decision making and authority, or other physical or cognitive demands that are not within the current recruiting stream; and

d. Recruiting, MOSIDs and Career Progression Strategy: Describe the strategy to accommodate new personnel requirements across the full range of recruiting new personnel, developing new MOSIDs and the provision of career paths for personnel. This shall include estimates of personnel numbers, scheduling of personnel recruiting/development (e.g. for initial training and deployment as the system is developed and delivered, and projections of life cycle personnel retention). Any identified gaps in career progression resulting from the system design shall have the Personnel/Human Resources management solution described.

Annex I: HSI Web Site

The Human Systems Integration (HSI) website is the central Canadian DND repository for information on Human Systems Integration. The Web Site's homepage can be accessed at: http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/. This homepage directs the user to either the English or French version of the website.

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Annex I: Human Systems Integration (HSI) Web Site

Prepared for:
Defence R&D Canada, Director General R&D Programs
Director Science and Technology – Human Performance
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Completed by:
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Kanata, Ontario, Canada K2K 3G7

March 2005

Figure 1: HSI Homepage

The unveiling of the updated HSI website introduced the design of the new Canadian DND HSI logo, as well as the new logos to each of the HSI domains (Figures 2 and 3).

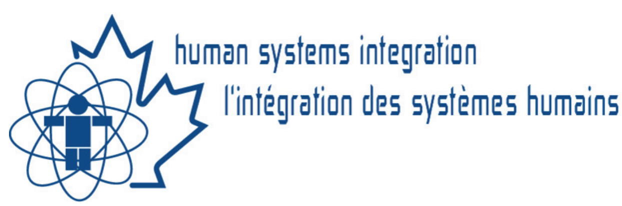

Figure 2: Canadian DND HSI Logo

Figure 3: HSI Domain Logos

The HSI website's intent was to provide a broad scope of information that would introduce the domain of HSI to novice users, as well as provide detailed information for expert users who utilize the website as a resource for current HSI projects.

The site map presented in Figure 4 outlines a high-level overview of the type of information contained within the website.

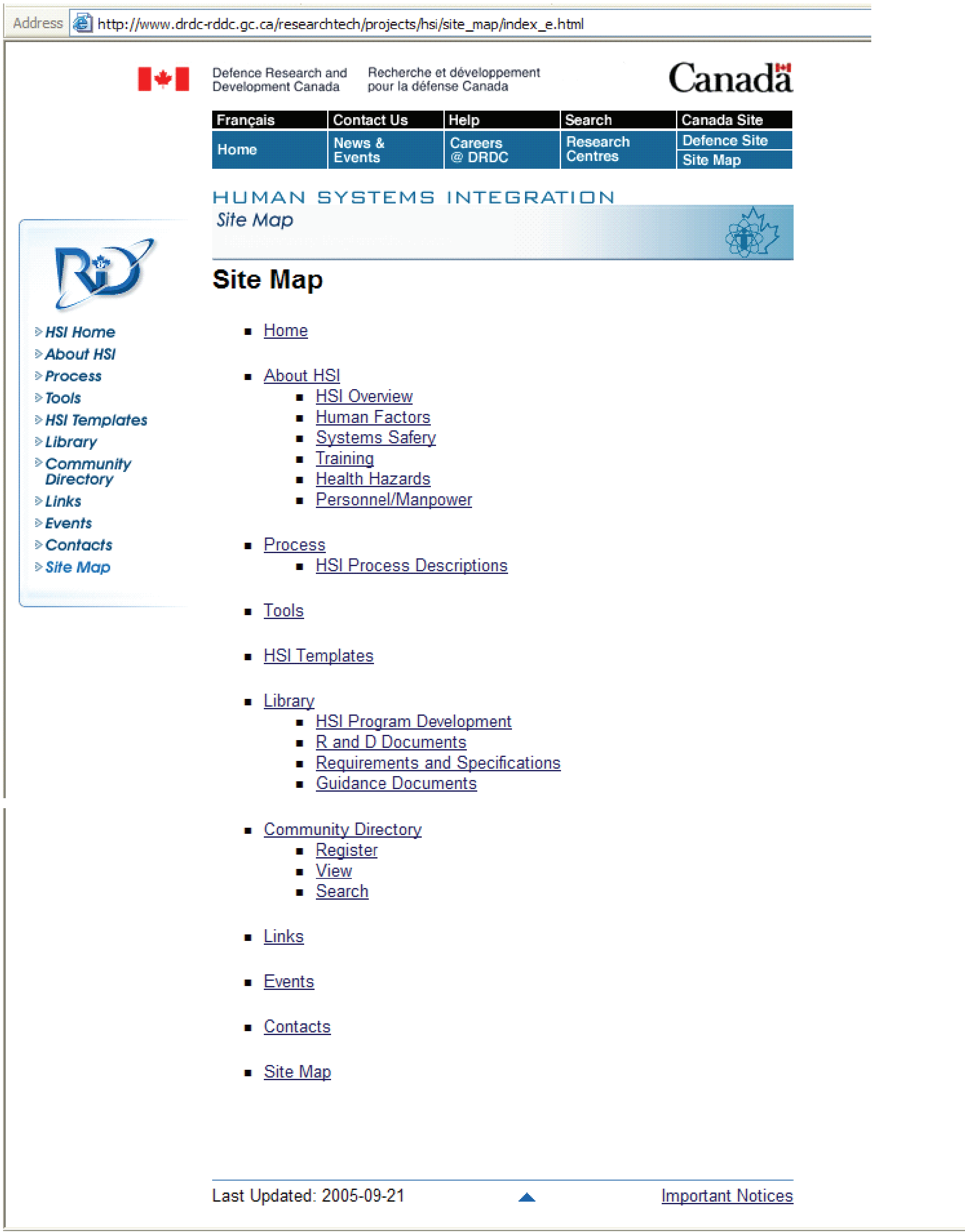

Figure 4: Site Map

The information presented in each section (page) is briefly described below:

1. **HSI Home** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/hsi_e.asp
   Provides a brief introduction to the HSI domain.

2. **About HSI** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/index_e.html
   Provides a brief overview of the purpose of each of the five HSI domains. Links are provided for further domain information

   - **HSI Overview** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/hsi_overview_e.html
     Identifies the goal of HSI, and outlines the relationship between the HSI domains.

   - **Human Factors** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/human_factors_e.html
     Identifies the primary aim of human factors, and outlines human factors sub areas and descriptions.

   - **Systems Safety** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/systems_safety_e.html
     Identifies the primary aim of systems safety, and outlines information that should be considered when systems safety is involved within a project.

   - **Training** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/training_e.html
     Identifies the primary aim of the training domain, and outlines training sub areas and descriptions.

   - **Health Hazards** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/health_hazards_e.html
     Identifies the information that should be considered when health hazards are involved within a project and outlines health hazards sub areas and descriptions.

   - **Personnel/Manpower** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/about/personnel_manpower_e.html
     Identifies the information that should be considered when the personnel and manpower domain is involved within a project and outlines personnel and manpower sub areas and descriptions.

3. **Process** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/process/index_e.html
   Describes how to apply HSI in a DND acquisition or development project. Provides information regarding the MA&S process, HSI processes in the MA&S model, implementers of HSI within the MA&S process, and HSI requirements before the MA&S process.

   - **HSI Process Descriptions** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/process/hsi_process_descriptions_e.html
     Describes each HSI process in the MA&S model.

4. **Tools** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/tools/index_e.html
   Provides a brief introduction to current human systems integration tools (Canadian Forces and 'Other').

5. **HSI Templates** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/templates/index_e.html
   Provides Data Item Description (DID) templates characterized according to each of the five HSI domains.

6. **Library** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/library/index_e.html
   Provides links to a series of reference documents that can be downloaded.

- **Canadian HSI Program Development** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/library/hsi_program_development_e.html
  Provides documents that outline the process and development of the Canadian HSI program.

- **R&D Documents** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/library/rd_documents_e.html
  Provides documents that identify how HSI was used in previous research and development projects.

- **Requirements and Specifications** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/library/requirements_specifications_e.html
  Provides documents that identify projects that required the development of human systems integration requirements and specifications.

- **Guidance Documents** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/library/guidance_documents_e.html
  Provides a series of resources that guide the implementation of human systems integration within a project.

7. **Community Directory** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/index_e.html
   Provides a medium for DND/CF personnel as well as personnel from Industry to provide summary information on their interests, expertise and capabilities in Human Systems Integration.

   - **Register** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/registration/registration_e.asp
     Provides an online form for registration of an individual's capability within the HSI domain.

   - **View** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/view/index_e.asp
     Provides an online Point of Contact Directory to enhance access to and raise awareness of other individuals interested in and performing work in Human Systems Integration.

   - **Search** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/search/search_e.html
     Provides a medium for conducting an advanced search of the HSI Community Directory.

8. **Links** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/links/links_e.html
   Provides a listing of World Wide Web links will be of interest to the HSI community.

9. **Events** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/events/index_e.html
   Provides a listing HSI events (conferences/seminars).

10. **Contacts** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/contacts/index_e.html
    Provides a listing of current DND acting HSI coordinators (Ottawa and Toronto).

11. **Site Map** - http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/site_map/index_e.html
    Provides a high-level overview of the type of information contained within the HSI website.

Annex J: HSI Registration Tool

This Annex contains the Human Systems Integration (HSI) Web Based Directory Registration form. The Registration form can be accessed at:

English: http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/registration/registration_e.asp

French: http://www.drdc-rddc.gc.ca/researchtech/projects/hsi/community_directory/registration/registration_f.asp

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Annex J: Human Systems Integration (HSI) Registration

Prepared for:
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Director Science and Technology – Human Performance
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Completed by:
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HUMAN SYSTEMS INTEGRATION

Community Directory

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Registration Guidelines

Only one entry should be made per capability (or Group). For small groups, please indicate the group and identify the lead contact.

The information provided on the registration form will not be edited; please try to be as accurate as possible. The information will be displayed on the HSI Internet & Intranet sites as an online directory.

Please forward any comments to Major Carolyn Shaw, Directorate Science and Technology (Human Performance) - 6 at Carolyn.Shaw@drdc-rddc.gc.ca.

Human Systems Integration Community Directory Registration

- Mandatory fields are marked with an asterisk (*). Please answer all these fields to facilitate presentation of your information.
- Your registration information will only be used for the DND HSI online directory and will not be used for any other purposes. Your information will be posted on a publicly accessed website.
- The Government of Canada privacy act will be respected (Important Notices). If you have any concerns, please do not register for the HSI directory.

Capability Information

Background*:

SELECT

Last Name*:

First Name*:

Salutation/Rank:

Work Title:

Department/Company*:

Password* (Providing a password will enable you to edit your personal information as required):

Repeat Password*:

Do you reside in North America?*:

Yes No

If you reside in North America please provide the following information:

Street Address*:

City*:

Province/State*:

SELECT

Postal Code/ZIP*:

Country*:

SELECT

Phone*:

( ) Ext

Fax:

( )

If you reside outside North America, please enter your address, phone and fax number.

Email*:

Web Site:

http://

Total Number of HSI Related Personnel at this Location:

Level of Interest in HSI*:

Please indicate your level of interest in HSI

SELECT

HSI Capability Areas*:

I, or our group, has interest, expertise or capability in the following areas (select all that apply):

- ☐ Integrated HSI Capability
- ☐ Human Factors Engineering
- ☐ Training
- ☐ Manpower/Personnel
- ☐ Systems Safety
- ☐ Health Hazard Assessment

HSI Capability Description

Please provide a short description of your HSI related interest, expertise or capability, as selected above:

DND Environment*

I, or our group, provides support to the following Environment (select one):

SELECT

For INDUSTRY Registrants only:

Do you contract HSI services to the Department of National Defence?

○ Yes ○ No

If you selected yes, in what areas was your project experience (select all that apply):

- ☐ Integrated HSI Capability
- ☐ Human Factors Engineering
- ☐ Training
- ☐ Manpower/Personnel
- ☐ Systems Safety
- ☐ Health Hazard Assessment

Submit

Please click on the "Submit" button when you are finished.

Submit

Thank you for completing this form.

Annex K: HSI Newsletter

This Annex contains the Web Based interface for the creation of the Human Systems Integration (HSI) Community Newsletter.

Annex K: Human Systems Integration (HSI) Newsletter

Prepared for:
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Director Science and Technology – Human Performance
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March 2005

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The Human Systems Integration Program publishes a HSI newsletter, distributed via e-mail bi-annually (April, October). Subscription to the newsletter is free. Currently, the newsletter will be distributed to DND/CF personnel only.

If you currently work for DND/CF, and would like to subscribe to the newsletter, please complete the following subscription form. The 'Subscriber List' is updated monthly. You will receive the latest publication of the newsletter at the end of the month.

Registration Information

Salutation/Rank:

Last Name:

First Name:

Email:

Work Title:

Department:

Organization:

Please click on the "Submit" button when you are finished.

Submit

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Human Systems Integration Newsletter Content Submission

If you are interested in submitting an article for the next HSI Newsletter, please fill in the form below. Please submit articles reflecting the five HSI domains: Human Factors Engineering, Manpower and Personnel, Training, System Safety, and Health Hazards. Fields marked with a '*' are mandatory.

Articles will be accepted in both English and French, but will not be translated for the HSI newsletter.

Article Information

Last Name*:

First Name*:

Affiliation:

Name of other authors (if any):

Article Title*:

Article Text*:

Please copy and paste the article text into this field. Please limit article length to 1000 words.

Email*:

Related Web Site:

http://

Please click on the "Submit" button when you are finished.

Submit

This information will be included in the HSI Newsletter.

DOCUMENT CONTROL DATA

(Security classification of the title, body of abstract and indexing annotation must be entered when the overall document is classified)

1. ORIGINATOR (The name and address of the organization preparing the document, Organizations for whom the document was prepared, e.g. Centre sponsoring a contractor's document, or tasking agency, are entered in section 8.) Publishing: DRDC Performing: CAE Professional Services (Canada) Limited DRDC Director Science and Technology − Human Performance Monitoring: Contracting:	2. SECURITY CLASSIFICATION (Overall security classification of the document including special warning terms if applicable.) UNCLASSIFIED

3. TITLE (The complete document title as indicated on the title page. Its classification is indicated by the appropriate abbreviation (S, C, R, or U) in parenthesis at the end of the title)

The Development and Validation of a Human Systems Integration (HSI) Program for the Canadian Department of National Defence (DND). (U)
L'élaboration et la validation d'un programme d'intégration humain−systèmes (IHS) pour le ministère de la Défense nationale. (U)

4. AUTHORS (First name, middle initial and last name. If military, show rank, e.g. Maj. John E. Doe.)

Mike Greenley; Andrea Scipione; Jeremy Brooks; Alice Salway; Walter Dyck; Carolyn M. Shaw

5. DATE OF PUBLICATION (Month and year of publication of document.) September 2008	6a NO. OF PAGES (Total containing information, including Annexes, Appendices, etc.) 397	6b. NO. OF REFS (Total cited in document.) 12

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Contract Report

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(U) From 2000 to 2004, Defence Research and Development Canada conducted multi−year Research and Development (R&D) activities under contract to develop, demonstrate and validate a Human Systems Integration (HSI) approach for the Canadian Department of National Defence (DND) with the aim to transition this approach to an operational program within the DND's Material Acquisition and Support community. The foundation of an HSI Program was applied to 31 Defence acquisition projects from 2001−2004. Various components of the HSI Program were researched, developed, demonstrated, and iteratively improved. A cost−benefit analysis derived from this effort was used to determine whether a permanent HSI Program within the DND would be worthwhile. $3,331,000.00 was spent on exercising a full or partial HSI process. This resulted in $3,515,000.00 in immediate savings based on observed data, providing a 106% payback. The cost of HSI application compared with immediate savings plus at least $133,000,000.00 in extrapolated savings (based on the impact the application of HSI had on projected life cycle costs) resulted in a 4000% payback, suggesting that HSI is a worthwhile investment. The possibility in hundreds of millions of dollars in further downstream savings based on lives saved or re−engineering costs avoided also existed but was not calculated. This study found that HSI costs ranged from 4−20% of a project's engineering budget and that Canada's integrated approach to HSI, whereby analyses are shared between HSI domains, can save up to 25% of HSI costs. This R&D effort developed and validated the Canadian HSI approach and supports the implementation of a formalized and enhanced HSI program within the Canadian DND.

(U) De 2000 à 2004, l'agence Recherche et développement pour la défense Canada a mené, en vertu d'un contrat, des activités de recherche et développement (R & D) pluriannuelles pour élaborer, démontrer et valider une approche d'intégration humain−systèmes (IHS), pour le compte du ministère de la Défense nationale (MDN) du Canada. Le but consiste à transformer cette approche en un programme opérationnel au sein de la communauté de l'acquisition et du soutien du matériel du MDN. De 2000 à 2004, 31 projets d'acquisition de la Défense ont été fondés sur un programme d'IHS. Différents éléments du programme d'IHS ont fait l'objet de recherche, de développement, de démonstration et d'amélioration itérative. Une analyse coûts−avantages issue de cet effort a servi à déterminer la rentabilité d'un programme d'IHS permanent au MDN. Les dépenses engagées pour la conduite à bon terme d'un processus complet ou partiel étaient de 3,3 millions de dollars, ce qui a permis de réaliser 3,515 millions de dollars d'économies immédiates, d'après les données constatées, soit une retombée de 106 %. Le coût de l'application de l'IHS par rapport aux économies immédiates plus au moins 133 millions de dollars d'économies extrapolées (selon les incidences de l'application de l'IHS sur les coûts du cycle de vie prévus) a entraîné une retombée de 4 000 %, ce qui suppose que l'IHS constitue un investissement intéressant. Il y a eu également la possibilité d'économies d'aval s'élevant à des centaines de millions de dollars, mais dont le calcul n'a pas été fait. Dans la présente étude, il s'est révélé que le coût de l'IHS variait de 4 à 20 % du budget d'un projet technique et que l'approche intégrée

d'IHS du Canada, par laquelle les analyses sont partagées parmi les domaines de l'IHS, peut épargner jusqu'à 25 % des coûts de l'IHS. Ce travail de R & D a engendré et validé une approche d'IHS canadienne et soutient la mise en œuvre d'un programme d'IHS formel et amélioré au sein du MDN canadien.

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(U) Acquisition support, Capability engineering, Health hazards, HFE, HSI, HSI case studies, HSI concept, HSI cost−benefit, HSI policy, HSI process, HSI program, HSI team, HSI tools, Manpower, Personnel, Safety systems, Selection, Training.