



# Risk Mitigation in Capital Acquisition: Modelling and Simulation Approaches

*Survey of the Canadian Forces Acquisition*

*Curtis Coates  
CMC Electronics*

*Catherine Burns  
University of Waterloo*

*Wenbi Wang  
DRDC Toronto*

*Prepared By:  
ESTERLINE|CMC ELECTRONICS INC.  
415 Legget Drive  
Ottawa, ON  
K2K 2B2*

*Contract Project Manager: Curtis Coates, (613) 592-7400 x 2048  
PWGSC Contract Number: W7719-115018/001/TOR  
CSA: Wenbi Wang, Defence Scientist, (416) 635-2000 x 3063 Salas*

The scientific or technical validity of this Contract Report is entirely the responsibility of the Contractor and the contents do not necessarily have the approval or endorsement of Defence R&D Canada.

**Defence R&D Canada**  
Contract Report  
DRDC Toronto CR 2011-155  
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## **Defence R&D Canada – Toronto**

Contract Report  
DRDC Toronto CR 2011-155  
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Principal Author

*Original signed by Curtis Coates*

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Curtis Coates

Project Lead

Approved by

*Original signed by Dr. Wenbi Wang*

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Dr. Wenbi Wang

Contract Scientific Authority

Approved for release by

*Original signed by Dr. Stergios Stergiopoulos*

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Dr. Stergios Stergiopoulos

Acting Chair, Knowledge and Information Management Committee

Acting Chief Scientist

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## Abstract

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This applied research project is aimed at developing Modelling and Simulation capabilities for addressing Human Systems Integration issues in the Canadian Department of National Defence capital acquisition process. It is a three phase project with this report covering the first phase. The goal of the first phase was to identify a capital acquisition project that would best serve as a basis for the development of a modelling or simulation tool and a case study for the new capability. Structured interviews were held with three major Royal Canadian Navy projects and with other headquarters staff. The results of the interviews were evaluated as to the appropriateness of the project to support the follow-on phases of the research and a decision was made as to which project and modelling tools were to be used for phases two and three.

## Résumé

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Ce projet de recherches appliquées vise le développement des capacités de modélisation et de simulation qui permettront de résoudre des problèmes liés à l'intégration des systèmes humains dans le processus d'acquisition d'immobilisations du ministère de la Défense nationale. Le présent rapport porte sur la première de trois étapes. L'objectif de cette étape était d'identifier le meilleur projet d'acquisition d'immobilisations pouvant servir d'élément de base pour l'élaboration d'un outil de modélisation ou de simulation, de même que pour l'étude de cas de la nouvelle capacité. Des rencontres structurées ont eu lieu avec les responsables de trois importants projets de la Marine royale canadienne et d'autres employés du quartier général. Les résultats ont été évalués selon la pertinence des projets pour les prochaines étapes de la recherche. Le projet et les outils de modélisation qui serviront lors de la deuxième et de la troisième étapes ont été sélectionnés.

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## Executive summary

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### **Risk Mitigation in Capital Acquisition: Modelling and Simulation Approaches: Survey of the Canadian Forces Acquisition**

**Curtis Coates; Catherine Burns; Wenbi Wang; DRDC Toronto CR 2011-155; Defence R&D Canada – Toronto; September 2011.**

**Introduction or background:** The general goal of this Defence Research and Development Canada (DRDC) Applied Research Project (ARP) is to develop Modelling and Simulation (M&S) capabilities for addressing Human Systems Integration (HSI) issues in the Department of National Defence (DND) capital acquisition projects. Funded by Thrust 14d, this ARP is focused on using one of the three current Royal Canadian Navy (RCN) capital acquisition projects as a platform to extend and test existing or new M&S capabilities.

This project has three phases: Phase One is a survey that involves interviewing Subject Matter Experts (SMEs) from the navy acquisition projects: Joint Support Ship (JSS), Arctic Offshore Patrol Ship (AOPS), and Canadian Surface Combatant (CSC). Phase Two involves an expansion of DRDC's current M&S capabilities to support manpower and personnel analysis. Phase Three will focus on a validation study, in which the newly developed crew modelling capability will be applied to the user case identified in the Phase One survey. The entire project will be completed before the end of March 2013.

**Results:** Discussions by the research team based on interviews with SMEs led to the decision to pursue the Joint Support Ship project as the candidate to use as a basis for development of a tool and a case study. The modelling tool to be developed is Human Views which is an extension of the DND Architecture Framework (DNDAF).

**Significance:** Advances in modelling and simulation to support Human Systems Integration in the acquisition process has the strong possibility of improving efficiencies in manning, training, recruiting, and career progression throughout the life of the platform.

**Future plans:** The next steps of this research project are to develop and apply the Human Views in support of the JSS project.

## Sommaire

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### **Risk Mitigation in Capital Acquisition: Modelling and Simulation Approaches: Survey of the Canadian Forces Acquisition**

**Curtis Coates; Catherine Burns; Wenbi Wang ; DRDC Toronto CR 2011-155 ; R & D pour la défense Canada – Toronto; septembre 2011.**

**Introduction ou contexte :** Le Projet de recherches appliquées (PRA) de Recherche et développement pour la défense Canada (RDDC) vise le développement des capacités de modélisation et de simulation (M & S) qui permettront de résoudre des problèmes liés à l'intégration des systèmes humains (ISH) dans le processus d'acquisition d'immobilisations du ministère de la Défense nationale (MDN). Ce PRA, financé à partir du vecteur 14d, est axé sur l'un des trois projets d'acquisition actuels de la Marine royale canadienne (MRC) afin de prolonger et de mettre à l'essai les capacités M & S (actuelles et nouvelles).

Ce projet comporte trois étapes : 1) Sondage et entrevues avec des experts en la matière participant aux projets d'acquisition de navires de soutien interarmées (NSI), de navires de patrouilles extracôtier de l'Arctique (NPEA) et de navires de combat de surface canadiens (NCSC); 2) Augmentation des capacités M & S actuelles de RDDC afin de soutenir l'analyse des effectifs; 3) Étude de validation du cas identifié dans le sondage de la première étape à l'aide de la nouvelle capacité de modélisation des équipes. Le projet sera terminé avant la fin de mars 2013.

**Résultats :** Après avoir rencontré les experts en la matière, l'équipe de recherche a convenu d'utiliser le Projet NSI comme élément de base pour l'élaboration d'un outil et l'étude de cas. L'outil de modélisation « Human Views » qui sera conçu fait partie du Cadre d'architecture du MDN (DNDAF).

**Portée :** Les progrès M & S pour soutenir l'ISH dans le processus d'acquisition peuvent grandement améliorer la dotation, l'instruction, le recrutement et l'avancement professionnel durant toute la durée de vie de la plateforme.

**Perspectives :** Les prochaines étapes de ce projet de recherche consistent à développer et utiliser l'outil « Human Views » en appui au Projet NSI.

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# 1 Project background

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## 1.1 Overall project

The general goal of this Defence Research and Development Canada (DRDC) Applied Research Project (ARP) is to develop Modelling and Simulation (M&S) capabilities for addressing Human Systems Integration (HSI) issues in the Department of National Defence (DND) capital acquisition projects. Funded by Thrust 14d, this ARP is focused on using one of the three current Royal Canadian Navy (RCN) capital acquisition projects as a platform to extend and test existing or new M&S capabilities. This project has three phases: Phase One is a survey that involves interviewing Subject Matter Experts (SMEs) from the navy acquisition projects: Joint Support Ship (JSS), Arctic Offshore Patrol Ship (AOPS), and Canadian Surface Combatant (CSC). The intent of the survey is to understand the HSI challenges, particularly manpower and personnel related issues, faced by the Project Management Offices (PMOs), and identify areas that M&S may provide a viable solution. Phase Two involves an expansion of DRDC's current M&S capabilities to support manpower and personnel analysis. This will be reflected in either a software tool or a crewing model development. Phase Three will focus on a validation study, in which we plan to apply the newly developed crew modelling capability in a user case identified in the Phase One survey. The entire project will be completed before the end of March 2013.

## 1.2 Current work

This report covers the activities of Phase One. In the current task survey, the research team was most interested in the activities that take place within the "options analysis" and "requirements specification" phases in an acquisition project. One particular area of interest is issues associated with manpower and personnel requirements, for example, ship complement design and crew knowledge/skill requirement analysis. The complexity of such issues, particularly when they are considered in the context of various technological factors, such as the use of automation, leads the team to believe that M&S may provide a very useful solution.

## 2 Phase One overview

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The general objective of Phase one was to develop an understanding of the types of manpower and personnel modelling capabilities required to support the current RCN acquisition projects. This objective was achieved by a series of SME surveys. More specifically, the following four tasks were conducted in Phase One:

- (1) Finalize a survey questionnaire based on a draft supplied by the DRDC Scientific Authority;
- (2) Select Subject Matter Experts (SMEs) and conduct interviews;
- (3) Analyze the interview data, identify one of the RCN acquisition projects as a test case, and determine the modelling capability to be developed and applied in Phases Two and Three of this ARP; and
- (4) Further consultation with relevant stakeholders.

These tasks were completed by the research team, which consisted of members from both DRDC and the industry, as shown in Table 1.

*Table 1. Phase one research team members.*

Dr. Wenbi Wang	Scientific Authority – DRDC Toronto
Dr. Catherine Burns	HSI expert – University of Waterloo
Mr. Jean-Yves Lamarre	DND Procurement SME
Mr. Andrew Stewart	HSI expert – CMC Electronics
Mr. Curtis Coates	Project Manager – CMC Electronics

The study commenced with a kick-off meeting held on 29 June 2011, in which the research team discussed the scope of the overall ARP, the objectives of the current Phase, detailed tasking and the schedule, and the intended SMEs that should be included in the survey. In the ensuing three months, three interview sessions and two consultation meetings were conducted. The survey results enabled the research team to prioritize the HSI challenges faced by three on-going naval acquisition projects, identify the M&S capabilities that can be developed in the timeline of the current ARP, and select a candidate acquisition project that best suited for a future validation case study. A more detailed description of these tasks is provided in the following subsections.

### 2.1 Survey questionnaire

Task 1 involved the finalization of a survey questionnaire. A draft version was provided by the Scientific Authority (SA) which had been originally created by Dr. Wenbi Wang and Dr. Renee Chow for a cognitive task analysis of the generic acquisition process. To reflect the current study's focus on naval platform acquisition, the draft questionnaire required review and amendment. A meeting was held among the research team members on July 6, 2011, during which the draft questionnaire was modified to focus specifically on planned naval projects, with questions like, how M&S could assist in these projects, and

how M&S in general could be used to suit the needs of the PMOs. The finalized questionnaire is included as Appendix A.

## **2.2 SME interviews**

The research team conducted three SME interviews between 20 and 28 July 2011. The scheduling of the interviews went better than anticipated and the SMEs were available on relatively short notice. Specifically, the team interviewed JSS on 20 July, CSC on 21 July, and AOPS on 28 July. All three sessions took place at 105 Hotel de Ville in Gatineau with Dr. Wang and Dr. Burns participating by teleconferencing. Due to the short notice, Jean-Yves Lamarre was only present for the AOPS interview. Prior to the start of each interview, background materials on the project, HSI, and M&S were provided to the interviewees. A copy of these materials is included in Appendix B. During the interview, the survey questionnaire (see Appendix A) was followed and notes were taken by each of the participating research team members. After the session was completed, these notes were distributed to each research team member prior to consolidation and analysis.

## **2.3 Data consolidation and analysis**

After the completion of the SME interviews, a teleconference was held among the research team to compare interview notes, discuss which project was most suitable for Phases 2 and 3 of this ARP and which M&S tools should be trialled or tested. The team assessed the pros and cons associated with each acquisition project and a preliminary decision was reached.

## **2.4 Further consultation**

Two additional consultation meetings were held to discuss the preliminary decision with other project stakeholders. On 17 August, the team met with the Director of Maritime Personnel (D MAR PERS) 5 and his staff, including DRDC scientists from the Maritime Operations Research Team. On 31 August, Dr. Wang and Mr. Coates presented the results and further discussed them with the Director Maritime Requirements Sea (DMRS).

## 3 Results

### 3.1 Project analysis

A discussion on the pros and cons of each of the three RCN acquisition projects in relation to the current ARP was conducted after the interviews. The research team assessed each project for its timeline, its stage in the acquisition process, the manpower and personnel challenges, as well as the PMO staff's task priority. Such information was then compared to the plan and schedule of the current ARP. The results are summarized in Table 2.

*Table 2. Summary of the analysis of three RCN acquisition projects*

Project	Pros	Cons	Other Information
CSC	<ul style="list-style-type: none"> <li>• Project is in the definition phase – ideal to allow M&amp;S to support decision making.</li> <li>• CSC's HSI Engineer is a very engaged officer and is an asset to this research project.</li> <li>• Project is open to top-down analysis.</li> <li>• Crew size is large and could possibly benefit the most from this research project.</li> <li>• Project ideal to support options analysis decisions.</li> </ul>	<ul style="list-style-type: none"> <li>• While in the options analysis phase the overall timing could be troublesome as work may not advance quickly enough to support phase 2 and 3 of this research project.</li> <li>• This research project would have to generate data causing timing and level of effort concerns.</li> </ul>	<ul style="list-style-type: none"> <li>• Overall size and scope may be too large for the current ARP.</li> <li>• CSC would be better served as a project to which the new tool may be applied.</li> </ul>
JSS	<ul style="list-style-type: none"> <li>• Project is in the options analysis phase – ideal to allow M&amp;S to support decision making.</li> <li>• Project has a good understanding of the crew solution.</li> <li>• Very mature Watch and Station bill considering the 165 crew.</li> <li>• Project is concerned about validation.</li> <li>• Project has well-defined structural levels.</li> <li>• Project offers a unique procurement strategy with the comparison of two Military Off the Shelf (MOTS) and one design to purpose vessels.</li> <li>• Timing works well for phases 2 and 3 of this research project.</li> <li>• Project is ideal for validation. No need to develop the data as the project has already generated it.</li> </ul>	<ul style="list-style-type: none"> <li>• Late in the procurement cycle – M&amp;S may not influence decision making.</li> </ul>	<ul style="list-style-type: none"> <li>• M&amp;S could be used for validation or trade-off decisions.</li> <li>• The project expects it will need support when asking for additional crew for the MOTS vessels. Scientific support for this task is expected.</li> </ul>
AOPS	<ul style="list-style-type: none"> <li>• Project has the BMT Fleet Technology crew study for data generation and model output validation.</li> <li>• Project has not considered specific mission requirements which M&amp;S could support.</li> <li>• Deferring many decisions to the implementation phase.</li> </ul>	<ul style="list-style-type: none"> <li>• Late in the procurement cycle. Project near end of definition phase - would be difficult to influence any decisions.</li> <li>• Poor project with respect to timeliness as documentation is awaiting legal review.</li> </ul>	<ul style="list-style-type: none"> <li>• Some challenges to meet the Navy's target of a 35 person crew.</li> <li>• Very small crew, therefore not much to be saved with respect to crewing or manning.</li> </ul>

All members of the research team were in agreement that the CSC project held the most promise for research potential, however, the timeline of the project, being still in the definition phase, will be too far behind DRDC's goals of completing a case study by March 2013. Data required for the population of a tool or simulation in support the CSC project would be difficult to produce and require far too many assumptions.

The AOPS project was determined to have the least need for research into manning or personnel given the small crew and the maturity of the project.

The JSS was interesting in that the design was relatively mature and there were still a number of crewing questions to be addressed. The timing of the JSS project fits well with DRDC goals of modelling a test case by 2013. The staged timelines of the various acquisition projects presents an opportunity for DRDC. Knowledge gained from modelling the JSS crewing options could be used as a foundation for models in support of the CSC project in the future.

### **3.2 HSI challenges and selection of an M&S solution**

A list of HSI issues were raised by the PMO staff during the interviews, including crew design and validation, rank specification, workload assessment, spatial layout design of key platform compartment, and crew training needs analysis. Limited by the resources available to the current ARP, the research team had to select a particular challenge as a target for the next two phases of this project. This decision was also based on a careful consideration of the existing M&S capabilities that DRDC possesses. In particular, the research team discussed the applicability of four modelling tools, that is, the Complement Generation Tool (CGT), the Integrated Performance Modelling Environment (IPME), the Virtual Navigation and Collaboration Experimentation Platform (VNCEP), and the Human Views (HV). More specifically, the CGT is a crew modelling software that was developed by QinetiQ for the Defence Procurement Agency of the United Kingdom's Ministry of Defence. The IPME is a discrete-event simulation tool that supports human performance (particularly mental workload) modelling and analysis. The VNCEP is a generic three-dimensional (3D) visualization tool that supports fast 3D prototyping and versatile visualization; a variant of VNCEP has been modified to address command and control room layout issues. The HV are a set of architecture frameworks that defines a common approach for development, presentation, and integration of architecture descriptions that are related to Human Systems Integration, including areas such as manpower, career progression, and training. The first three are software tools whereas the HV is currently a conceptual product and a tool for creating Human Views is yet to be developed.

The following conclusions were reached through team discussion:

1. Human Views were given top billing of the three tools for two reasons. First, the type of issues and the level of detail captured by models based on the Human Views are appropriate for addressing manpower and personnel concerns faced by the PMOs. Second, the development of Human Views is an on-going effort. Although a NATO Human View was produced by the NATO RTO HFM 155 working group, DND has been working on its own version of Human Views and their integration into DNDAF. Similar research activities have been conducted by the Allied Nations too, including the United Kingdom and the United States of America. The application of Human Views in the context of these Navy acquisition projects provides an excellent opportunity to verify and validate the architecture framework.

2. Layout analysis (e.g., ops room design) is another area where Research and Development (R&D) support is needed. In this regard, VNCEP was recommended as a tool that DRDC Toronto could potentially employ to support these three acquisition projects. Specifically VNCEP's capabilities to conduct equipment layout and team communication analyses are most relevant to the procurement stages targeted by the current ARP.
3. Although many SMEs pointed out workload analysis as important, such an analysis is often required at a later stage of the procurement process after sufficient details of the platform become available. Consequently, the use of IPME for workload assessment was given a lower priority to the other tools in the context of this project.
4. Complement generation and validation are critical questions faced by all three PMOs. However the urgency of these issues differed across projects. For example, detailed crewing solutions were completed for JSS and AOPS, and mature tools like the CGT can be used to resolve these issues relatively well. Since the current ARP aims to develop new M&S capabilities, the research team considered the application of the CGT a lower priority.

### **3.3 Further consultation with other stakeholders**

The research team consulted two other key stakeholders, D MAR PERS and DMRS, after the preliminary decisions on project and M&S solution selection were made. The discussion with D MAR PERS 5 and his staff revolved around the current need to validate crewing and manning decisions with the absence of models. His review of the timeline of the capital acquisition projects and the uncertainty of information confirmed the decisions made by the research team to pursue the extension of HV and its application for the JSS project. The interview notes made with D MAR PERS are held by the SA. During this meeting, a proposal of applying M&S tools to validate the crewing of the modernized Halifax Class Frigate was also raised. However, considering the refit of the HMCS CALGARY, the first Frigate to receive the complete modernization package, will not be completed until the spring of 2013, the timing did not fit into the current ARP's schedule. Another DRDC project may be initiated to support this effort.

The meeting with DMRS confirmed his support to the preliminary decisions. DMRS emphasized the need for M&S capabilities that support the generation and validation of novel crewing concepts that are not merely extensions of how the RCN has done business in the past, in other words, revolutionary rather than evolutionary crewing solutions. In addition, DMRS indicated that he would assist as required with the follow-on phases in this ARP.

## 4 Conclusions

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The next steps of this research project are to develop and apply the Human Views in support of the JSS project. A statement of work will be generated by the Scientific Authority. Given that the Human Views extension of the DND Architecture Framework (DNDAF) is currently only a conceptual framework, there will be a great amount of work to produce a working tool. The work will include analysis of work progressed in the United Kingdom and the United States on their Architecture Frameworks. The actual development of the Human Views tool and the population with data from the JSS project is not without technical and schedule risk. The research aspect of the work must be considered when providing scope for the next two phases. The possibility for the JSS modelling exercise to provide a foundation for later contributions to the CSC project presents an opportunity for both DRDC and the RCN.

# Annex A Interview questionnaire

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## A.1 Pre-interview materials

### Pre-interview materials

- Introduction to project
- Introduction to HSI
- Introduction to M&S - Explain modeling and simulation – what we mean.

## A.2 Acquisition related questions

- Review the acquisition process (from the information provided) to confirm our understanding of their role

### Roles and responsibilities (tailor to or person being talked to, or answer ourselves based on some prior research)

- What tools (M&S) do you use? (Ideally if we can identify the roles of the people we are talking to it would be good to tailor a question like this so it is less exploratory, aware of what they do)
  - What are the key benefits or shortfalls of current tools? (things we are looking for are outputs, reporting needs, usefulness, usability, integration with other parts of the process)
- What type of feedback do you receive on completed acquisition related products?
- How do your experiences with current platforms feed into current/future acquisition processes?
- What is the lifespan of the information needed for the next step in the acquisition process? Will it be used for only the current project phase, or does it need to be maintained, updated to the follow-on phases?
- If the project is past the options analysis phase then indicate that the project literature says this should have been done during the O.A. phase – did you? If not why not?

## A.3 Crewing specific questions

General:

- How is a new platform assessed for crewing compatibility? Bottom-up (i.e., by modifying the solution from an existing platform) versus top-down (design from scratch by using, e.g, Mission, function, task analysis MFTA – type of methods) or was the project given a target crew number?
- Does the project analyze crewing specifically:
  - Get assessments and recommendations from experienced or high level staff?
  - Use of M&S tools?
- What information is typically available for crewing analysis? How is it generated and maintained?

- In what kind of format is the crewing analysis output typically presented? Perhaps in a Watch and Station Bill? Is there a standard requirement?

#### Numbers / costs:

- Is the crewing output formulated into lifecycle costs?
- Are the training requirements considered – would a model be useful for that within the acquisition process (*be prepared to discuss Human Views*).
- Do you need information about support costs ashore for your analysis?
- How do you currently get that information?
- Do you need to produce a manning list or watch and station bill?
- Do you consider manning in terms of personnel at given workstations, maintenance, and non-equipment related functions? How do you currently get that information?
- Is your manning analysis based on mission profiles (operational states [cruising, In 2, action stations] / composite mission scenarios)?
- Do you break missions down into a particular selection of systems, maintenance, and automation?

#### Workload:

- Does your manning consideration include environmental factors/ performance factors such as temperature, humidity, time of day?
- Does your manning consideration include operator workload/ mental ability/ fatigue/ physical ability/ training/ rank?
- Does your manning analysis consider time to perform tasks, operator loading, and probability of failure?
- Do you consider detailed operator scheduling in your analysis? Do you need to produce an operators schedule?
- Do you have to establish crew demands (workload) at each watch state?
- Do you consider non-equipment related functions (washing the deck) in your manpower analysis?
- Do you consider tasks performed by an individual versus a team when determining the time required to complete tasks?
- What are the particular challenges with assessing crewing needs or crewing compatibility? (*be prepared to introduce IPME or the Complement Generation Tool*).

#### Target Audience Description:

- Do you establish operator knowledge, skills and abilities for a given function?
- Do you establish the require operator rank for a given function?
- Do you need to establish a cost associated with a given function?
- Does that determination include consideration of skill type, rank etc.?

#### Personnel and Training (TNA):

- In particular for new positions or functions do you establish training requirements/ training progression?
- In particular for new positions or functions do you establish career progression strategies?

- In particular for new positions or functions do you establish if new recruiting is required to gain particular KSA?
- In your manning analysis do you consider posting cycles?
- In your manning analysis do you attempt to identify gaps in personnel required?
- Are you required to determine if personnel will be available when the system/function is fielded?
- Do you consider the mix of personnel (rank and KSA) required to operate, maintain, and sustain a capability?
- Do you address the impact of new systems on training requirements?
- Do you address the impact of new systems on career progression?

## **A.4 Specific M&S questions**

### **M&S (background)**

- If modeling and simulation could be useful, then:
  - Are there any key tools already in use that tools should be compatible with? (e.g. requirements database, or assessment tracking tool)
  - Who will use this tool? Would you use it, or someone else? If someone else, who?
  - Have you validated the assumptions used to generate manning information?
  - Is there a need to flow down the resulting models to the Prime Contractor, and if so do you expect the Prime to maintain, update and report their findings throughout the implementation phase?

## **A.5 Close-out questions**

- Are there any Crewing, manpower or personnel type challenges the PMO is currently experiencing?
- If DRDC(T) could provide support or help, could it be of use?
- If so, what are the driving factors:
  - Comprehensiveness of the information
  - Timeliness
  - Robustness
- Do you have resident Subject Matter Experts (SME) or access to them for:
  - Preparing and analysing the data
  - As source of technical or operational information required to conduct the work
- Who is responsible for the information:
  - Generation;
  - Validation;
  - Configuration control;
  - Distribution.
- What is the lifespan of the needed information? Will it be used for only the current project phase, or does it need to be maintained, updated to the follow-on phases?

## **A.6 Additional questions regarding options analysis phase**

(Only applicable if the project is in the OA phase as we need to support work going forward not review what has been done)

- Which phases of the OA phase are the most time consuming? Why?
- What size of a team would work on this? How would activities be divided up?
- Who does the analysis and modeling work? How much is contracted out? What are the deciding factors to contract out versus manage in-house?
- Would better tools improve the capability to handle this work in house? Is that capability desirable?
- Do they use tools for any of the other options analysis studies (e.g. environmental assessments, socio-economic studies, market analysis) Continue probing along these – what makes these useful to them? Or not?
- What tools do their industry contractors use? Do they specify the tools their contractors use?
- Which activities tend to occur together (or alternative: in analyzing personnel, what other OA activities are compatible with this? (thinking equipment or technology assessment, scenario testing)
- By impact on other capabilities, how is the impact of crewing for a new acquisition assessed for its impact on existing resources?

## Annex B Background material

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### B.1 Project introduction

- 1) This task survey is funded by a DRDC applied research project entitled "Risk Mitigation in Capital Acquisition: Modelling and Simulation Approaches" within Thrust 14d.
- 2) The general goal of the project is to develop Modelling and Simulation (M&S) capabilities for addressing Human Systems Integration (HSI) issues in DND capital acquisition projects.
- 3) This project has three phases: Phase (1) is a task survey that involves interviewing Subject Matter Experts from the navy acquisition projects (i.e., JSS, AOPS, CSC). The intent of the survey is to understand the HSI challenges (particularly crewing-related issues) faced by the PMOs, and identify areas that M&S may provide a viable solution. Phase (2) involves an expansion of DRDC's current M&S capabilities to support manpower and personnel analysis. This will be reflected in either software tool or crewing model development. Phase (3) will focus on a validation study, in which we plan to apply the newly developed crew modeling capability in a user case identified in the task survey.
- 4) The project will be completed before the end of Mar 2013.
- 5) In the current task survey, we are most interested in the activities that take place within the "options analysis" and "requirements specification" phases in an acquisition project. One particular area is manpower and personnel, for example, ship complement design and crew knowledge/skill requirements. The complexity of such issues (particularly when they are considered in the context of technological factors, e.g., automation) leads us to believe that M&S may provide a very useful solution.
- 6) While the input provided the SMEs will help us to sharpen our project focus, we also like to explain our M&S and HSI capabilities in order to better discuss future collaboration opportunities.

## **B.2 Potential HFE M&S analytical methods and software tools.**

The Human-Systems Integration section (HSIS) in DRDC Toronto, particularly its Human Modelling Group, has expertise in the following areas:

- Requirements Analysis (i.e., Cognitive Work Analysis, Hierarchical Goal Analysis, Mission Function Task Analysis)
- Workload Prediction and Validation
- Workspace Design and Evaluation
- Task Network Simulation
- Physiological Modelling
- Cognitive Modelling

The expertise is also reflected by the M&S tools that the group develops and uses:

- Integrated Performance Modelling Environment (IPME): A discrete-event simulation tool that supports human performance (particularly mental workload) modelling and analysis.
- LOCATE: A spatial layout design tool that creates and optimizes workspace (e.g., command centres) layouts based on operators' information and communication requirements.
- Complement Generation Tool (CGT): a crewing modelling tool developed by QinetiQ.
- Virtual Navigation and Collaborative Experimentation Platform (VNCEP): A generic three-dimensional (3D) visualization tool that supports fast 3D prototyping and versatile visualization. Variant of VNCEP has been modified to address command and control room layout issues.
- G2/Rethink: A third-party discrete-event simulation tool that specializes in process modelling.
- Department of National Defence Architecture Framework (DNDAF): A comprehensive framework that enables the development of architectures for describing complex systems. Of particular note are a set of four Human Views that have been under development which are aimed at addressing manpower, career progression, and training. The basis of the analysis is provided by a rich understanding of human competencies (knowledge, skills, and abilities) required and provides the foundation for capturing the human requirements in the acquisition process.
- Modelica: An object-oriented, multi-domain modelling language for component-oriented modelling of complex systems.
- Emergent: A neural simulation software tool for creating complex models of the brain and cognitive processes.

### B.3 Overview of Human-Systems Integration (HSI)

Human Systems Integration (HSI) refers to the interdisciplinary technical and management processes for integrating human considerations within and across all system elements. In the context of DND, the general objective of HSI is to enhance soldier-system design, reduce life-cycle ownership costs, and optimize total system performance, by ensuring the human is fully and continuously considered as part of the total system (i.e., hardware and software) in the development and /or requisition of all systems.

Below is the excerpt from a report entitled *The Development and Validation of a Human Systems Integration (HSI) program for the Canadian Department of National Defence (DND)*. It outlines the Canadian versions of the five HSI domains, as shown in Figure 1.



Figure 1: Conceptual illustration of Canadian HSI

#### B.3.1 Human factors engineering

Human Factors Engineering is 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.

#### B.3.2 Personnel

The personnel portion focuses on the number of military and civilian personnel required and potentially available to operate, maintain, sustain, and provide training 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.

### **B.3.3 Training**

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.

### **B.3.4 System safety and health hazards**

System safety and health hazards aims to identify 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.

## List of symbols/abbreviations/acronyms/initialisms

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3D	Three Dimensional
AOPS	Arctic Offshore Patrol Ship
ARP	Applied Research Project
CGT	Complement Generation Tool
CSC	Canadian Surface Combatant
D MAR PERS	Directorate of Maritime Personnel
DMRS	Director Maritime Requirements Sea
DMTE	Directorate of Maritime Training and Education
DND	Department of National Defence
DNDAF	DND Architecture Framework
DRDC	Defence Research and Development Canada
HIS	Human Systems Integration
IPME	Integrated Performance Modelling Environment
JSS	Joint Support Ship
KSA	Knowledge, Skills, and Abilities
MFTA	Mission Function Task Analysis
M&S	Modelling and Simulation
MOTS	Military Off The Shelf
OA	Options Analysis
PMO	Project Management Offices
RCN	Royal Canadian Navy
SME	Subject Matter Expert
TNA	Training Needs Analysis
VNCEP	Virtual Navigation and Collaboration Experimentation Platform

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(U) This applied research project is aimed at developing Modelling and Simulation capabilities for addressing Human Systems Integration issues in the Canadian Department of National Defence capital acquisition process. It is a three phase project with this report covering the first phase. The goal of the first phase was to identify a capital acquisition project that would best serve as a basis for the development of a modelling or simulation tool and a case study for the new capability. Structured interviews were held with three major Royal Canadian Navy projects and with other headquarters staff. The results of the interviews were evaluated as to the appropriateness of the project to support the follow-on phases of the research and a decision was made as to which project and modelling tools were to be used for phases two and three.

(U) Ce projet de recherches appliquées vise le développement des capacités de modélisation et de simulation qui permettront de résoudre des problèmes liés à l'intégration des systèmes humains dans le processus d'acquisition d'immobilisations du ministère de la Défense nationale. Le présent rapport porte sur la première de trois étapes. L'objectif de cette étape était d'identifier le meilleur projet d'acquisition d'immobilisations pouvant servir d'élément de base pour l'élaboration d'un outil de modélisation ou de simulation, de même que pour l'étude de cas de la nouvelle capacité. Des rencontres structurées ont eu lieu avec les responsables de trois importants projets de la Marine royale canadiennes et d'autres employés du quartier général. Les résultats ont été évalués selon la pertinence des projets pour les prochaines étapes de la recherche. Le projet et les outils de modélisation qui serviront lors de la deuxième et de la troisième étapes ont été sélectionnés.

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(U) Capital acquisition; Modelling and simulation; Manpower and personnel modelling

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