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TEAM MODELLING: REVIEW OF EXPERIMENTAL SCENARIOS AND COMPUTATIONAL MODELS

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Abstract

Defence Research and Development Canada (DRDC) Toronto is in the process of developing team research scenarios aimed at supporting the Canadian Forces (CF) future integrated operations, and interoperability with allies, other government departments (OGDs) and non-government organizations (NGOs). This work falls within a 4-year Applied Research Project (ARP) to include a literature review of relevant team literature, the creation of a platform for conducting experiments on teams, the running of team experiments using a scenario involving one or more Human Systems Integration (HSI) intervention(s), the development of a computational model of team performance, and some preliminary validation of this model. Previous reports (Sartori, Waldherr and Adams, 2006; Go, Bos and Lamoureux, 2006) have reported the outcomes of exhaustive literature reviews on team research and team research platforms respectively.

This report describes the outcomes of two parallel streams of work. The first stream was the development of three team experimental scenarios, in a domestic operational context, appropriate for studying the targeted teamwork factors (i.e. teams-of-teams, joint, interagency, distributed environment). This was done by identifying and reviewing scenarios used previously in team research, leveraging concepts important to team research scenarios identified by the literature review, and incorporating knowledge of future CF requirements in new, composite team research scenarios. The second objective of this report was to evaluate a variety of computational modelling applications for their adequacy in modelling the targeted teams in the targeted scenarios, and to recommend one application as the most suitable.

This report provides detail regarding the different scenarios and computational models evaluated, and provides direction for the further development of scenarios to suit the detailed requirements of the ARP.

Résumé

Recherche et développement pour la défense Canada (RDDC) Toronto élabore actuellement des scénarios de recherche sur les équipes afin d'appuyer les futures opérations intégrées des Forces canadiennes (FC) et l'interopérabilité avec les alliés, avec d'autres ministères et avec des organisations non gouvernementales (ONG). Ces travaux s'inscrivent dans le cadre d'un projet de recherche appliquée (PRA) d'une durée de quatre ans, qui comprendra l'analyse documentaire d'études pertinentes consacrées aux équipes, la création d'une plate-forme pour mener des expériences sur les équipes, la réalisation d'expériences à partir d'un scénario comportant au moins une intervention basée sur l'intégration des systèmes humains (ISH), l'élaboration d'un modèle informatique de rendement d'équipe et certains travaux préliminaires de validation de ce modèle. Des rapports antérieurs (Sartori, Waldherr et Adams, 2006; Go, Bos et Lamoureux, 2006) faisaient état des résultats d'analyses documentaires détaillées portant sur des études consacrées aux équipes ainsi que sur les plates-formes d'étude.

Le présent rapport décrit les résultats de deux volets de recherche parallèles. Le premier volet était consacré à l'élaboration de trois scénarios expérimentaux dans un contexte opérationnel national convenant à l'étude de facteurs spécifiques du travail d'équipe (c.-à-d. des équipes d'équipes, des équipes interarmées, interagences ou décentralisées). Pour ce faire, les auteurs ont réuni et examiné des scénarios ayant servi dans le cadre d'études antérieures sur les équipes, ils ont développé d'importants concepts dégagés par l'analyse documentaire et applicables aux scénarios de recherche sur les équipes, ils ont intégré les connaissances sur les futurs besoins des FC en matière de nouveaux scénarios pour l'étude d'équipes composites. Le deuxième objectif du rapport consistait à évaluer diverses applications de modélisation informatique pour vérifier leur adaptation à la modélisation d'équipes dans des scénarios ciblés et recommander l'application la plus adaptée.

Le rapport fournit des détails sur les divers scénarios et modèles informatiques évalués et propose une orientation quant à l'élaboration de futurs scénarios qui conviendront aux besoins détaillés du projet de recherche appliquée.

Executive Summary

Defence Research and Development Canada (DRDC) Toronto is in the process of developing team research scenarios aimed at supporting the Canadian Forces (CF) future integrated operations, and interoperability with allies, other government departments (OGDs) and non-government organizations (NGOs). This work falls within a 4-year Applied Research Project (ARP) to include a literature review of relevant team literature, the creation of a platform for conducting experiments on teams, the running of team experiments using a scenario involving one or more Human Systems Integration (HSI) intervention(s), the development of a computational model of team performance, and some preliminary validation of this model. Previous reports (Sartori, Waldherr and Adams, 2006; Go, Bos and Lamoureux, 2006) have reported the outcomes of exhaustive literature reviews on team research and team research platforms respectively.

This report describes the outcomes of two parallel streams of work. The first stream was the development of three team experimental scenarios, in a domestic operational context, appropriate for studying the targeted teamwork factors (i.e. teams-of-teams, joint, interagency, distributed environment). The second stream was the evaluation of a variety of computational modelling applications for their adequacy in modelling the targeted teams in the targeted scenarios, and to recommend one application as the most suitable.

Both streams of work began with extensive literature reviews to identify team research scenarios and computational models of interest to this work. The search resulted in a high number of possible scenarios, so scenarios were restricted to those that had already been used for team research, as opposed to those that are used for training.

The review of scenarios was conducted against a number of criteria. Based on the number of criteria the scenario addressed, it was deemed highly relevant, relevant, or somewhat relevant. A total of 37 scenarios were evaluated, of which 15 were deemed highly relevant. Based on the evaluation, it was clear what criteria were consistently addressed in team research, and what criteria have been seldom addressed. This led to the development of a plan to create new scenarios for the purposes of team research at DRDC. This plan was reviewed by the Scientific Authority (SA) and detailed guidance was provided.

Following the guidance of the SA, three scenarios for team research in the CF were created: a natural disaster, a terrorist threat, and an influenza pandemic. These scenarios all involve a three-person CanadaCom team, a three-person Joint Task Force team, and a three-person OGD team (ranging from federal to provincial/local level). The scenarios all have the capability to address the team research factors identified by Sartori et al (2006) as well as being structured to offer a medium level of fidelity and a high level of control. A template is also provided against which to develop the detailed scenario events and their associated measures of performance.

In common with the scenario development work, the evaluation of the computational models proceeded against a list of criteria. A total of 26 modelling applications were assessed against 15 criteria. Given the requirements of the team research ARP, it was concluded that the Integrated Performance Modelling Environment (IPME) was the most appropriate computational modelling platform. This conclusion included the belief that IPME already has a core of experienced and

skilled users which would obviate the need for a ‘new’ learning curve associated with a ‘new’ computational modelling application. No computational modelling application offered any capability above-and-beyond those offered by IPME.

Both the scenario development and the computational model review have the potential to lead to real benefits to the CF. In the first instance, the computational model can quickly and effectively provide insights into the likely impact of human-systems integration (HSI) interventions, as well as identifying where DRDC should focus its attention, either with respect to HSI or with respect to team research. This can result in significant time and financial savings with a greater likelihood of project success. Then, having embarked upon a program of team research, the insights gained will be helpful to the CF when structuring teams, providing tools to enhance team performance, and understanding how to overcome team dysfunction (especially in stressful situations).

This work was performed under contract W7711-047911//001/TOR, call up number 7911-05. The SA for this work was Dr Renee Chow.

Sommaire

Recherche et développement pour la défense Canada (RDDC) Toronto élabore actuellement des scénarios de recherche sur les équipes afin d'appuyer les futures opérations intégrées des Forces canadiennes (FC) et l'interopérabilité avec les alliés, avec d'autres ministères et avec des organisations non gouvernementales (ONG). Ces travaux s'inscrivent dans le cadre d'un projet de recherche appliquée (PRA) d'une durée de quatre ans, qui comprendra l'analyse documentaire d'études pertinentes consacrées aux équipes, la création d'une plate-forme pour mener des expériences sur les équipes, la réalisation d'expériences à partir d'un scénario comportant au moins une intervention basée sur l'intégration des systèmes humains (ISH), l'élaboration d'un modèle informatique de rendement d'équipe et certains travaux préliminaires de validation de ce modèle. Des rapports antérieurs (Sartori, Waldherr et Adams, 2006; Go, Bos et Lamoureux, 2006) faisaient état des résultats d'analyses documentaires détaillées portant sur des études consacrées aux équipes ainsi que sur les plates-formes d'étude.

Le présent rapport décrit les résultats de deux volets de recherche parallèles. Le premier volet était consacré à l'élaboration de trois scénarios expérimentaux dans un contexte opérationnel national convenant à l'étude de facteurs spécifiques du travail d'équipe (c.-à-d. des équipes d'équipes, des équipes interarmées, interagences ou décentralisées). Le deuxième objectif du rapport consistait à évaluer diverses applications de modélisation informatique pour vérifier leur adaptation à la modélisation d'équipes dans des scénarios ciblés et recommander l'application la plus adaptée.

Les deux volets des travaux ont commencé par des analyses documentaires détaillées, pour repérer des scénarios de recherche sur les équipes et des modèles informatiques pertinents. Ce travail a dégagé un grand nombre de scénarios possibles, et il a été décidé de s'en tenir aux scénarios qui avaient déjà été utilisés dans le cadre d'études sur les équipes, par opposition à ceux utilisés pour la formation.

L'examen des scénarios a été réalisé en fonction d'un certain nombre de critères. D'après le nombre de critères auquel il répondait, un scénario était jugé très pertinent, pertinent ou plus ou moins pertinent. Au total, 37 scénarios ont été évalués, et 15 ont été jugés très pertinents. L'évaluation a permis de bien cerner les critères qui étaient traités de façon cohérente par les études sur les équipes et ceux qui avaient été négligés. Il a donc été possible d'établir un plan pour créer de nouveaux scénarios aux fins de la recherche sur les équipes à DRDC. Ce plan a été examiné par l'autorité scientifique (AS), et une orientation détaillée a été fournie.

Suivant l'orientation donnée par l'AS, trois scénarios de recherche sur les équipes dans les FC ont été établis : une catastrophe naturelle, une menace terroriste et une pandémie de grippe. Ces scénarios sont tous basés sur une équipe de trois personnes, soit trois membres de COM Canada, trois membres de la Force opérationnelle interarmées et trois personnes venant d'autres ministères (aux niveaux fédéral et provincial/local). Les trois scénarios permettent d'examiner tous les facteurs intervenant dans la recherche sur les équipes, tel que défini par Sartori et ses collaborateurs (2006), et ils sont tous structurés pour offrir un niveau moyen de fidélité et un niveau élevé de contrôle. Un modèle est également au point pour détailler les scénarios et les mesures de rendement connexes.

Parallèlement aux travaux d'élaboration de scénario, un modèle informatique a été évalué en fonction d'une liste de critères. En tout, 26 applications de modélisation ont été évaluées suivant 15 critères. Compte tenu des besoins du PRA sur les équipes, il a été conclu que l'Environnement intégré de modélisation des performances (IPME) était la plate-forme de modélisation informatique la plus adaptée. Cette conclusion sous-entent l'existence d'un noyau d'utilisateurs expérimentés de l'IPME, ce qui élimine la nécessité de prévoir une « nouvelle » courbe de l'apprentissage pour une « nouvelle » application de modélisation informatique. Aucune application de modélisation informatique n'offrait de capacités supérieures à celles de l'IPME.

Tant l'élaboration de scénarios que l'examen des modèles informatiques peuvent déboucher sur de véritables avantages pour les FC. Dans le premier cas, le modèle informatique peut rapidement et efficacement aider à comprendre l'incidence probable des interventions basées sur l'intégration des systèmes humains (ISH) et à cerner les domaines auxquels RDDC devrait s'intéresser en priorité, qu'il s'agisse d'ISH ou de recherche sur les équipes. Cela pourrait donner lieu à d'importantes économies de temps et d'argent et faciliter la réussite des projets. Après le lancement d'un programme de recherche sur les équipes, les notions ainsi acquises aideront les FC à structurer les équipes, à leur fournir des outils qui améliorent leur rendement et à comprendre comment corriger leurs dysfonctionnements (en particulier en situation de stress).

Ce travail a été réalisé aux termes du contrat W7711-047911//001/TOR, numéro de commande 7911-05. L'AS pour ce travail est Mme Renée Chow.

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1. Introduction

Defence Research and Development Canada (DRDC) Toronto is in the process of developing a team research platform aimed at supporting the Canadian Forces (CF) future integrated (rather than air, maritime, or land-only) operations, and interoperability with allies, Other Government Departments (OGDs) and Non-Government Organizations (NGOs). To support the development of a platform for running team experiments, DRDC Toronto has sponsored two studies focusing on the existing literature on teams, and team research platforms used around the world and the manner in which they are implemented. The review will support the Crown in choosing a specific type of team in a specific work context as the focus of team experiments and team modelling to be conducted in a multi-year Applied Research Project (ARP). DRDC Toronto can apply this understanding to the development of a team research platform that adds to the existing corpus of knowledge about teams, and builds upon the best aspects of the extant platforms while avoiding known deficiencies with these systems. The second of these two studies also reviews the current team research platforms with respect to the scenarios they present to teams, as well as reviewing the available computational models that have been used to model and predict team performance. The direction of this work corresponds to the DRDC Science and Technology (S&T) challenge areas PS-3: Strategies for promoting collaborative behaviour among teams, agencies, organisations and societies; and HU-2: Human systems integration.

In pursuit of this information, DRDC Toronto has sponsored four related streams of work:

1. Conduct a literature review on teams;
2. Conduct a literature review into existing platforms for running team experiments;
3. Review team research scenarios and develop domestic scenarios involving the CF, and,
4. Review projects from around the world describing computational models of teams.

The current contract addresses the latter three work items and this report in particular describes the last two work items. This work has been contracted to Human*systems* Incorporated® as contract no. W7711-047911, call up no.7911-05. The Scientific Authority (SA) for this work is Renee Chow.

1.1 Objectives

The stated objectives of the information in this report are twofold:

To support the identification of an appropriate context for conducting new Human-Systems Integration (HSI) research on teams and to define the approaches for subsequent experimental and modelling work by:

1. developing scenario(s) for team experiments and modelling that are representative of the targeted context;

2. assessing the suitability of a proposed software tool for modelling teams in the targeted context, and recommending alternatives as appropriate.

This particular phase of work focused on an in-depth review of team research literature for the purposes of meeting the objectives. In order to achieve this, the following tasks were performed:

1.1.1 Scenario Development

1. Meet with the Scientific Authority to select a niche for subsequent research.
2. Review relevant documentation to arrive at a thorough understanding of the teamwork of interest.
3. Develop scenarios that are representative of the teamwork of interest. The scenario must be able to support a team experiment involving one or more HSI intervention(s). It must also be able to serve as a basis for developing a computational model of team performance.
4. Propose Measures of Performance (MOPs) and Measures of Effectiveness (MOEs) appropriate for an experiment using the scenarios.
5. Propose one or more augmentation(s) or variation(s) to the scenario developed that can be used for training subjects for the team experiment(s) or for testing the generalisability of the team model.

1.1.2 Computational Models

1. Review IPME manuals.
2. Review open literature and/or technical reports that document the development and/or validation of computational models of team performance implemented in IPME.
3. Propose how the scenario developed above may be implemented as an IPME task network model.
4. Propose how the scenario developed above may be implemented in an IPME crew model.
5. Propose how the scenario developed above may be implemented in an IPME environment.
6. Identify key similarities and differences between the proposed implementation and previous implementations of team models in IPME.
7. Propose how the MOPs and MOEs proposed above may be implemented in IPME.
8. Propose the use of an existing or a new model of workload in IPME for modelling the scenario developed above, and provide the rationale for choosing this workload model.
9. Propose changes or additions to IPME that will increase IPME's utility for modelling the scenario developed above.
10. Propose changes or additions to IPME that will increase IPME's usability for modelling the scenario developed above.

11. If more suitable computational modelling platforms are identified, recommend one or more alternative(s) to IPME that will be more appropriate for modelling the scenario developed above and provide the rationale for the recommendation(s).

An exhaustive bibliographic list and associated literature review was produced under a separate contract (Sartori et al, 2006), but was used extensively to shape this report. In particular, scenarios and computational modelling applications uncovered by that report were drawn upon extensively in developing this work. The bibliographic listing will not be replicated in full in this report. Instead, this report focuses on the detailed findings from the literature reviews undertaken subsequent to the initial literature review. This reflects the fact that the initial literature review identified the most prominent literature and subsequent searches focused on finding additional detail and contacts.

The method adopted for each aspect of this work (i.e. scenario development and computational models) is described in greater detail in the next section.

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2. Method

The methods by which the two discrete parts to this work were addressed are described at a high level in the following two sections.

2.1 General approach to scenario development

In developing a scenario for team modelling, three main steps were taken. The first step was to review the outcome of preceding phases of this ARP. The second step was to conduct a general search for scenarios in support of team experimentation. The last step was to establish the desired scope and breadth of the scenario to be generated. This was done through a number of informal deliverables (described below) highlighting the direction of potential scenarios and the subsequent receipt of feedback and additional guidance from the SA.

2.1.1 Literature review

The literature review of team performance, completed in the first phase of this project (Sartori et al., 2006), identified several key concepts and factors that relate to team performance. Early in the scenario generation process, a brainstorming session was held with HSI® team members who were involved in the literature survey (Sartori et al., 2006), the experimental platform survey (Go et al., 2006) and the scenario development (current task) to identify critical themes relating to team performance that could serve as a basis for scenario development. As a result of this process, four main themes emerged – team factors, task factors, team processes and team measures. Team factors include identifying who is involved in the team, where they are located and what the inter-team relationships are. Task factors describe characteristics inherent to the task, such as task complexity and workload that affect team performance. Team processes refer to those aspects (such as shared knowledge) that emerge out of group interactions. Lastly, team measures define ways of evaluating effects on team performance. These four main themes have been decomposed into a series of criteria. Table 1 presents a list of the criteria that were identified as important to defining a team scenario. Abbreviated definitions are found in Table 1, detailed explanations of these terms can be found in Sartori et al. (2006).

Table 1: List of Criteria

1. TEAM FACTORS	
1.1 Team Size	
Small	Less than or equal to 5 members.
Medium	6 to 19 members.
Large	20+ members.
Teams-of-teams	A team composed of two or more teams (sub-teams).
1.2 Team History	

Ad Hoc	A team without prior history that is assembled in response to a particular situation or problem, likely to be from diverse backgrounds.
Fixed	Teams that have worked together for a long time and have a prolonged history. Personnel routinely working together.
1.3 Physical Distribution	
Distributed	Geographically distributed teams that consist of individuals in different locations, typically understood to use technologically mediated communications.
Co-located	Teams that are located in the same physical space.
2. TASK FACTORS	
2.1 Task Complexity	
Uncertainty	Degree of predictability or confidence associated with a given task.
2.2 Workload	
Physical	i.e. fatigue
Cognitive	i.e. decision complexity
Time Pressure	Urgency, time constraints
2.3 Task Interdependence	
Additive	Individual resources are summed or averaged in order to perform the task (e.g., brainstorming task).
Conjunctive	Performance is based on the team's lowest performer (e.g., assembly line task).
Disjunctive	Based on the team's highest performer (e.g., problem solving task).
Discretionary	Performed by self-managed work groups as they have the authority to autonomously decide how to divide their resources (e.g., management team initiating organizational initiatives).
Pooled interdependence	Requires less coordination as sub-tasks are performed separately and in no specified order.
Sequential interdependence	Requires linear coordination, such that subtasks are completed in a specified sequence (with no return to earlier steps).
Reciprocal interdependence	The completed subtask of one team member becomes the input for the second, and the second's completed subtask becomes the input for the third and so on.
3. TEAM PROCESSES	
3.1 Shared Knowledge	
Team Mental Models	Knowledge about roles/responsibilities, abilities of one's team member(s).
Task Mental Models	Knowledge about task requirements.
3.2 Communication	
Implicit	Voluntary or spontaneous delivery or provision of information without an explicit request for it. (i.e. push)

Explicit	Offering information in response to a specific request. (i.e. pull)
Centralized Network	Messages are routed through a key member.
Decentralized Network	All group members have a potentially equal impact on communication flow.
Hierarchical Network	Similar to centralized networks in that there is a key member, the leader. For example, a tier immediately beneath the leader consists of more junior leaders, who communicate the top leader's messages to the bottom tier.
3.3 Team Coordination	
Implicit	Describes the ability of team members to act in concert without the need for overt communication.
Explicit	Requires that team members communicate to articulate their plans and responsibilities. i.e. planning of roles, responsibilities, tasks, and procedures, and communicating
3.4 Team Adaptability	
Monitoring	Team members observe and assess their own and each other's performance for the purpose of remediating deficient task work and teamwork behaviours.
Feedback	Providing information to other team-mates in order to improve or correct their behaviour.
Backup Behaviours	Promoting team effectiveness by responding in a timely manner to other team-mates needs.
3.5 Planning	
Resource Allocation	Division of team resources including personnel, time, materials, energy, etc.
4. TEAM MEASURES	
4.1 Outcome	
Automation	i.e. Computer
Self-Report	i.e. Questionnaire
Observer	i.e. SMEs
4.2 Level of Analysis	
Individual Performance	Performance considered at the individual level of analysis.
Team Performance	Performance considered at the team level.

2.1.2 Scenario search

A detailed search was conducted using the internet and library system at the University of Toronto to identify scenarios used to date in team research. The goal in conducting this search was to identify example scenarios that have actually been used for team research, in the hopes of better understanding the progress of research within this field. The scope was therefore not limited to the military domain. The search uncovered a large number of team related scenarios, however many were not representative of team experiments. The majority of uncovered scenarios were those that facilitated team training. It was therefore decided that the search for team scenarios should exclude those scenarios used for the purpose of team training, in order to reduce the number of scenarios and allow for a greater focus on team experiments involving data collection and analysis. Only those training scenarios that were associated with the platform review (Go et al., 2006) or the military domain are included in this report. These modifiers refined the search and resulted in a manageable number of scenarios. A total of 37 scenarios were identified.

2.1.3 Mapping of criteria to scenarios

The scenario search led to the identification of existing experimental scenarios that have been used in the area of team research, while the literature survey emphasized criteria that could be important to scenario generation. The 37 reviewed scenarios were then mapped to the criteria listed in Table 1 to uncover emerging patterns. These mappings can be found in Annex A. The end result of this process was the identification of the 'best' or most relevant aspects of scenarios used for team research in the past, while highlighting those factors or dimensions that have been left unexplored by current research. The HSI® team used this approach to ensure that standard 'features' of team research are maintained while emphasizing the opportunities for original and groundbreaking research.

2.1.4 Creation of scenarios

A preliminary plan for the creation of scenarios was presented to the SA outlining expected scenario requirements, two potential scenarios, and the next steps for this work. In this report, it was emphasized that the scenarios should be leveraged from the results of the platform and literature surveys, as well as general knowledge of future CF requirements. From the outset, the SA also identified that the scenario should include joint, interagency and interdisciplinary teams performing operational level activities. Satisfying the SA's requirements led to the identification of other factors that should be incorporated into the scenario. For example, a team composed of joint CF units, multiple agencies, and personnel performing distinct roles can be satisfied by selecting a scenario that allows for teams-of-teams. The same can be said for team history, team distribution, and team size. A team composed of sub teams, assembled to accomplish a specific goal is likely to be an ad hoc team. Further, a scenario that fulfills the requirements of interagency and interdisciplinary will likely involve small or medium teams working from different locations (i.e. distributed). Details of the scenario plan presented to the SA can be found in Annex B. The scenario plan also described potential controlled and manipulated variables, and categories of MOPs. Suggested MOPs came from the literature survey and include shared knowledge, communication and team performance measures. To demonstrate the application of the different criteria to scenarios, two scenarios were described by answering questions outlined in the SOW. The first scenario was based on a real-life domestic joint operation force – Winnipeg Floods, and the second scenario described an international peace support operation involving non-combatant evacuation using a multinational joint force headquarters. The last section of the scenario plan identified steps that could be taken once a scenario was finalised.

After reviewing this plan, the SA proposed a revised plan that emphasized certain aspects and deemphasized other aspects of the original plan with regards to scenario development. The main modification was to consider multiple domestic scenarios and not to develop an overseas scenario. The SA specified that the domestic scenarios should model a natural disaster, a terrorist threat and a pandemic scenario. These scenarios would be broadly sketched out rather than defined in detail. It was noted that the Winnipeg Floods scenario presented in the original scenario plan could be used as the natural disaster scenario. Further, the SA identified key teams (3 teams of 2-3 members) that should be involved in each of the domestic scenarios. Ideally in each scenario, the first team should represent a high level of command within DND, the second team should be representative of a lower level of command within DND, and the third team should include players from an OGD (e.g., Public Safety and Emergency Preparedness Canada (PSEPC)). The SA provided a modified set of questions to be answered when developing the three scenarios. This list of questions, along with additional modifications that were requested by the SA can be found in Annex C.

2.2 General approach to evaluation of computational modelling tools/approaches

Three converging approaches to this work were followed: literature review, email questionnaire and domain expert interview. The information gathered was used to assess the computational models on a number of different criteria (described below).

2.2.1 Literature Review

Extensive literature search were conducted through the Internet (e.g. via Google) and the University of Toronto library system (key words used were "computational modeling", "cognitive modeling", "team modeling", "team performance", "team process"). A total of 26 computational models were identified (see Section 4). The reader should note that "computational model" is taken to mean both unique applications built specifically for some specific purpose and modeling tools/environments that can be used to model any cognitive system. During this research, several good resources for reviews and comparisons of computational models were found and listed in the references to this report.

2.2.2 Email Questionnaire

A questionnaire comprising 14 questions was sent to the contact person (if identified) of each model's developer organization (e.g. research group, institute or company) via email. In total, 23 questionnaires were sent, excluding only 3 models: RESA, PUMA and Wildfires Fight Simulation for Training (the contact persons could not be identified for these models). The questionnaire sent to developer organizations is presented in Annex D, with the responses from the developer of Brahms. Questionnaires sent to the developer organizations of the other 22 models follow the same format except that the name of the model being surveyed was different. 20 responses were received form the following 15 models (Affiliations of the questionnaire responders are included in parenthesis):

IPME (MA&D)

IMPRINT (MA&D)

MIDAS (NASA Ames Research Center) (two responses)

DDD (Aptima, Inc.)

TOD (Aptima, Inc.)

Soar (USC Institute for Creative Technologies, Pennsylvania State University, Soar technologies[1])

Apex (NASA Ames Research Center) (two responses)

D-OMAR (BBN Technologies)

GLEAN (University of Michigan, Soar Technologies[2])

Brahms (NASA Ames Research Center)

JIMM: (Naval Air Systems Command)

C3TRACE: (U. S. Army Research Laboratory)

CAST: (Texas A&M University)

EADSIM (US Army)

Cogitoid (Academy of Sciences of the Czech Republic)

Although responses from all the developer organizations were not received, this method was an efficient method of gathering information quickly in the sense that data received directly from the developers and researchers of each model are more reliable and convenient. It is believed that if more time were available to improve the approach (e.g. improving the way of contacting the developer organization, including a description of each criterion in the questionnaire etc.), more (valid) responses would be received. Regardless, through this process, a contact with the developer organization of a model has been made for in-depth discussions should they be required at a later date.

2.2.3 Domain Expert Interview

One computational modeling expert from NASA Ames Research Center and one human performance modeling researcher from DRDC Toronto were *informally* interviewed via telephone for their opinions on the selected models for assessment. This was also a good way to acquire hidden information and find answers for difficult questions (e.g. publicly unavailable information or new progress/trends or in-depth expert perspective). If time and resources were available, additional expert interviews could have been conducted to evaluate functionality and

[1] Note that Soar has multiple developers

[2] Soar Technologies is not the developer of GLEAN. But a person from Soar Technologies provided opinions on GLEAN.

suitability of identified computational models, especially on those models for which sufficient open information were not available.

As noted above, the information was used to describe the computational model's adequacy in terms of a set of criteria. The criteria were developed from the statement of work and an understanding of what characteristics would be useful to discriminate between different modeling applications. These criteria are listed in Table 2 below:

Table 2: Criteria used to describe Computational Models

Name of computational models	Model specified team tasks
Developer organization	Model specified team interactions
Measure workload	Model HSI interventions of interest
Compatible with IPME	Analyze team's strategies
Scenario flexibility	Analyze team's performance
Domain independent	Available in the public domain
Model team as entity	Stable
Model team as a group of individuals	Real-time computer generated forces

Using this multi-dimensional evaluation of the available computational modeling applications, it would be possible to answer the questions raised in the original statement of work.

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3. Scenario Development Results

The results stemming from scenario development are subdivided into two main parts: discussion of the results of the scenario search and the presentation of scenarios generated specifically for this ARP.

3.1 Scenario Review Results

The scenario search led to the identification of 37 scenarios relevant to team experiments. Fourteen of the reviewed scenarios are associated with platforms described in the previous report (Go et al., 2006). Platforms and scenarios can be tied together in a number of ways. A platform can be used to run multiple scenarios or a single scenario can be used by multiple platforms. Therefore the relation between scenarios and platforms is not a one to one mapping.

Each scenario included in this report was carefully reviewed and evaluated. Of the 37 scenarios, 15 were deemed 'highly relevant', 9 were judged 'relevant' and 13 were deemed 'somewhat relevant' as depicted in Table 3 below. Relevance rankings are based on a 9 point scale that is subdivided into three categories: originality, expandability and complexity. Originality refers to the how original the scenario is, expandability refers to a scenario's ability to incorporate more variables, and complexity refers to the number of variables involved in the scenario. Each scenario can score a maximum of three points in any of the categories and a minimum of one point in each of the categories. A scenario was ranked 'highly relevant' when it scored the maximum number of points in at least two of the categories. A scenario was ranked 'relevant' when it scored a perfect score in one of the three categories. Lastly, a scenario was ranked 'somewhat relevant' when it did not score a perfect three in any of the categories. It is important to remember that all scenarios described in this report have been included because they are suitable for team research.

Twenty-five of the reviewed scenarios were at the operational level and the majority of scenarios included in this report were used for research purposes (N=31). The categories 'level of activity' and 'purpose' were not treated as mutually exclusive categories since a scenario sometimes involved strategic and operational level components, and similarly is used for both training and research purposes. Therefore the summed totals for these categories exceed the number of reviewed scenarios.

Table 3: Overview of Reviewed Scenarios

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria
Relevance	
Highly relevant	15
Relevant	10
Somewhat relevant	12
Total	37
Level of activity	
Strategic	4
Operational	25
Tactical	12
Total	41
Purpose	
Training	10
Research	31
Total	41

The next step in evaluating the team experiment scenarios was to document which criteria the scenarios tended to cover and which criteria have been unexplored by previous research. The mappings of each scenario to the criteria can be found in Annex A. It is important to note that when scenarios were reviewed, if a criterion was explicitly described or alluded to (i.e. the reader could infer that a factor was addressed, then that scenario is assumed capable of supporting that criterion. In the latter case, the mapping of scenarios to the criteria required some judgment on the part of the evaluator. The specific words chosen to describe a criterion are not necessarily the same terms that are used in the scenario descriptions. Therefore the evaluator had to interpret and judge meaning before answering 'yes' to a criterion, especially when the exact term did not appear in the scenario description. To minimize discrepancies in subjective judgement and maintain consistency in mappings, the evaluator was given clear definitions of each criterion beforehand (Table 1), and all 37 scenarios were mapped by the same evaluator. Descriptions of each scenario can be found in Annex E.

It is valuable to understand the context in which the criteria are used. A criterion can be either an independent or dependent variable. An independent variable is that which is controlled for by the experimenter, while a dependent variable is that which may vary and what the experimenter is tracking during a scenario. When the reviewer was unable to determine if a criterion was an independent or dependent variable then the box 'unknown' was populated, indicating that the criteria was used in the scenario but the conditions are unclear.

If a criterion is left blank during the mapping process then this could mean one of two things, that either that level of detail is not given (i.e. the reviewer did not have enough information to make a conclusion) or the scenario is incapable of supporting that feature. Therefore, frequencies tabulated across scenarios should only be considered indicative.

Table 4 below illustrates the clusters and gaps of knowledge for team factors.

Table 4: Team Factors in Reviewed Scenarios

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria			
	Independent Variable	Dependent Variable	Unknown	Total
1.1 Team Size				
Small	27			27
Medium	1			1
Large	2			2
Teams-of-teams	12			12
			Total	42
1.2 Team History				
Ad Hoc	10			10
Fixed	26			26
			Total	36[3]
1.3 Physical Distribution				
Distributed	18			18
Co-located	18			18
			Total	36[4]

Table 4 shows that in each of the reviewed scenarios team factors were considered independent variables. This means that team factors tended to be selected and controlled for by experimenters. The findings suggest that team factors have generally focused on small (N=27), fixed (N=26), and distributed (N=18) and co-located (N=18) teams. Conversely, a small number of scenarios have supported large (N=2) teams.

The team size category is not mutually exclusive. For example team size can be small, medium, or large but also teams-of-teams. If a scenario presented a case where three teams of four, eight and twelve members are working together, then the checkboxes small, medium and teams-of-teams are populated.

[3] Scenario 31, Air Defense Mission of an AWACS using platform C3STARS, did not specify details regarding team history.

[4] Scenario 35, Team C2 Task did not specify the physical distribution of its team.

When the scenario involves teams-of-teams, team history is referring to the history between the teams. When the scenario involves a single team, then team history is referring to the history between members of the team (in real-life). Reviewers applied the fixed criterion to scenarios where teams-of-teams or individual participants are expected to regularly work together. For example, a scenario involving teams of fire, police and ambulance services are considered fixed teams. It is likely that these teams work together regularly and therefore have in place set procedures. The criterion ad hoc is reserved for those scenarios that involved an unusual combination of teams. For example in the ATC pilot scenario (#33), military air crews flew two simulated missions. During one of the simulated flights, 'something went wrong' and thus required the team to communicate and cooperate with persons that don't normally work together. Scenarios are considered ad hoc when the teams were formed in response to unusual emergency situations.

The physical distribution of teams-of-teams is referring to the location of different teams, while the physical distribution of a single team is referring to the location of team members. Reviewed scenarios used both distributed (N=18) and co-located teams (N=18). A scenario was judged to include distributed teams when participants or teams could not communicate face to face but did so via technology.

Table 5 below illustrates the clusters and gaps of knowledge for task factors.

Table 5: Task Factors in Reviewed Scenarios

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria			
	Independent Variable	Dependent Variable	Unknown	Total
2.1 Task Complexity				
Uncertainty	19			19
			Total	19
2.2 Workload				
Physical		2		2
Cognitive	8	6	1	15
Time Pressure	7	2	1	10
			Total	27
2.3 Task Independence				
Additive	33	1		34
Conjunctive	2			2
Disjunctive	1			1
Discretionary	4			4
Pooled	2			2
Sequential	1			1
Reciprocal				
			Total	44

Findings suggest that most of the reviewed scenarios incorporated uncertainty (N=19), cognitive workload (N=15) and additive tasks (N=34). Conversely, a small number of scenarios have explored conjunctive, disjunctive, discretionary, pooled, sequential and/or reciprocal tasks. Although a small number of scenarios have addressed physical workload, we do not recommend that this ARP address physical workload since it is less significant to future CF requirements at the operational level.

Uncertainty was used as an independent variable by 19 of the reviewed scenarios. This is not to say that the remaining 18 scenarios do not incorporate uncertainty of any degree. Although it is expected that all scenarios have some level of uncertainty, it was usually the case that scenario descriptions did not emphasize uncertainty as a variable and therefore the reviewer was unable to confidently draw such a conclusion.

Physical workload was used as a dependent variable, and cognitive workload and time pressure were used as both independent and dependent variables in the reviewed scenarios. A scenario could impose both physical and cognitive workload, as well as time pressure on team members. Therefore the category workload does not comprise mutually exclusive options. It is difficult to gauge whether a scenario has time pressure, so a scenario would answer 'yes' to this criterion when time pressure was indicated as an important variable.

Task interdependence describes how members interact and depend on each other in order to attain a goal. The majority of scenarios consisted of additive tasks, meaning that individual resources are summed or averaged. The category, task interdependence, is not necessarily comprised of mutually exclusive options. For example, a task can be both conjunctive and discretionary. A task of this nature would involve work performed by self managed work groups (discretionary) with the team's lowest performer as responsible for the performance of the team (conjunctive).

Table 6 below illustrates the clusters and gaps of knowledge for team processes.

Table 6: Team Processes in Reviewed Scenarios

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria			
	Independent Variable	Dependent Variable	Unknown	Total
3.1 Shared Knowledge				
Team mental model	3	4	5	12
Task mental model	4	4	5	14
			Total	26
3.2 Communication				
Implicit	2	10	14	26
Explicit		7	15	12
			Total	38

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria			
	Independent Variable	Dependent Variable	Unknown	Total
Centralized network	6		2	8
Decentralized network	6	4	2	12
Hierarchical network	6	1	2	9
			Total	29
3.3 Coordination				
Implicit	4	8	11	23
Explicit		4	12	16
			Total	39
3.4 Team Adaptability				
Monitoring		3		3
Feedback	3	7		10
Back-up behaviour		1		1
			Total	14
3.5 Planning				
Resource Allocation		14		14
			Total	14

With regards to team processes, findings suggest that the reviewed scenarios have focused on task mental models (N= 14), team mental models (N=12), implicit communication (N=26), a decentralized network (N=12), implicit coordination (N=23), feedback (N=10), and resource allocation (N=14). Only one of the 37 scenarios addressed the criterion back-up behaviour.

The category shared knowledge consists of team mental models and task mental models. These two types of mental models are not mutually exclusive. Both criteria are used as independent (presented as part of the scenario) and dependent (measured and analyzed) variables in the reviewed scenarios. No scenario used one mental model as the independent variable and the other mental model as the dependent variable. When both team mental models and task mental models were integral to a scenario, they were classified together as either independent variables, dependent variables or unknown.

Implicit communication is the voluntary or spontaneous delivery of information while explicit communication is the offering of information in response to a specific request. These two types of communication are not mutually exclusive. A scenario answered 'yes' to this criterion when information push (implicit) and information pull (explicit) are allowed or exist within the scenario. In the reviewed scenarios, implicit and explicit communications were both independent and dependent variables. No scenario used one type of communication as the independent variable and the other type of communication as the dependent variable.

Twelve of the reviewed scenarios had teams functioning in a decentralized network, nine in a hierarchical network and eight in a centralized network. The communication networks were classified as independent and dependent variables. Some scenarios (#19, 26, 32, and 34) studied the effects of different communication networks on team performance.

Implicit coordination is team member's ability to act in concert without the need for overt communication and explicit coordination requires team members to communicate and articulate their plans and responsibilities. In reviewed scenarios, implicit coordination was used as the independent and dependent variable while explicit coordination was used only as the dependent variable. Implicit and explicit coordination are not mutually exclusive.

Team adaptability consists of monitoring, feedback and back-up behaviours. Monitoring is when team members observe and assess their own and each other's performance. Feedback is providing information to other team members in order to improve or correct behaviours, and backup behaviour is promoting team effectiveness by responding in a timely manner to team members' needs. Monitoring and back-up behaviours were used in the reviewed scenarios as dependent variable. Feedback was used as both independent and dependent variables. These behaviours are not mutually exclusive.

In 14 of the 37 scenarios resource allocation was a dependent variable. In many of the scenarios, resource allocation was tracked by a computer and analyzed by graphic tools.

Table 7 below illustrates the manner in which the reviewed experimental scenarios were measured.

Table 7: Measures of Performance in Reviewed Scenarios

Evaluation Criteria	Number of Scenarios that met Evaluation Criteria
4.1 Outcome	
Automation	28
Self-Report	12
Observer	13
Total	53
4.2 Level of Analysis	
Individual	11
Team	35
Total	46

These findings suggest that most experimental scenario outcomes were measured automatically (N=28) and the level of analysis tended to be teams (N=35). The method employed to measure the dependent variable is selected by experimenters. Automation, self-report and observer are not mutually exclusive criteria. Similarly, the level of analysis can be both at the individual or team level.

3.2 Team Research Scenarios

Having received detailed guidance from the SA regarding the emphases of the scenario to be developed, three scenarios were developed. Of these, two were fictitious and incorporated the most desirable features identified in the review of previous team research scenarios. The first scenario is based on real events that occurred during the Winnipeg Floods of 1997. This scenario is also the subject of large-scale joint exercises at the operational and strategic level in and around the National Capital Region.

At a high level, the SA provided significant direction regarding the structure of the teams to be represented in the scenario and the subjects of the scenarios. Further to that, the SA provided guidance regarding the factors she would like described within each scenario.

3.2.1 Team Structure – General Approach

For expediency in an experimental environment and due to a lack of publicly available information, the team structures adopted for the scenarios represent an abstraction of how teams from different organizations might actually operate if an emergency situation were to occur in Canada. Accordingly, any reference to specific team members and the flow of information between teams is an approximation of how the Department of National Defence (DND) and Other Government Departments (OGDs) could operate.

The scenarios were developed with the goal of emphasizing interactions within and between teams at the operational level. Therefore three teams were chosen. One team is representative of a high level of DND Command such as CanadaCom, the second team is a lower level of DND Command such as a Regional Joint Task Force, and the third team represents an OGD such as PSEPC. Choosing these teams to participate in the scenarios fulfilled the requirements of an environment that supports teams-of-teams in a joint, interagency and distributed setting. The expected relationship between teams is depicted in Figure 1, whereby arrows represent possible lines of communication.

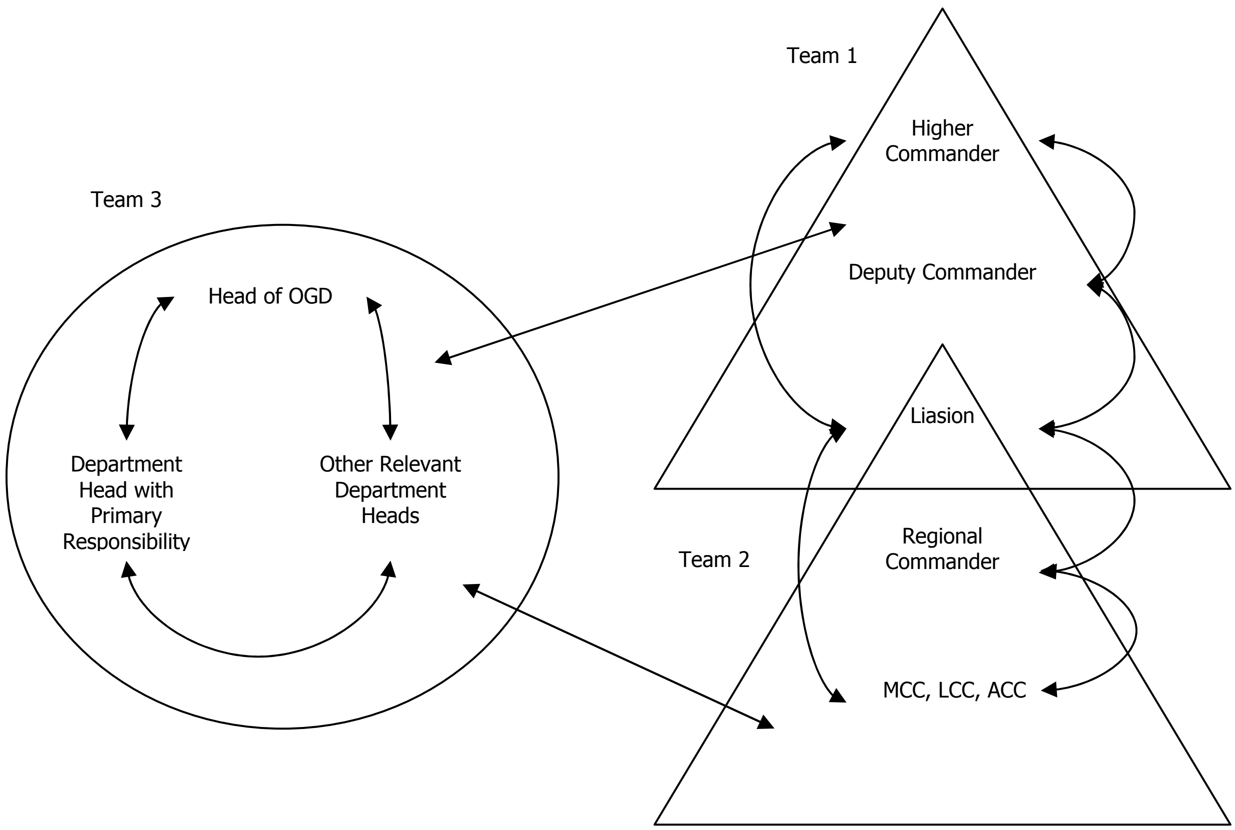

Figure 1: Proposed structure of teams-of-teams for team research scenario

The lines of communication between teams are unclear because of a lack of publicly available information since the CanadaCom organization the regional joint task forces have only gained operational readiness in February of 2006. Further, there is a lack of publicly available detailed examples demonstrating how CanadaCom would execute its responsibilities in a manner that is coordinated with other local, provincial and federal government bodies during a domestic emergency situation. However it is expected that when teams would work together in response to an emergency domestic situation the following information would be regularly communicated and updated:

- Who: who is the requesting agency and what are the points of contact
- What: what types of support is required to accomplish the mission
- When: when is the support required and what the desired duration is
- Where: what is the specific location for the proposed operation
- Why: statement as to why support is needed. This will also help in determining what types of resources are required.

Although the lines of communication are unclear at this point, it is expected that the lines of communication between CanadaCom, the Regional Task Force and the OGD would be preserved from scenario to scenario since the goals of the CF transformation and the subsequent inception of CanadaCom is a centralized organizational scheme. The updated CF structure is expected to clearly delineate authority, responsibility, chain of command and accountability. Further, the new CF structure emphasizes a clear separation of strategic and operational responsibilities. The strategic level of command is responsible for strategic decision making, policy, strategic planning, resource allocation, processes and strategies. The operational level of command is responsible for the execution of standards set out by the strategic level.

The Commander of CanadaCom is to report directly to the Chief of Defence Staff (CDS). CanadaCom is further divided into six task forces based on geography. Each regional joint task force is responsible for all domestic and contingency operations within their region. The six regional joint task forces are:

- Pacific Command (British Columbia),
- Prairie Command (Alberta, Saskatchewan, Manitoba),
- Central Command (Ontario),
- Eastern Command (Quebec),
- Atlantic Command (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador),
- and Northern Command (Yukon Territories, Northwest Territories and Nunavut).

The operational level of command (CanadaCom and Regional Joint Task Forces) is responsible for employing forces to attain strategic objectives in a theatre or area of operations through the design, organization and conduct of campaigns and major operations. Further, at the operational level, activity is conceived and conducted as one single concentrated effort, rather than according to the various environmental forces.

CanadaCom and Regional Joint Task Forces are likely to communicate via a CF liaison. It is unclear as to how the CF would communicate with OGDs and vice versa, but it is also expected that this would be facilitated by a liaison officer. Within each of the three teams, team members can communicate directly, therefore the relationships between and within CanadaCom, a Regional Joint Task Force and an OGD allows for horizontal and vertical communication.

The structure described above does not present detailed descriptions of how CanadaCom, a regional joint task force and the OGD would operate. This is due to a lack of publicly available information as well as to preserve flexibility within the scenarios. The above structure results in a medium level of fidelity which affords some degree of experimental control. Ideally, the goal is to balance experimental control with realism.

3.2.2 Scenario Events – General Approach

The above section presents a model of how teams could be structured within a scenario. In addition to this, it is valuable to conceive of a possible flow of events that could take place during a scenario. This section presents a model of how a scenario and its sub events could be staged by researchers.

From the onset, the SA specified an interest in multiple domestic scenarios with less granularity, sketched out rather than fully instantiated. Therefore this section suggests a systematic method for developing detailed scenarios (although the detailed scenarios is not developed), ensuring that relevant components can be cultivated to a level sufficient to run an experiment. If this were not done, any experiment would always run the risk of failing due to some incongruity in the scenario.

To demonstrate the sorts of detail that would need to be specified in a final scenario, conceptual diagrams are presented below: one is a high level view (Figure 2) and one is a lower level view (Figure 3).

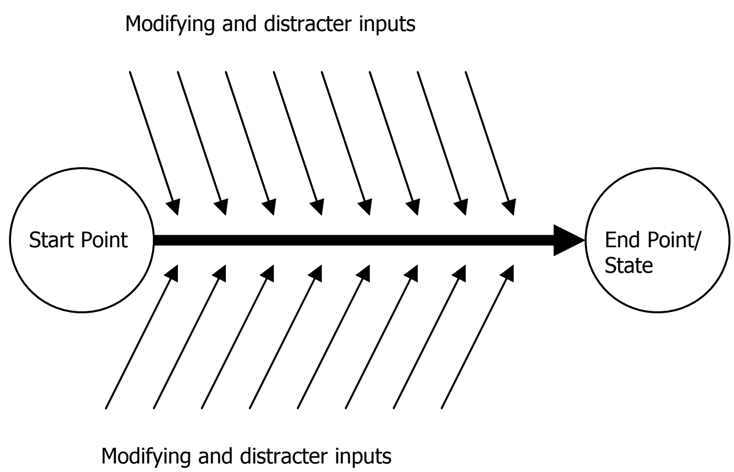

Figure 2: Overview of scenario flow

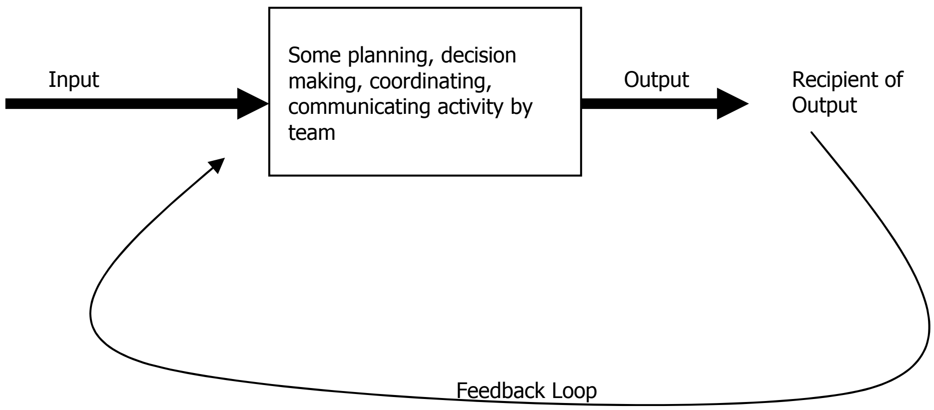

Figure 3: General task structure throughout scenario

The overview of the scenario (Figure 2) shows that each scenario must have a trigger point. This could be a request from a regional authority, intelligence information, or some actual event. An option could be to direct the trigger point to the OGD who must then decide if and when to involve DND. The trigger point will need to be adequately defined and delivered to the recipient as some sort of input (to account for situation awareness needs, this trigger point will most likely take the form of a written brief with accompanying maps and/or animations). The teams participating in the experiment will need to plan the actions of their resources to resolve the scenario. Each scenario will have a number of conditions that will need to be satisfied before the scenario will be deemed over. Although this point may become increasingly apparent to participants, it will be the responsibility of the lead researcher to call a halt to the experiment.

The other feature of the scenario overview is the incorporation of modifying or distracter inputs throughout the scenario. It was felt that these additional inputs are necessary to ensure that experimental results mirror real-world situations. These inputs do not compromise experimental control. Indeed, they are under the complete control of the researchers and can be planned in advance and deployed as appropriate. These inputs are likely to directly serve the research purposes of the team running the experiment. Because these inputs will either modify the task performed by the team (e.g. intelligence changes the area of operations), or distract the team from the task at hand (e.g. media request for a briefing) different team processes and factors can be provoked and exercised. Thus, when developing the detailed scenario, the start and end points must be defined, as must the planned inputs.

Figure 3 shows the detail of how each input (both the start point and modifying or distracter inputs) will be acted upon and how it may further modify the scenario. The team or the team member will receive an input via some route (e.g. paper, telephone, etc.). This will trigger some activity by the team and its members, resulting in an output. That output will be received by someone, either internal to the team or external to the team (e.g. other teams in the experiment, peripheral organisations, subordinate formations, etc.) thus triggering further activities. However, this may also result in feedback to the team, which itself is another input which may modify the task. The output could also just be some step (internal to the team) on the way to achieving a broader goal for the team. When developing the detailed scenario, the specific inputs must be defined as should the expected outputs. Further, the possible expected feedback must be defined so the scenario does not move in unanticipated directions. With this detailed understanding, it will be possible to develop detailed scenario-based MOPs.

Feedback to the team could be provided by simulation players or an overall 'Experiment Manager'. This approach is used by the large-scale simulations undertaken by the Army Simulation Centre (ASC). The ASC employs many contractors and actual subordinate units to operate the ATHENA tactical system, implement the plan at a tactical level, and feed back information into the planning staffs. Given that scenario development will identify the desired output based on an input that occurs at a specific time, if the output is not produced in a timely manner, feedback could be negative (e.g. casualty rate rises, flood waters pass a critical dam, etc.).

3.2.3 Scenarios

The SA requested that three scenarios be developed at a coarse level of detail: a natural disaster; a terrorist threat; and a pandemic. The SA requested that these scenarios be described according to a number of dimensions. Each scenario is briefly described below and then the specific dimensions of each scenario are described in Table 8.

3.2.3.1 Scenario 1 – Natural Disaster: Winnipeg Floods

The first scenario is the Winnipeg Floods. The Red River Flood of 1997 was a major flood that occurred in April and May 1997, along the Red River in North Dakota, Minnesota, and Manitoba. It was the most severe flood of the river since 1826. The flood reached throughout the Red River Valley, affecting the city of Winnipeg. Operation Assistance was the name given by the Canadian Forces for military support to the civil authorities during the flooding.

Organizations that could be involved (as well as DND):

- City/Provincial Departments – Ambulance, Fire, City of Winnipeg Police Service, Harbour Patrol, Social Services, Emergency Preparedness and Coordination Committee (EPCC), Centre for Emergency Preparedness and Response (CEPR)
- Federal – Royal Canadian Mounted Police (RCMP), Public Safety and Emergency Preparedness Canada (PSEPC), Emergency Public Information Team (EPIT), Public Health, Public Utilities, Public Works
- Outside Agencies – Media
- Private Sector – United Way, Meals on Wheels, Red Cross, Salvation Army

3.2.3.2 Scenario 2 – Terrorist Threat

This scenario is fictitious but would involve an intelligence report that a terrorist organisation is to launch an imminent attack on the financial district of Toronto. The report is not specific enough to deploy forces to counter the threat. Rather, the warning is such that the precise nature of the threat is unknown, and the various teams must mobilise resources to address a wide range of potential eventualities.

Organizations that could be involved (as well as DND):

- City/Provincial Departments – Ambulance, Fire (Hazmat), Ontario Provincial Police (OPP), Toronto Police Service (TPS), Toronto Police Bomb Squad
- Federal – RCMP, PSEPC, Canadian Security Intelligence Service (CSIS), National Security Investigation Sections (NSIS), Integrated National Security Enforcement Teams (INSETs) (NSIS and INSETs are specialized units within the RCMP), RCMP Bomb Squad, Public Health
- Outside Agencies – Media
- Private Sector – Salvation Army

3.2.3.3 Scenario 3 – Influenza Pandemic

This scenario is fictitious but based on the recent Severe Acute Respiratory Syndrome (SARS) outbreak and the looming threat of the avian flu (H5N1) virus. A variety of parties would need to be involved in order to set up and enforce quarantine, conduct widespread health monitoring and testing, and take steps to ensure that disease vectors are blocked.

Organizations that could be involved (as well as DND):

- City/Provincial Departments – Fire, Police, Ambulance
- Federal – Health Canada (to act as a Federal authority on this health matter, to involve other appropriate Federal Ministries (i.e. Defence, Finance, Citizenship and Immigration etc.) in effecting an emergency response), Global Public Health Intelligence Network (GPHIN) Officials, Centre for Emergency Preparedness and Response (CEPR) (part of Public Health Agency of Canada), Pandemic Influenza Committee (PIC)
- Outside Agencies – Media
- Private Sector – Salvation Army, Red Cross

Table 8: Team Research Scenarios

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
Teams-of-teams	**Yes**. Local/provincial officials contact higher authorities. JTFPrairie is activated. CanadaCOM and JTFPrairie work with Local and Provincial Authorities such as the Manitoba Emergency Measures Organization (EMO), to coordinate the disaster response process, plan the evacuation of danger zones as well as coordinate resources (water, food and shelter to sandbags etc.).	**Yes**. Intelligence of a threat is passed on to CanadaCOM and RCMP. RCMP is tasked as the main coordinator for evacuating the area and ensuring the bomb is diffused before any damage is done. Responsibilities include the investigation of any offence relating to a threat to the security of Canada. Joint Task Force Central is also involved.	**Yes**. Local BC hospitals have seen an influx in the number of patients being treated for Influenza. The Ministry of Health is contacted, and subsequently delegates the Public Health Agency of Canada. Assistance is requested from CanadaCOM to help coordinate a plan of action to control and diffuse the pandemic.
Clear and meaningful start and end points	**Start**: Local officials are unable to deal with rising flood waters and associated impacts, and are therefore asking for assistance. **End**: The situation is managed, natural escalation (e.g. rain, snow melt) has passed, dangers are minimized and local authorities are capable of dealing with the situation.	**Start**: CanadaCOM and the RCMP have been notified of intelligence indicating that a bomb will explode in the downtown financial district of Toronto **End**: Bomb is diffused, and citizens are evacuated in a timely manner.	**Start**: Influenza is identified and confirmed in multiple human cases and is becoming a pandemic within the BC region. **End**: Influenza vectors are known and controlled for.
Joint	**Yes**, Land, Sea and Air may be involved.	**Yes**, the Task Force (TF) comprises Land and Air Forces (evacuate citizens using helicopters and other aircraft).	**Yes**, the TF comprises Land and Air Forces. (The Air Force can be used to evacuate civilians and/or bring in supplies)
Interagency	**Yes**, there are agencies from DND as well as OGDs and the local and provincial level.	**Yes**, there are agencies from the Department of National Defence (DND) as well as Other Government Departments (OGD)	**Yes**, there are agencies from the Department of National Defence as well as Other Government Departments (OGD)
Who are the 3 Teams?	**Team 1**: CanadaCOM **Team 2**: Joint Task Force Prairie **Team 3**: Local/Provincial Authorities - i.e. Ambulance, Fire, City of Winnipeg Police Service	**Team 1**: CanadaCOM **Team 2**: Joint Task Force Central **Team 3**: RCMP	**Team 1**: CanadaCOM **Team 2**: Joint Task Force Pacific **Team 3**: Public Health Agency of Canada

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
Distributed	**Yes**, agencies involved are not co-located. CanadaCOM – Ottawa JTFPrairie– Edmonton Local Authorities – Winnipeg	**Yes**, agencies involved are not co-located: CanadaCOM – Ottawa JTFCentral – Toronto RCMP – national security related criminal investigations are centrally coordinated by personnel located at RCMP National Headquarters (Ottawa).	**Yes**, agencies involved are not co-located. CanadaCOM – Ottawa JTFPacific– Victoria Public Health Agency of Canada – Winnipeg
Who are the team members?	**Team 1: CanadaCOM** Higher Commander Deputy Commander **Team 2: Joint Task Force Prairie** Regional Commander (and 2 of the 3) J2 (Intelligence) J3 (Plans) J9 (CIMIC) **Team 3: Local/Provincial Authorities** Police, Fire Ambulance	**Team 1: CanadaCOM** Higher Commander Deputy Commander **Team 2: Joint Task Force Central** Regional Commander (and 2 of the 3) J2 (Intelligence) J3 (Plans) J9 (CIMIC) **Team 3: RCMP** Deputy Commissioner in charge of the Central region (Quebec and Ontario) Chief Information Officer Integrated National Security Enforcement Teams (INSETs) (specialized unit within the RCMP).	**Team 1: CanadaCOM** Higher Commander Deputy Commander **Team 2: Joint Task Force Pacific** Regional Commander (and 2 of the 3) J2 (Intelligence) J3 (Plans) J9 (CIMIC) **Team 3: Public Health Agency of Canada** Co-ordination and Operations Group (COG) Technical Advisory Group (TAG) Emergency Communications Group (ECG)
How are teams organized?	Please refer to Figure 1; more detail regarding organization was beyond the scope of this contract.		

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
What function does each team perform? (i.e. strategic, operational, tactical)?	**CanadaCOM** – operational **JTFPrairie** – operational **Local and Provincial Authorities** – operational	**CanadaCOM** – operational **JTFCentral** – operational **RCMP** – operational	**CanadaCOM** – operational **JTFPacific** – operational **Public Health Agency of Canada** – operational
Overall Goals	Overall goal: To evacuate and accommodate all those in danger and minimize property damage Without conducting a detailed analysis it is not possible to specify goals and priorities at the team or team member level. This level of detail was beyond the scope of this contract.	To evacuate area, maintain public calm, manage situation, investigate, ensure other areas are not under threat, protect high valued resources, mobilize resources surveillance, alert public and necessary agencies, debriefing, reporting Without conducting a detailed analysis it is not possible to specify goals and priorities at the team or team member level. This level of detail was beyond the scope of this contract.	To control the spread of the pandemic, to minimize risk/threat, use of precautionary measures, preservation of health within the community, to maintain order, surveillance, vaccine programs, use of antivirals, health services, emergency services, public health measures and communications. Without conducting a detailed analysis it is not possible to specify goals and priorities at the team or team member level. This level of detail was beyond the scope of this contract.

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
What are the teams' primary and secondary tasks?	**Team 1: CanadaCOM** – mobilize JTFPrairie, carry out strategic goals **Team 2: JTFPrairie** – Execute the military support required by the lead department or ministry: deploy units to evacuate people in danger zones, ensure open lines of communication with citizens, accommodation for those evacuated, protection of high risk properties, dike construction, sandbags, support agencies effectively **Team 3: Local and Provincial Authorities** – Coordinate the efforts of the local Police, Fire and Ambulance services, as well as local public works. Also, use local knowledge to assist other agencies (i.e. DND) to be most effective.	**Team 1: CanadaCOM** – mobilize JTFCentral, carry out strategic goals **Team 2: JTFCentral** – Deploy units to evacuate people in danger zones, ensure open lines of communication with citizens, accommodation for those evacuated, protection of high risk areas, support agencies effectively **Team 3: RCMP** – the investigation of any offence relating to a threat to the security of Canada	**Team 1: CanadaCOM** – mobilize JTFPacific, carry out strategic goals. **Team 2: JTFPacific** – Deploy units to assist in controlling the movements of the population, ensure open lines of communication with citizens, support agencies effectively, contribute to the overall surveillance and status of the situation, ensure that the health of CF personnel and citizens, and the impact on CF operations is minimized **Team 3: Public Health Agency of Canada** – tend to infected and deceased. Provide basic needs to citizens (food, water, lodging, clothing) hygiene, public health (waste disposal, assessment of vulnerable populations, immunization, psycho-social support, quarantine or isolation, identification of deceased), health care services (triage)
What demands are imposed on the teams?	**Emergency Situation**: High time pressure High level of uncertainty High level of risk to public safety (emergency crews and citizens)	**Emergency Situation**: High time pressure High level of uncertainty High level of risk to public safety (staff and bystanders)	**Emergency Situation**: High time pressure High level of uncertainty High level of risk to those involved in trying to control the pandemic (staff) High level of risk to public safety
Options for communication and coordination	Existing Lines of Communications (LOC) such as land and cellular telephone, radio, person to person, pagers, wireless tools (internet, instant messaging(chat)), satellite communications, teleconferencing, videoconferencing, text-based communication (text messaging on cell phones, email), faxes		

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
Highlight key decisions and/or action points for teams	**Team 1: CanadaCOM**– number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, specify Transfer of Authority (TOA) **Team 2: JTFPrairie** – number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, determine Area of Operations (AOO), direct planning for the operation **Team 3: Local/Provincial Authorities** – providing overall direction and coordinating activities of City departments, outside agencies, the public sector and volunteer groups during an emergency.	**Team 1: CanadaCOM** – number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, specify Transfer of Authority (TOA) **Team 2: JTFCentral** – number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, determine Area of Operations (AOO), direct planning for the operation **Team 3: RCMP** – employ investigate methods and tools such as surveillance and the use of agents, proper handling of sensitive information	**Team 1: CanadaCOM** – number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, specify Transfer of Authority (TOA) **Team 2: JTFPacific** – number of CF to deploy, allocate resources, specify mission, specify Command and Control (C2) arrangements, delegate authority, determine Area of Operations (AOO), direct planning for the operation **Team 3: Public Health Agency of Canada** – prioritization of needs, alert other health institutions (hospitals, paramedics, fire services), determine number of public health staff required, what basic needs are required (amount of food, water…), amount of medication needed

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
Define positive vs. negative outcomes	**Positive**: all citizens are evacuated, minimal casualties, minimal property damage, coordinate maximum number of resources in shortest amount of time **Negative**: Mass casualties, significant property damage, failure to coordinate resources in a timely manner	**Positive**: all citizens are evacuated within danger zone, no fatalities, no property damage, coordinate appropriate resources in required amount of time, safety of citizens is maintained, maintain control **Negative**: Terrorist threat is realised, mass casualties, significant property damage, failure to coordinate resources in a timely manner, incident is out of control (public chaos and panic), inappropriate resources deployed for threat	**Positive**: Transmission rate and the spread of the disease is significantly reduced, the Pandemic does not travel beyond the BC border or into new area within BC, minimal fatalities and infection, coordinate maximum number of resources in shortest amount of time, safety and hygiene of citizens is maintained, maintain control **Negative**: Influenza had spread to new areas of BC and may also have crossed beyond the BC borders making it a national pandemic, mass casualties and infection, failure to coordinate resources in a timely manner, incident is out of control – citizens are panicking, rate of transmission increases, safety and hygiene of citizens is at jeopardy
Identify one or more HSI intervention(s) whose effectiveness may be explored using these scenarios	Communication tools between/within agencies Communication channels/media for public dissemination of info Decision support systems for command teams Systems to enhance situation awareness (a necessary precursor to decision making), not just of the evolving situation and how it will evolve, but also of the possible resources that are available.		

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
Further develop MOPs and MOEs	**MOEs:** Did teams accomplish mission? Was mission accomplished within targets (i.e. budget, time)? Did all teams feel they were used effectively? (possibly a subjective/questionnaire measure) Number of lives saved (based on geographical density and evacuation/quarantine areas developed) **MOPs:** Response time of individual teams and team members' Number of resources employed Match of resources to need Effectiveness of communications between/within teams Shared team mental model(s) Quality of Plan Coordination among teams Ability to effectively and efficiently use all the resources available to the different teams Individual team members' workloads Number of outputs made in specified time Observed versus desired outputs Prioritisation of tasks and information		
Which factors of team performance or team effectiveness can each scenario explore?	Shared knowledge, communication, coordination, team adaptability, planning, task complexity, workload		
Which factors are expected to be especially influential in the scenarios?	Time Pressure, Task Complexity, Task Interdependence, Planning, Individual Experience, Stress, Risk, Availability of (new) Information, Prioritisation, Participant Availability		
For each influential factor, what level of the factor does this scenario represent?	Each factor can be manipulated to suit the experimental aims of the research		

Points of interest	Scenario: Natural Disaster: Winnipeg Floods	Scenario: Terrorist Threat	Scenario: Influenza Pandemic
How well do scenarios support team experiments? How well do scenarios support computational modelling of teams?	All scenarios are flexible enough to accommodate investigations into the relevant team factors, processes, etc. identified in Sartori et al (2006). Scenario can provide inputs, entities involved, processes, individual tasks and outputs. The three team scenarios developed for this report are meant to serve as a starting point for developing a customized domestic scenario that can be used for either live team experiments or computational modelling of teams. However, before this can be done, the following types of information should be further explored: • Network configuration between teams and within teams (i.e. centralized network, decentralized network or hierarchical network). • Similarities and difference in team tasks/goals and team members' tasks/goals.		
Is there a conceptual model of team performance/effectiveness (from literature) that can be tested by experiments using this scenario?	1) Command Team Effectiveness Model: Essens et al. (2005): model of team performance that was developed in order to identify critical factors in command team effectiveness 2) Contextual Model of Groupware Development: Driskell & Salas (2006) contextual model of groupware development		
Is there a computational model (i.e. IPME) of team performance/effectiveness (from survey) that can be tested by experiments using this scenario?	**No**: existing computational models are for intact teams performing tasks at a tactical level		
To conduct experiments with low/medium fidelity and medium/high control, who should participate in the experiment (i.e. profile sketch)?	Participants should have operational experience, be familiar with relevant policies and procedures for emergency planning and response Commanders who are fully conversant with the tactics, techniques, capabilities, needs and limitations of forces, and the environment. However, with adequate briefing materials, time to familiarise and a carefully managed and bounded scenario (communicated by the briefing materials) novices could be drafted in to participate. This would be problematic though, because each of the three teams would therefore be an ad hoc team, decreasing the control over the experiment.		
What screening/training should be provided to the experiment participants?	Training - Doctrine for emergency planning, relevant software and hardware that will be used to conduct experiment, adequate briefing of roles, responsibilities, available information, available resources, etc. (If option to use novices is pursued). Screening – Relevant operational experience, familiarization with emergency planning and response		

As mentioned in Table 8, the most relevant conceptual models to the team research scenarios are Essens et al. (2005) and Driskell & Salas (2006). Essens et al (2006) present the Command Team Effectiveness Model (CTEM) to identify critical team performance factors in command team effectiveness. The Command Team Effectiveness Model (CTEM) is illustrated in Figure 4.

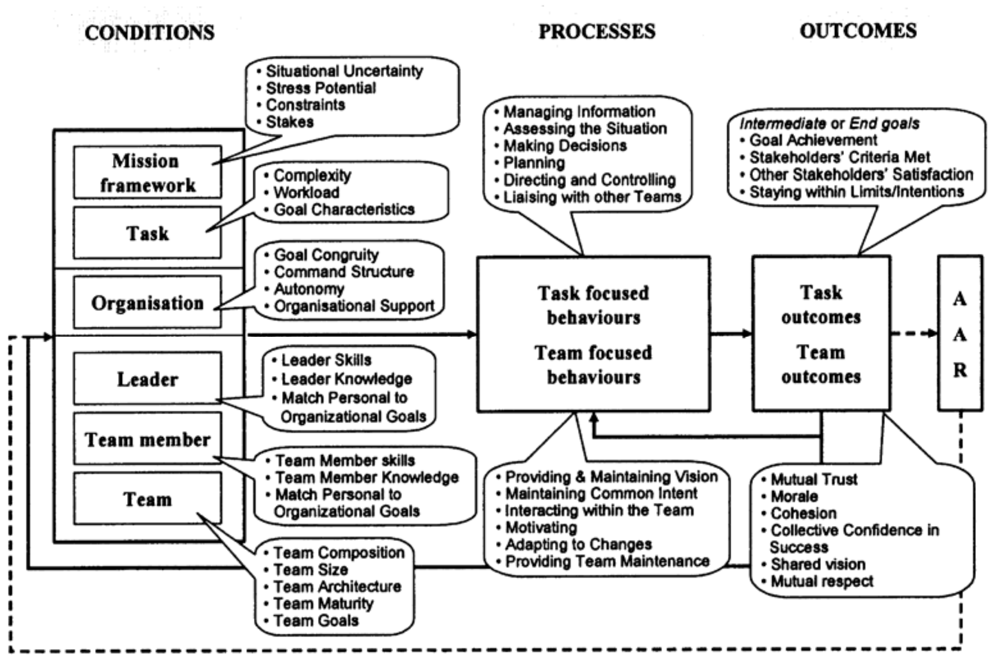

Figure 4: Command Team Effectiveness Model (Essens et al. (2005))

As illustrated in the figure above, many factors presented in the CTEM model are also found in the criteria that came from the literature survey including uncertainty, complexity, workload, team size, planning, etc. The other model that may be applicable to our scenarios is the Contextual Model of Groupware Development developed by Driskell & Salas (2006) (Figure 5).

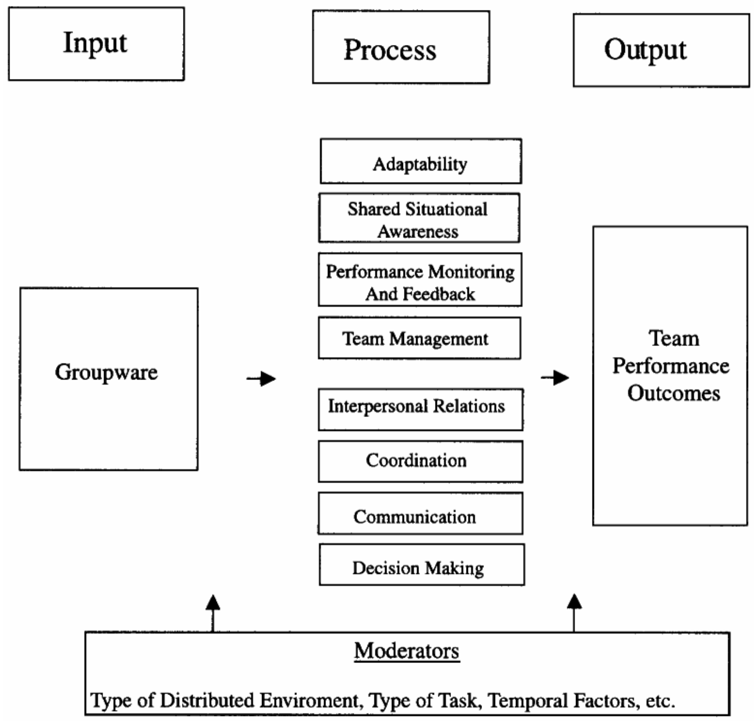

Figure 5: Contextual Model of Groupware Development (Driskell & Salas (2006))

This model supports distributed teams and is geared towards team functions that support team performance. Therefore a large emphasis is placed on team processes. More detailed explanations of both these models can be found in Sartori et al. (2006). The primary reason these conceptual models are deemed most relevant to the team research scenarios developed in this project is the scenarios that were generated include a complex number of tasks, factors and processes, and therefore most closely matched conceptual models that adequately represented the interplay of multiple tasks, factors and processes. Other models reviewed by Sartori et al (2006) are less inclusive and address a smaller range of factors, ignoring the role of contextual or situational factors. Conversely, both Essens et al. (2005) and Driskell & Salas (2006) provide conceptual models that perform more than a limited aspect of team performance, and though not corresponding precisely to the scenarios developed for this project, these models are the better conceptual matches.

3.3 Mapping the developed scenarios to the criteria

Earlier, the criteria identified in the literature review (Sartori et al., 2006) were mapped to the reviewed scenarios. To get a sense of how the developed scenarios compare to the reviewed scenarios, the developed scenarios have been mapped according to the same criteria that came out of the literature review.

As noted earlier, team factors consist of criteria such as team size, team history and physical distribution. Most reviewed scenarios used teams that were small in size. Conversely, the developed scenarios would include three teams of 2-3 members each. Two of the teams would be of DND (CanadaCom and JTF) origin and the third team would be an OGD. Each sub team is considered small while the entire teams-of-teams structure is of medium size (N=8). The majority of the reviewed scenarios focused on fixed teams. The developed scenarios provide opportunities for both fixed and ad hoc teams. The individual teams (CanadaCom, JTF, OGD) are expected to be fixed as individuals within teams likely have a history of working together. CanadaCom and the JTF are also likely to be a fixed team since they are expected to have worked together in the past. Even if these two teams have not had the opportunity to work together, it is likely that DND has in place set procedures governing responsibilities and interactions. On the other hand, The DND teams and the OGD team are more likely to be an ad hoc team. Although it is conceivable that DND has worked with OGDs, it may not be the case that the specific OGD involved in the scenario has worked with DND in the past. The reviewed scenarios used both distributed and co-located teams. The developed scenarios propose to do the same thing. The individuals within each team are co-located while the headquarters each of each team are distributed across the country; therefore sub teams are co-located while teams-of-teams are distributed.

Task factors consist of criteria such as task complexity, workload and task interdependence. More than half of the reviewed scenarios emphasized uncertainty as an important variable. The developed scenarios can accommodate varying levels of uncertainty since the nature of the scenarios is an emergency situation where teams are required to manage a dynamic and constantly changing set of circumstances. In terms of workload, reviewed scenarios focused on cognitive work. The developed scenarios also focused on cognitive workload as teams are actively involved in decision making, planning etc. To increase the impact of the emergency situation, experimenters can manipulate time pressure. In the Winnipeg floods scenario, experimenters can increase the rate at which flood waters rise; in the terrorist threat scenario teams could be alerted of intelligence regarding another bomb in a different location; in the influenza pandemic scenario the rate of transmission could occur at an unprecedented rate. Among reviewed scenarios, additive tasks were most common. The developed scenarios could accommodate additive type tasks, as well as other types of tasks. In each of the developed scenarios, many tasks are being performed by individuals with different roles. The extent and type of interdependence within teams and between teams is unclear. However, the magnitude of the scenarios makes it unlikely that teams could succeed if they worked in isolation.

Team processes consist of criteria such as shared knowledge, communication, coordination, team adaptability and planning. In the developed scenarios, mental models could be examined on various levels. Team mental models may refer to the resulting mental model of each team or the teams-of-teams mental model. Task mental models could be referring to the tasks given to each team member, the tasks given to each team, or the task given to all teams as a whole. Similarly, implicit and explicit communication as well as implicit and explicit coordination can occur at various levels – between individuals and between teams. It is expected that in the developed scenarios, the network configuration within teams will be a hierarchical network, especially within the DND teams. This is because the CF is hierarchical by nature and the developed scenarios aim to accurately depict real team configurations. What is unclear for each of the scenarios is what the teams-of-teams network configurations would be. Furthermore, if teams-of-teams formed a centralized network it would be necessary to identify the lead team. In the developed scenarios, team adaptability is important to monitor, especially if planned modifying inputs (discussed in section 3.2.2) are integrated into the scenarios. How well teams are able to respond to changes and correct for inefficient practices can provide valuable insights. Resource allocation can also be triggered by planned distracter inputs (discussed in section 3.2.2) which require team members to manage non-emergency related events that may arise during the emergency scenarios. Research into team processes that are relevant to the CF can lead to the identification of hardware and software requirements (such as video teleconferencing, wireless devices etc.) that can enhance team capabilities.

Most reviewed scenarios measured performance automatically. Although not specified by the developed team research scenarios, computers could measure a variety of MOPs such as the number and types of available resources in relation to the number and types of resources employed, number of outputs made etc. Self reports could be employed to measure MOPs such as the effectiveness of communication between/within teams and perceived workload. Observers could supplement these measures by evaluating subjective points such as the quality of the plan, and to what extent did teams accomplish their mission. In addition, the levels of analysis for the team research scenarios are at both the individual and team levels as the mission requires the accomplishment of group and individual goals.

Comparing reviewed scenarios to those produced specifically for this project highlights how the developed scenarios differ. Specifically, for the natural disaster, pandemic and terrorist threat scenarios the team factors are somewhat different from the teams used in the reviewed scenarios. The task factors highlighted in the reviewed scenarios are similar to the task factors highlighted by the developed scenarios. Without actually specifying in more detail the team research scenarios, it is difficult to assume which processes would be the result of team interactions. However, as the team research scenarios stand, they are capable of supporting all team processes from shared knowledge, to communication, planning, team adaptability and coordination. Lastly, which performance measures to use and how to collect them will depend greatly on the details of the experiment, but in its present state, the team research scenarios could employ automated, self-report and observer measures.

4. Results of Evaluation of Computational Modelling Tools/Approaches

IPME is a potential tool for developing a computational model of the targeted teams in the targeted context, but it may or may not be the most appropriate tool. This evaluation attempted to conclude whether IPME can be used, with reasonable effort, to:

- model the specified team tasks?
- model the specified team interactions?
- model the various HSI interventions that may be of interest?
- analyze the team's strategies?
- analyze the team's performance?

In addition, this evaluation assessed if and how IPME can be used to model the specified team as an entity, as well as if and how it can be used to model the team as a collection of individuals. With respect to the possible HSI interventions, this evaluation should consider whether a whole new IPME model would need to be developed for each new intervention or each new level of an existing intervention, or whether interventions can be modelled as modules that are added to or removed from the main model as needed. If appropriate, enhancements or alternatives to IPME should be proposed.

The goal of this project is to research and assess various computational models based on a series of assessment criteria in terms of team processes modelling. A total of 26 platforms have been evaluated in this task according to 14 criteria (see Table 2).

Several key concepts are explained as follows:

Constructive Simulations: This term is relative to live or virtual simulations both of which involve *real people* operating real or simulated systems respectively. In contrast, constructive simulations are simulations that involve *simulated people* operating *simulated systems*. Real people stimulate (make inputs to) such simulations, but are not involved in determining the outcomes. Computational models of human behaviour potentially provide the simulated people for the constructive simulations, i.e. synthetic forces for constructive military simulations (for example, in the integration of *CAST* and *DDD*, the *CAST* architecture was extended to replace some or all of the players in a *DDD* simulation task). Generally speaking, all the models identified in this report are constructive simulations, except for *Wildfires Fight Simulation for Training*.

Computational Cognitive Models: Computational cognitive models are integrated models of how humans perform complex cognitive tasks, e.g. human cognition, perception, sensation, motor action and knowledge, that embody a principled underlying theory or framework for human information processing. These models, which can be run on a computer, capture human knowledge in an abstract form and allow behaviour and cognition to be simulated across a broad range of situations. Such models can provide a priori performance predictions of how well a certain system will support the tasks workers perform by assessing factors such as how easy the system will be to learn and use, the workload it imposes, and the propensity for errors. Software agents that perform work tasks in the same way that humans perform work tasks can be used to evaluate proposed system designs without the need to conduct these types of evaluations with actual workers. This class of models include *ACT-R*, *COGNET*, *EPIC*, and *SOAR*, among others.

Computational Task Network Models: These models are the analogue of computational cognitive models, but instead focus only on modelling the overt behaviours necessary to perform tasks, rather than the underlying cognitive activities that drive task performance. Typically, human performance data that have been previously collected are provided as input to the simulation. The simulation can either simulate graphically the environment and workspace, or dynamically "run" the task in real or fast time as a way of estimating complete cycle times, error likelihoods, workload, etc. These techniques can be used to assess potential contributions of alternative configurations of tasks, equipment, and team organizations. They can also aid in the design and analysis of tasks by assessing how the characteristics, interactions, and sequences of tasks can impact operator workload. Further, they can be used to assess the effects of proposed changes to an existing system on operator workload and productivity without the need for person-in-the-loop testing. This class of models includes *IPME* and *IMPRINT*.

*Multi-Agent Models***:** There has been growing interest in using intelligent agents to model and simulate human teamwork behaviours. The five multi-agent teamwork simulation tools reviewed during the course of this research are *CAST, Brahms, COGNET/BATON, STEAM and Team-SOAR*. These models were specially designed to represent aspects of teamwork that are not found in most models (e.g., collaboration, “off-task” behaviours, multitasking, interrupt and resume, informal interaction, and geography). This suggests that this class of models would be highly applicable to military scenarios requiring collective action, such as tactical planning and preparing. It would seem that these multi-agent models, which are strong on social interaction but weak on individual cognition, would make a perfect match with Soar or ACT-R, which are strong on individual cognition but weak on social interaction. COGNET/BATON, STEAM and Team-Soar are examples of efforts towards this direction.

4.1 Results

Annex F compares the computational models with regard to the team process functions they simulate. The table entries generally describe the outcome of dichotomous yes/no judgments of whether each model is capable of emulating the function in question. Whenever necessary or available, a short textual passage is given to describe model capability with regard to the function as sort of rationale for the ratings assigned to the evaluation criteria for each team modeling platform. Although the research is extensive, it is by no means an exhaustive list of computational models. In the meantime, the judgements of each criterion were based on the three methods described in the Approach section and documents listed in the References section. References that were not unearthed may contain evidence for additional model capabilities. The resultant judgements are not conclusive but tentative and suggestive, considering the limited time and resources spent on the project and the complexity and flexibility of the application of computational models. Indeed, even domain experts of certain computational models have different judgements on the assessment criteria. References are provided for some applications in Annex F. They serve as information for further research on the issues.

Given the present format, a few words of caution are appropriate in interpreting Annex F:

Although every effort was made to qualify each yes/no judgment with a description as to the quality and the extent to which the model actually models a particular function, the reader may find that many cells are filled simply with yes/no answers; these cells are either self-explanatory or there was limited available relevant information. In those cases, the reader should regard the entries as suggestive and consult the appropriate references for a more detailed description of model capabilities.

To earn a "yes" judgment, either the documentation and other literature or the responses from the questionnaires or interviews associated with the model had to indicate or describe the model's capabilities specifically for that particular function. Sometimes inferences (educated guesses) were made about the model's potential capabilities in order to fill in the cell.

Despite appearances, Annex F does not represent a "scorecard" with which to rate the merits of computational models. The fact that one model emulates 5 functions and another emulates 10 functions does not reflect their relative worth to model users (see Table 9 below). The match of model functions to the simulation requirement is what should matter to the user.

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Table 9: Number of Criteria Met by each Application

Name of Application	Measure workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals	Model Specified Team Tasks	Model Specified Team Interaction	Model HSI Intervention of Interest	Analyze Team's Strategies	Analyze Team's Performance	Available in Public Domain (i.e. free)	Stable	Real-time Computer Generated Forces	Number of Criteria Matches
IPME	√	N/A	√	√	√	√	√	√	√	√	√		√	√	**12**
IMPRINT	√	√	√	√	√	√	√	√	√	√	√		√	√	**13**
BRAHMS		√	√	√	√	√	√	√	√	√	√	√	√	√	**13**
SOAR		√	√	√	√	√	√	√	√	√	√	√	√	√	**13**
MIDAS	√	√	√	√		√	√	√	√	√	√	√	√		**12**
STEAM			√	√	√	√	√	√	√	√	√	√	√	√	**12**
D-OMAR			√	√	√	√	√	√	√	√	√	√	√		**11**
DDD			√	√	√	√	√	√	√	√	√	√	√		**11**
TOD	√		√	√		√	√	√	√	√	√		√	√	**11**
Archimedes			√	√	√	√	√	√	√	√		√	√	√	**11**
JIMM			√	√	√	√	√	√	√	√	√		√	√	**11**
CAST		√	√	√	√	√	√	√			√	√	√		**10**
C3TRACE	√		√		√	√	√	√	√	√	√		√		**10**
RESA			√		√	√	√	√	√	√	√		√	√	**10**
SAMPLE			√	√		√	√	√	√		√	√	√		**9**
GLEAN	√		√	√		√	√	√	√	√	√				**9**
APEX			√	√		√	√	√	√			√	√	√	**9**
EADSIM	√		√				√	√		√	√		√	√	**8**
COGNET	√		√	√		√		√	√			√	√		**8**
ACT-R/PM			√	√					√			√	√	√	**6**
PUMA	√		√						√			√	√		**5**
A-SA				√					√			√	√		**4**
KOGSIT			√	√								√		√	**4**
EPIC			√	√								√	√		**4**
Cogitoid			√	√								√			**3**
Wildfires			√							√	√				**3**

5. Discussion

This report describes the output of two streams of work. The first objective was to develop scenarios that could be used for the purposes of team research. This was done by leveraging previous work (Sartori et al., 2006) conducted for this ARP. The second objective was to review available computational modelling applications and determine which model would be most appropriate for modelling team research scenarios in order to provide insights into teams, team processes, team factors and human-systems integration interventions. As an additional point, the resulting computational model needed to support modelling for the team scenarios developed for this project. This section considers general observations about the developed scenarios and the computational models assessed and their implications.

5.1 Scenario Development

Three scenarios were developed, a natural disaster scenario, a terrorist threat scenario and a pandemic scenario. These scenarios were developed with multiple research themes in mind (i.e. team factors, task factors, team processes and measures of performance), with practical application to organizations that could benefit from team research such as CanadaCOM, Joint Task Forces, PSEPC, etc. Therefore, the scenarios generated are geared toward CF requirements in support of unexplored areas of team research. Further, the three scenarios were created as an appropriate context for studying HSI interventions and to serve as a basis for the computational modelling of teams.

5.1.1 Implications for team research

This report identifies aspects of team performance that have been investigated using previous scenarios while highlighting less researched and unexplored areas of team research. In using this approach it was hoped that the scenarios designed could help breach gaps in knowledge about teams, while drawing on the successes of previous experiments. As a result, two main themes relevant to team research arose – investigation into less researched areas, such as team factors, and the development of scenarios that support the investigation of complex interactive, multi-factor, models instead of those that support the investigation of a single criterion.

Previous team research has focused on teams with the following characteristics – small sized teams, fixed teams, and co-located or distributed teams. The scenarios developed for this project propose to explore the multiple side of the team factors continuum by using medium, teams-of-teams that are both ad hoc and fixed, and distributed and co-located. Since limited attention has been given to some of these factors, the scenarios were developed to target this gap with the aim of offering empirical insight into an unexplored area of team research (such as team processes arising out of these specific types of teams).

By initiating a new stream of research, that is particularly applicable to real life teams (i.e. CF involvement in domestic emergency situations), it is hoped that insightful and applicable outcomes will result. Further investigation into team factors, for example, could allow researchers to draw conclusions on optimal composition and structure of teams that is relevant to the type of task being performed. Likewise, understanding the mediating factors in shared knowledge could lead to the development of tools and techniques to enhance shared knowledge. As a result of these insights, DND could formulate teams to maximize team performance on the basis of this research.

The scalability of the scenarios also lend themselves to the development of team research. The scenarios presented allow for the manipulation of a variety of factors relevant to team performance. For example, with the terrorist threat scenario different aspects of team performance can be targeted such as uncertainty, shared knowledge, time pressure, communication, etc. All scenarios are capable of dealing with more than a single factor in relation to team performance because the scenarios are capable of supporting complex and interactive processes. For example, the scenarios can support the interactive effects of shared knowledge and communication on team performance. It is hoped that using a complex scenario will prove fruitful in representing the different demands imposed on a real life team. Although as the complexity of a scenario increases, and the number of interactive processes increase, there is the danger of reduced experimental control. It is therefore necessary that the specific objective of any experiment involving these new scenarios be clearly defined in order to enable the research team to strike a balance between experimental control, fidelity and validity.

5.1.2 Implications for HSI interventions

The developed scenarios offer an appropriate context for conducting human systems integration research on teams, their processes, tools and tasks. Due to the complexity of the developed scenarios, they provide a broad spectrum of capabilities and therefore provide the opportunity to explore relationships within teams, between teams, and with technology in a complex setting. The purpose of determining and creating appropriate HSI interventions is to help the team and system realize the required level of performance. Performance in this case can be measured at several levels, from how well the task was performed, how well the teams-of-teams collectively performed, how well each individual team performed, to how well each individual team member performed.

The scenarios developed for this project also support such traditional HSI methods as Mission Function Task Analysis (MFTA). MFTA conducted on the experimental scenarios would serve as a baseline understanding of what the scenario is supposed to achieve. This understanding would allow objective evaluation throughout the introduction of new and varied HSI interventions, such that the researchers would be certain that any measured change in scenario performance would be attributable to the intervention and not random differences. For example, MFTA may show that the critical function for one of the scenarios is the allocation of appropriate levels of personnel to strategic points (e.g. in time or space) to curtail the spread of the threat. This requirement (to have a baseline understanding) remains constant irrespective of the research aims or the HSI intervention being assessed. If a decision support tool is implemented, the function remains the same and the researchers look for changes in performance. If a new organisational structure is implemented, again, the mission stays the same and researchers look for changes in performance. The compatibility of these scenarios with HSI leverages a great deal of experience and understanding from throughout the CF and beyond.

5.1.3 Implications for the CF

In addition to developing scenarios to make strides within the area of team research, the scenarios have been developed to address the future needs of the CF. The context within which the CF operates is changing and as a result new issues and skills have become significant. The CF may face more complex threats in the future, and therefore threat response requires greater collaboration between different levels of government and different organizations. The CF must be prepared to deal with this increase in scope and complexity in order to provide the level of stability and security demanded by the Canadian people. In addition, many organizations exist beyond the boundaries of the CF who are capable of contributing resources to deal with modern day events. It will therefore become more common for the CF to combine resources and capabilities with other government departments or non-government organizations to effectively deal with emergency events.

As the number of teams and players increase, new issues impact the resolution of a situation. Individuals from different organizations, with different backgrounds and training must work collectively to accomplish a task. Teams must share and divide authority and responsibility, ensuring that all available resources are appropriately used. Teams must be capable of organizing and contributing to a mission from different physical locations and must do so within a short timeline, with minimal time to prepare. All these issues must be managed so that mission accomplishment can remain the focal point.

The developed scenarios have therefore been created with the following teams in mind: interagency, joint, ad hoc, and distributed, teams-of-teams. For example, the Winnipeg Floods Natural Disaster Scenario draws on resources from various teams. Three main teams representing different organizations are employed – CanadaCOM, Joint Task Force Prairie (land and air forces), and Local and Provincial authorities. Incorporating these types of teams into a scenario will impose the constraints and limitations similar to what the CF is expected to face in the near future. By acknowledging and recognizing the changing face of teams involved in emergency situations, the CF and other organizations can begin training and planning so that team performance is maximised from the onset of the teams formation.

Research into teams will benefit the CF by providing a foundation on which to build their teams. The CF will gain better insights into how to organize teams for different types of tasks and what processes emerge out of team interactions. The CF can therefore build supporting structures such as communication networks, training, facilities, etc, around teams, rather than teams around structures. For example, if research indicates that shared team knowledge is facilitated for distributed teams through video teleconferencing, than the CF can incorporate this technology into future structures and training.

5.1.4 Implications for computational models

The computational model chosen for the purpose of this ARP should be able to represent the chosen scenario. However, the limits of the modelling tool may be met as the scenarios become more complex. As a scenario becomes increasingly complex, the dynamics between people, tools and tasks become exponentially greater, outstripping the capabilities of a computational modelling application. Therefore, there is a trade-off between the complexity of a scenario and the ability of a computational model to support it. The abilities and limitations of computational models are discussed in Section 5.2.6 below.

The scenarios developed for this project have the potential to be very complex, constructed as they are of up to three teams of 3 people each. It is unclear whether other applications have attempted to model such scenarios, and it was established that limited previous work has modelled teams-of-teams. Thus, it is likely to require a significant effort to model the scenarios described in this report to the level of fidelity required for research purposes.

5.1.5 Further Development

In their present state, the developed scenarios provide a general conception of how events would flow. A start point is expected to trigger the situation and the achievement of certain states will signify the end point (Figure 2). In between the start and end points, a series of modifier and distracter inputs will be introduced to simulate real life events and to provoke various team processes and (Figure 3). The next step in developing the scenarios is to therefore specify potential inputs, expected team activities and expected outputs. Table 10 below identifies questions that should be answered regarding possible inputs, expected activities and expected outputs to provide further detail to the scenarios.

Table 10: Further Development of Scenarios

	Input				Team Response/Activity					Output				
Modifier Input	Time of the Input	What is the input/its content?	Input recipient(s)	Input Medium	Expected response/ activity	Additional inputs required?	What tools will be used?	Is feedback delivered to the originator of the input?	What MOPs will be collected?	Expected time of output	Expected content of output	Recipient(s) of output	Output medium	What MOPs will be collected?
1														
2														
3...														
...n														

To specify the details of the inputs, the following questions can be asked: What is the content of the input; who is the input intended for, and in what medium is the input introduced? The introduction of the input will then trigger teams to work together on a task. Once the inputs have been identified in detail (this process can be facilitated by populating Table 10), the resulting expected output(s) can be assumed. Once experimenters know what types of outputs are likely to occur, s/he can choose the suitable Measures of Performance (MOPs) and/or Measures of Effectiveness (MOEs). For example, if the input is a telephone call to notify the Commander of

CanadaCOM of the availability of new resources, then the expected output is mobilization of these resources in order to accomplish the mission. An MOP could be the amount of time that passed between receipt of the input to when the resources were employed. By outlining an input and the expected team activities and expected outputs, MOPs and MOEs can be established. The benefit of formulating inputs, MOPs and MOEs ahead of time is that the experimenter is aware of the processes that should take place, and can therefore take a systematic approach to data collection and research. When performance differs between two teams carrying out the same scenario under different conditions, the experimenter, having adequately defined the scenario in the beginning, will be certain that the observed effect is due to their experimental manipulation, rather than random differences.

5.1.6 Limitations of the developed scenarios

The scope of this contract did not allow the HSI® team to develop fully formed team experimental scenarios that could effectively function as they presently stand. The purpose of this contract was to present options for team experimental scenarios that could then be further explored.

Another reason that the scenarios were not developed in detail was a lack of publicly available information. CanadaCom and JTF are relatively new CF organizations and therefore it was difficult to draw conclusions about who is involved in each team and how the teams would work together. Similarly it was unclear as to what the relationship between DND and an OGD would be since new organizations, such as CanadaCOM and PSEPC have not had the opportunity to work together in the emergency situations depicted by the scenarios (in fact, they have only had limited opportunity to work together at all). Future work with SMEs is therefore recommended to help bridge these gaps in knowledge.

5.2 Comparison of Computational Modelling Applications

As can be seen from Table 9 and Annex F, a number of computational models scored on greater than 10 out of 14 criteria (IPME, IMPRINT, MIDAS, D-OMAR, SOAR, BRAHMS, CAST, STEAM, DDD, TOD, C3TRACE, ACHIMEDES, RESA and JIMM). However, not all of these received 'yes' answers to the critical criteria of modelling the specified team tasks, the specified team interaction, HSI interventions, team strategies and team performance. CAST and ACHIMEDES did not satisfy all these criteria while still scoring above 10/14, while GLEAN, which did not score greater than 10/14, did support these criteria. The answer to the question of which one is the best is dependent upon a lot of variables. What is it that we are trying to predict about team processes? What precise questions are we trying to answer? Also, how complex is the environment we are trying to model? Is the team work co-located or remote? How big is the team? How much data do we have? How much time and money do we have? One is not really better than the other - they are simply different.

Most computational models were designed with the aim to model basic cognitive abilities or activities. The higher level cognitive abilities (e.g. working memory, decision making) on which team processes are predicated are subjects of a world-wide on-going research. At present, as one questionnaire respondent has indicated, none of the existing computational models of human behaviour could adequately be used for purposes outlined by this project. Bearing in mind the different types of computational models described above, it is also notable, however, that IPME falls into the category of computational task network applications that result in information about cognitive measures (e.g. workload, error, etc.), but do not set out to faithfully model cognition. Because this class of application models tends to generate insights into cognition, it is likely more amenable to modelling the scenarios being generated in this project.

Most tools have the capability of being linked together with some effort for specific applications. For example, IMPRINT has been linked up with IPME/MicroSaint; D-OMAR together with some military tools; Apex has been linked into MIDAS, etc. There is also a need to integrate models with different strengths to complement with each other, for example, integration of IMPRINT and ACT-R to combine strengths of task network and cognitive modelling. C3TRACE is another example of this type of integration. C3TRACE takes the basic task network modelling approach and adds an information-weighted decision making algorithm. Integration of CAST and DDD is an example of integrating domain independent multi-agent architecture with military C2 simulation software. The CAST architecture was extended to replace some or all of the players in a DDD simulation task.

The stability of a modelling tool depends on the match between the tool and the application domain. No tool is 100% stable but its stability is mainly dependant on the severity of the adaptations and/or extensions that are needed for applying the tool to the desired domain. Most tools are applicable outside of their originally designed-for applications. For example, using MIDAS for helicopter applications is solid. For experiments in outer space, MIDAS may be a little less solid but with some work, it can be applied successfully.

Given the criteria used to assess each model, it is felt that IPME represents the best value for money because it does everything that is required of it (by this project) and is in a continual process of improvement in whatever manner DRDC sponsors. It is also one of the classes that have been developed explicitly to model tasks, rather than to faithfully model cognition. And while there are IPME components intended to mimic cognition in terms of output, they are representative in terms of the outputs and not in terms of the “inner workings” of cognition (e.g. that cognition occurs via a multiple channel, limited capacity, information processor). This makes it ideal for future team research purposes. Further, there is a large defence research and industrial community who are comfortable in using IPME, and any attempt to introduce a new modelling application would likely result in significant time spent familiarising with the new application before insightful outputs were produced. Finally, it is felt that the windows-based interface of IPME lends itself to rapid model development, more-so than the others. The combination of windows dialogues with code, renders IPME even more flexible and compatible with the needs of team research.

5.2.1 Implications for the Canadian Forces

As will be apparent elsewhere in this report, the development of a strong computational model of team performance will provide value to the CF in a number of areas. First and foremost, it has been demonstrated in other projects for the CF that having a good computational model allows an interested party to assess the likely impact of human-systems integration interventions. For instance, Matthews et al (2005) developed an IPME model to assess the likely impact of automating the sanitisation task of sonar operators. The automation of this task led to much more time spent examining the beams of the towed array for real targets and less time spent considering clutter, which would lead to greater operational effectiveness in the CF. Further, because of the task network simulation, this investigation was run thousands of times, rather than just a few, and cost a trivial amount when compared to actually building the system and installing it in a simulator or a real ship.

A computational model is also useful for identifying where bottlenecks could occur in the team. By modelling an existing structure and roles the model will show where the highest workloads or greatest time constraints occur and will indicate what tasks are delayed and/or shed, and thus what the knock-on impact on other team members might be. This allows a more focused approach to developing support systems or making other HSI interventions to do with training, team or organisational structures.

In supporting development of new systems, a good computational model will also generate detailed requirements for system performance that supports operator performance. In many systems the operator will wait for system responses. Delayed responses adversely impact the operator's performance. Further, the operator will not necessarily realise the system is working and the operator will attempt to hurry the system along. This can result in the system hanging, or additional inputs being made extremely rapidly once the system is freed up, leading to errors. Setting appropriate system performance requirements that support the operator can be derived and tested from computational models.

A final benefit to the CF is a more effective use of their personnel. Currently, there is great demand on the CF to provide suitably qualified personnel to participate in experiments or test new systems, equipment, procedures, etc. With a suitably developed computation model, the demand will continue, but it would only be in support of systems or developments that have shown significant benefit in the computational model. This would reduce the ongoing demand for personnel. However, if intact teams could not be obtained for such testing, it may also be possible to use the computational model as an additional team member. This approach has been investigated by DRDC Toronto in the context of helicopter deck landing aboard the Halifax-Class frigate (Lamoureux et al., 2004), and in the provision of computer-generated armoured fighting vehicles (Mekdeci, 2004). Thus, CF personnel could be used much more effectively to support projects.

5.2.2 Implications for Scenarios

In the SOW for this project, the SA posed a number of specific questions referring to the manner in which the scenario developed above (Section 3.2.3) could be implemented in a computational modelling application. Each of these questions is answered individually below.

Propose how the scenario developed in Section 3.2.3 above may be implemented as an IPME task network model.

The scenario would be subject of a task analysis. This task analysis would describe the structure and interdependence of all tasks, uncover the various inputs and outputs of each task (including who the actor or recipient would most likely be, with a nominated alternative), along with the workload and expected task frequencies and completion times, and other task parameters such as error rates and consequences. The scenario could then be implemented in IPME as a task network model. Each task in the network would then be subject to the standard IPME implementation of task shedding, delaying, etc. subject to the workload being experienced by the actor. The task network model would be combined with the scenario event monitor which would create time- and event-based cues that would exercise the various elements of the network.

Propose how the scenario developed above may be implemented in an IPME crew model.

The crew model is a list of operators (or humans) who carry out tasks in the task model. The crew model always exists. An IPME model must always have at least one crew member. Crew members can be modeled in whatever degree of detail desired. The crew model includes three basic groups: properties (hands/feet/fingers, etc.), traits (height, weight, cognitive ability, etc.), and states (time since slept, temperature, etc.). Instead of using the task network approach of assigning individuals to a task, the crew model enables IPME to simultaneously monitor and assign workload for multiple individuals within a common scenario, while also accounting for interaction effects between properties, traits and states. Workload can be assigned dynamically to different operators within any active task using either syntax or rigid "rules" (IPME can be programmed or the built-in windows interface can be used) assigned within the task dialog. In this manner, procedural rules or skill/experience restrictions can be implemented and followed, but the tasks can be carried out flexibly in the same manner that they would likely be carried out by real teams.

Propose how the scenario developed above may be implemented in an IPME environment model, if applicable.

A team task would not be modeled in the IPME environment model. Rather, the environment model is something that can interact with the task network or team model to affect performance (generally time to complete a task and error rates). The environment model allows the developer to control the impact of external events on the scenario. For example, light conditions can be changed, temperature can be changed (all within the environment model) and as a result these values can be stored in variables used to influence task performance. For example, task completion times can be calculated according to daylight (e.g., in low light conditions, task completion times double or error probabilities increase by a factor of 2). If a team task takes place at night, or even over a long period of time during which conditions vary, the environment model can modify task success accordingly. A team task may also suffer extremes of cold or precipitation that may positively or negatively affect performance.

Further to these specific questions, it is questionable whether the computational model has any direct implications for the scenario being developed. In so far as the computational model should be technically able to represent the scenario being developed, the scenario will need to be of sufficient simplicity to facilitate this representation, but this is likely to be of secondary priority to the creation of scenario that will support the team research aims of DRDC Toronto. IPME should not, however, impose these constraints on the scenario because it is a powerful modelling application with a highly flexible syntax option. The limitation is likely to be speed, processing power and memory in the host machine, which itself is a limitation that various stakeholders are working to overcome.

5.2.3 Implications for Team Research

In the SOW for this project, the SA posed a number of specific questions about the implications of a computational model for team research. Each of these questions is answered individually below.

Identify key similarities and differences between the proposed implementation and previous implementations of team models in IPME.

Previous implementations of teams in IPME do not consider team performance as a variable in task performance. For instance, previous IPME models have assumed perfect team performance (as opposed to perfect individual performance as measured by shed, interrupted and delayed tasks). However, 'real' team members are not always available to assist each other or receive information from each other. The proposed implementation would be built using a theoretical model of team performance that includes variables to account for real variations in team performance. In this manner, the output of the model would more closely approximate actual performance and could thus be used for predictive purposes.

Propose the use of an existing or a new model of workload in IPME for modelling the scenario developed above, and provide the rationale for choosing this workload model.

The IPME model could generate significant insights into the cognitive impacts of the scenario on operators. With IPME, this insight has often been related to workload (at least, at a summary level). The VACP model is an appropriate workload model in IPME for evaluating team performance. VACP can be used in conjunction with the crew model to evaluate instantaneous workload for individual team members, and aggregate workload for the team as a whole (or entity). VACP is considered the 'basic' IPME workload model though. To better approximate 'real' team performance, the POP/IP model of workload is proposed. POP/IP (Prediction of Operator Performance/Information Processing) integrates Qinetiq's (POP) model with DRDC's IP/PCT (Perceptual Control Theory) models. In particular, the POP/IP model includes the concepts of structural interference, task deferment, task shedding, and prospective memory from the IP/PCT model, and the general interference from the POP model. The model is intended to reduce the potentially substantial effects of congestion within the POP model. Workload is calculated from the task scheduler, interacting with the workload parameters for a task. A comparison of POP/IP with POP and IP/PCT is presented in Table 11 below.

Table 11: Comparison of task schedulers for different IPME workload algorithms

	POP	IP/PCT	POP/IP
Task shed	No	Yes	Yes
Task delayed	Yes	Yes	Yes
Task Interrupted	Yes	Yes	Yes
Time penalty (concurrent task processing)	Task Demand Multiplier (TDM)	Time penalty	TDM
Workload	Operator1.workload	Operator1.MeanTimePressure	Operator1.workload Operator1.MeanTimePressure

	POP	IP/PCT	POP/IP
Structural Interference	Manual output	Visual, auditory, psychomotor	Visual, auditory, psychomotor
Task Demand	Input, central, output	Visual, auditory, cognitive, psychomotor	Input, central, output, visual, auditory, psychomotor
Task Priority	Internally/externally paced	Multiplier	Internally/externally paced and multiplier
Additional time penalty	Performance shaping factor (PSF)	Time performance modifier	PSF
Forgetting	No	Yes	Yes
Short-term memory	No	Yes	Yes
Interference coefficients	No	User can modify	Fixed values
Compatible task pairs	No	Yes	Yes

As apparent in the table above, POP/IP attempts to use the most successful and desirable features of the different workload algorithms.

Returning to the point made above that a computational model allows the focused development of needed tools, the computational model could indeed lead to the focused running of expensive 'man-in-the-loop' team experiments. Although founded in theory, many other team experiments have really proceeded in the hope that something insightful would result. Any hypothesis being tested has been necessarily high-level in its description. By developing a team scenario in a computational model, experimental manipulations (i.e. the independent variables) can be made to determine what manipulation results in the biggest insights. This can then be repeated in a 'human-in-the-loop' trial for both validation of the computational model and for additional insights.

The common assumption when considering live human experiments and the computational model is that the computational modeling is conducted first. In this way, it can inform the research. This means that the computational model must be built and exercised a significant time before the human-in-the-loop trial is scheduled, in order that its outputs can be considered and fed seamlessly into the live trial. Except for validation purposes, it is unlikely that the computational model should ever be created after the live trial has been run.

5.2.4 Implications for Human-Systems Integration

As noted above, the computational models can provide significant benefit for HSI purposes. In particular, the use of computational models will increase the confidence that a proposed intervention will in fact provide a significant beneficial effect. Further, it may reduce the demand upon the CF to provide personnel to test new HSI interventions.

Another possible, but less obvious, benefit to human-systems integration is the opportunity to ensure scenarios are best suited for testing the target intervention. Ideally, every system in the military has been subject to a Mission, Function and Task Analysis (MFTA) or a similar sort of analysis. The MFTA leads to a set of critical mission requirements which can be incorporated into a scenario to serve as the basis for live testing. With revolutionary designs or new capabilities, the critical mission requirements may not fully address the capabilities of the new system. A computational model can be used to create and test the scenario and the new system before the CF expends significant resources staging a live trial. Such a test would involve baselining the scenario before running the scenario with the new system. Depending upon the stated capabilities of the new system, the analyst will determine whether the model sufficiently exercises those capabilities. If it does not, then the scenario will need to be revised and tested again before it is incorporated in the live scenario. This approach would significantly improve the chances of an insightful trial and render such acceptance testing more than a 'rubber-stamping' process.

5.2.5 Further Development

In the SOW for this project, the SA posed a number of specific questions referring to the manner in which IPME could be improved. Each of these questions is answered individually below.

Propose changes or additions to IPME that will increase IPME's utility for modelling the scenario developed above.

In general, IPME is flexible enough to accommodate any team research scenario that needs to be built, provided enough time and data is available to create the model. However, implicit in this statement is an acknowledgement that an IPME model takes time to build and further time to calibrate to generate valid performance outputs. IPME also provides the raw data relating to task and actor performance to make any necessary calculation to generate predictive insights into team performance. Using this raw data IPME could output an overall metric of team performance, perhaps generating output for a team as an entity. IPME could also generate measures of situation awareness and error 'criticality' (i.e. what percentage of errors are considered critical to mission success). Thus, there are no changes or additions to IPME that cannot be implemented in the course of a suitably scoped project.

Propose changes or additions to IPME that will increase IPME's usability for modelling the scenario developed above.

To speed up the development of IPME models, it is desirable to implement a 'library' of 'typical' teams and tasks. Then the user could select the basic team or task structure and modify it to his/her own requirements. Such a hypothetical team model could be a component of the crew model, making a team a team (in the sense defined by Sartori et al., 2006), rather than a group of individuals. Teams could vary in size (e.g. 3 person, 5 person, etc.) and degree to which they are expected to work in a distributed rather than a co-located fashion. The degree to which they are stable teams, as opposed to ad-hoc teams, could also be varied. Likewise, tasks could be created in a generic fashion to facilitate the rapid development of scenario specific task networks. Tasks could comprise various combinations of input, decision making, iteration, feedback, output, monitoring and time pressure. To this end, Humansystems have developed a generic model of process control, modeled on the human information processing model of Wickens (1984). This accommodates, at a 'micro' level, all manner of cognitive work conducted by humans. This model can be re-used, within each task if necessary, as the basis of a task network. One further improvement refers to the current manner in which models interact. The user has to develop a model in IPME as a separate project and link the model using the HLA protocol so the models on different computers can 'speak' to each other. It would be more convenient to add additional model components to IPME as simple plug-ins.

Other ongoing improvements to IPME sponsored by DRDC and other compatible applications (e.g. TaskArchitect) will also increase the utility and usability of IPME and render it more generally complimentary to team research.

5.2.6 Limitations

As with any computational modelling application, a major limitation is the availability of suitably qualified and experienced resources to do the modelling. It is felt that the Canadian modelling community is very strong so this is unlikely to be a significant hurdle.

With respect to the comparative review of computational models, there were a few limitations to the conclusions that could be made. Although every effort was made to qualify each yes/no judgment with a description as to the quality and the extent to which the model actually models a particular function, the reader may find that many cells in Table 9 are filled simply with yes/no answers; these cells are either self-explanatory or there was limited available relevant information. In those cases, the reader should regard the entries as suggestive and consult a wider selection of references for a more detailed description of model capabilities. The only way that this could have been overcome is to conduct an assessment that involved modelling the same scenarios in different applications. This would obviously have been prohibitively expensive in terms of time and effort.

To earn a "yes" judgment, either the documentation and other literature or the responses from the questionnaires or interviews associated with the model had to indicate or describe the model's capabilities specifically for that particular function. Sometimes inferences (educated guesses) were made about the model's potential capabilities in order to fill in the cell. Again, this could only be overcome with a detailed comparative assessment.

The information in Annex F does not represent a "scorecard" with which to rate the merits of computational models, but a composite 'score' that reflected the relative weights of the different criteria would have been helpful. However, this would have had no validity and limited reliability (analyst perspectives would likely have been wildly variable) so no attempt was made to create one.

On balance, however, it is felt that within the constraints of this work, there were few limitations and that IPME is a worthy application to use as part of the toolkit for team research. In summary, the current state of the art in computational modelling seems to indicate that IPME is the most appropriate tool for modelling team research scenarios. Further, the unique and extensive community of IPME users in DRDC and Canadian industry at large makes it the logical choice for such efforts.

6. Conclusions

This work investigated the team research literature for existing experimental scenarios, and the computational modelling literature for modelling platforms. Based on the review, no pre-existing team research scenarios were appropriate for the purposes outlined by DRDC. With respect to computational modelling, it was concluded that the employment of IPME does indeed meet the requirements of DRDC and, further, there are minimal improvements that can be made to that platform, beyond enhancing the manner in which models can be networked in order to accommodate large, complex teams performing complex tasks.

The scenario development work resulted in three experimental scenarios: a natural disaster; a terrorist threat; and an influenza pandemic. These scenarios all exercise joint, interagency and multidisciplinary aspects of teamwork, and exhibit a mixture of ad-hoc and fixed, and distributed and co-located teams. The scenarios focus on operational level work, rather than tactical level work. The scenarios were developed to a coarse level of detail, but a template was also developed to assist in further developing the detail for each scenario. The scenarios exhibit a medium level of fidelity that while offering experimental control. The scenarios permit team research factors uncovered by Sartori et al (2006) to be addressed, either through experimental manipulation or through measures of performance. This means the scenarios are inherently flexible and responsive to the research needs of DRDC Toronto.

It is recommended that three follow-on pieces of work be undertaken as soon as is reasonably practicable:

1. Develop the detail for the three scenarios. This will include identifying all the inputs to the scenario and also the expected actions and their outputs. A template has been provided for this purpose.
2. Build the baseline IPME model for each scenario. This will have to wait until at least one scenario is fully realised.
3. Draw up detailed plans for the development of an experimental laboratory that will accommodate the scenarios. These plans should include details of how participants will interact with other participants and the system.

Subsequent to this, human-in-the-loop experiments should be conducted in the experimental facility to provide a baseline for the IPME model and to perform preliminary model validation, before new research begins.

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Annex A: Evaluation of Reviewed Scenarios

No.1

Scenario name:	Search-and-Rescue Mission in Antarctica
Platform name (asterisk if reviewed in platform report)**:**	*NASA Ames Centre - Distributed Research Facilities (based on Optima Technology's simulation software)

Level of activity

Strategic	☐
Operational	✓
Tactical	☐

Relevance

Highly relevant	✓
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	✓

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	✓	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	✓	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	✓	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	✓	☐	☐
2.2 Workload			
Physical	☐	✓	☐
Cognitive	☐	✓	☐
Time pressure	✓	☐	☐
2.3 Task Interdependence			
Additive	✓	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	✓	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	✓	☐	☐
Task mental model	✓	☐	☐
3.2 Communication			
Implicit	✓	☐	☐
Explicit	☐	☐	☐
Centralized network	✓	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	✓	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	✓	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	✓	☐

4 Team Measures

4.1 Outcome	
Automation	✓
Self-Report	☐
Observers	✓
4.2 Level of Analysis	
Individual Performance	✓
Team Performance	✓

Comments: N/A

Reference(s):

http://www.nasa.gov/centers/ames/research/technology-onepagers/distributed-team-decision.html

http://www.nsbri.org/Research/Projects/viewsummary.epl?pid=170

http://gtresearchnews.gatech.edu/reshor/rh-ss03/sp-team.html

No.2

Scenario name:	Team Resource Allocation Problem in Emergency Criss Management
Platform name (asterisk if reviewed in platform report)**:**	*NeoCITIES

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☑	☐	☐
Task mental model	☑	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☑	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☑	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☑	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: At its core, NeoCITIES is a team resource allocation problem designed to mimic the emergent situations that comprise real-life emergencies and measure decision-related outputs in a virtual environment. The simulation emulates the complex functions involved in the resource management of a city's emergency services. Crisis management is conducted through the joint interaction of three distinct teams: a Police team, a Fire/EMS team, and a Hazardous Materials team, each consisting of an information manager (IM) and resource manager (RM).

Reference(s):

http://minds.ist.psu.edu/index.php?option=com_content&task=view&id=54&Itemid=67

R.E.T. Jones, M.D. McNeese, E.S. Connors, T. Jefferson, Jr., D.L. Hall, (2004). "A distributed cognition simulation involving homeland security and defense: The development of NeoCITIES," Proceedings of the Human Factors and Ergonomics Society 48th annual meeting (New Orleans, Louisiana), Santa Monica, CA: Human Factors and Ergonomics Society, pp. 631-634.

McNeese, M.D. et al (2005). The NeoCITIES Simulation: Understanding the design and experimental methodology used to develop a team emergency management simulation. Proceedings of the Human Factors and Ergonomics Society 49th Annual meeting, pp591-.594

No.3

Scenario name:	Uninhabited Air Vehicle (UAV) Ground Control Operations to Taking Reconnaissance Photos
Platform name (asterisk if reviewed in platform report)**:**	*Synthetic Task Environment (STE) in Cognitive Engineering Research on Team Tasks (CERTT) Lab

Level of activity

Strategic	☐
Operational	☑
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☐	☐	☐
Conjunctive	☑	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☑
Task mental model	☐	☐	☑
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☑	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☑
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments:	The CERTT Lab houses a Synthetic Task Environment (STE) for studying team cognition. The premier task in this STE is a simulation of Uninhabited Air Vehicle (UAV) Ground Control operations.In the UAV-STE a three-person team controls the UAV for the purpose of taking reconnaissance photos. The task is based on the actual operations of the Air Force's Predator UAV. The synthetic task environment in made up of four industrial Participant Consoles and one Experiment Console.The three team members have a distinct role: AVO (Air Vehicle Operator), PLO (Payload Operator) and DEMPC (Data Exploitation, Mission Planning and Communications Operator)
Reference(s):	http://www.certt.com/

No.4

Scenario name: Command and Control Simulation - Defending a region against invasion from unfriendly entity

Platform name (asterisk if reviewed in platform report)**:** *DDD

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☑
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☐	☐	☐
Conjunctive	☑	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☑	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☑	☐	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
Centralized network	☐	☐	☐
Decentralized network	☑	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☑	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☑	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: N/A

Reference(s): http://www.aptima.com/Projects/Distributed_Dynamic_Decision_making.html

Article: Team Learning: Collectively Connecting the Dots, Ellis, et al (secondary ref: Miller, Young, Kleinman & Serfaty, 1998)

http://www.dodccrp.org/events/2005/10th/CD/papers/358.pdf

No.5

Scenario name: Combat Information Center - Monitoring radar display for targets

Platform name (asterisk if reviewed in platform report)**:** *Tactical Navy Decision Making System (TANDEM)

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☑	☐
Time pressure	☐	☑	☐
2.3 Task Interdependence			
Additive	☐	☑	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☑	☐	☐
Task mental model	☑	☐	☐
3.2 Communication			
Implicit	☑	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☑	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☑	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☑
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: TANDEM was designed to be a more ecologically valid simulation of a command, control, and communication environment; rather than use synthetic work it employs tasks that are closer to the real- life counterpart of a combat information center. Decision-making skills require information-sharing among one to three participants, as decisions must be made based on provided information regarding unknown contacts. For each contact, characteristics – type, threat level, and intent – must be determined, and fifteen pieces of information are required to make a ruling on each contact (five pieces for each characteristic). Each participant receives information pieces, some of which might be conflicting or ambiguous. Task characteristics such as interdependence, time pressure, and work load can be examined, and the scenario is reconfigurable. However, TANDEM does not require the integration of new or changing information over time; participants are equipped with the same knowledge set for the duration of the session.

Reference(s):

Dwyer, D., Hall, J., Volpe, C., Cannon-Bowers, J. A., & Salas, E. (1992). A performance assessment task for examining tactical decision-making under stress (Report No. 92-002). Orlando, FL: Naval Training Systems Center.

http://www.iwm-kmrc.de/workshops/sim2004/pdf_files/VanBerlo.pdf

http://usl.sis.pitt.edu/ulab/pubs/HFES99LHLR.pdf

No.6

Scenario name: Naval Surveillance and Threat Assessment Operation

Platform name (asterisk if reviewed in platform report)**:** *Team and Individual Tactical Assessment Network (TITAN)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☑	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☑	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: N/A

Reference(s): The effect of individual differences in cognitive styles on decision-making accuracy.Blais, Ann-Renee; Baranski, J.V. ; Thompson, M.M. (DRDC-Toronto)

http://www.toronto.drdc-rddc.gc.ca/publications/factsheets/f09_e.html

No.7

Scenario name:	Tank Battle Game
Platform name (asterisk if reviewed in platform report)**:**	*Bolo

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☑	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures	
4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: N/A

Reference(s): Article: The relationship of team goals, incentives, and efficacy to strategic risk, tactical implementation, and performance; Don Knight, Cathy C. Durham, Edwin A. Locke

http://www.lgm.com/bolo/

http://www.twinforces.com/tf/bolo3d.htm

No.8

Scenario name:	Naval Combat Experience
Platform name (asterisk if reviewed in platform report)**:**	*Dangerous Waters

Level of activity

Strategic	[ ]
Operational	[x]
Tactical	[ ]

Relevance

Highly relevant	[ ]
Relevant	[ ]
Somewhat relevant	[x]

Purpose

Training	[ ]
Research	[x]

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	[x]	[ ]	[ ]
Medium	[ ]	[ ]	[ ]
Large	[ ]	[ ]	[ ]
Teams of teams	[ ]	[ ]	[ ]
1.2 Team History			
Ad Hoc	[ ]	[ ]	[ ]
Fixed	[x]	[ ]	[ ]
1.3 Physical Distribution			
Distributed	[x]	[ ]	[ ]
Co-located	[ ]	[ ]	[ ]

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	[ ]	[ ]	[x]
2.2 Workload			
Physical	[ ]	[ ]	[ ]
Cognitive	[ ]	[ ]	[ ]
Time pressure	[ ]	[ ]	[ ]
2.3 Task Interdependence			
Additive	[x]	[ ]	[ ]
Conjunctive	[ ]	[ ]	[ ]
Disjunctive	[ ]	[ ]	[ ]
Discretionary	[ ]	[ ]	[ ]
Pooled	[ ]	[ ]	[ ]
Sequential	[ ]	[ ]	[ ]
Reciprocal	[ ]	[ ]	[ ]

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	[ ]	[ ]	[ ]
Task mental model	[ ]	[ ]	[ ]
3.2 Communication			
Implicit	[ ]	[ ]	[ ]
Explicit	[ ]	[ ]	[ ]
Centralized network	[ ]	[ ]	[ ]
Decentralized network	[ ]	[ ]	[ ]
Hierarchical network	[ ]	[ ]	[ ]
3.3 Coordination			
Implicit	[ ]	[ ]	[ ]
Explicit	[ ]	[ ]	[ ]
3.4 Team Adaptibility			
Monitoring	[ ]	[ ]	[ ]
Feedback	[ ]	[ ]	[ ]
Back-up behavior	[ ]	[ ]	[ ]
3.5 Planning			
Resource Allocation	[ ]	[ ]	[ ]

4 Team Measures

4.1 Outcome	
Automation	[x]
Self-Report	[ ]
Observers	[ ]
4.2 Level of Analysis	
Individual Performance	[x]
Team Performance	[ ]

Comments:	N/A
Reference(s):	Dangerous Waters Manual http://www.strategyfirst.com/en/games/DangerousWaters/ http://www.scs-dangerouswaters.com/

No.9

Scenario name:	Helicopter flight simulator
Platform name (asterisk if reviewed in platform report)**:**	*Longbow 2

Level of activity

Strategic	☐
Operational	☑
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☑	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☑	☐
Task mental model	☐	☑	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☑	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☑	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments:

Roles were divided as follows: (a) The pilot was in charge of flying the aircraft; (b) the gunner operated the weapon systems, which included selecting, loading, and shooting various ammunition; and (c) the radar specialist was responsible for monitoring and interpreting radar systems containing critical enemy information. Team members communicated with each other during the simulation through an aircraft cockpit system consisting of interconnected microphone-equipped headphones. There was no redundancy in role functions (e.g., only the pilot could fly the helicopter; only the gunner could select, load, and shoot ammunition; and only the radar specialist had access to enemy radar and waypoint information).The task was highly interdependent: To perform it effectively, team members had to work together closely. There was no way to effectively complete the task without the integrated contributions of all three members. A good plan of attack aided team performance, although it was impossible to plan for the precise nature and timing of the challenges that the teams faced.

The complex and dynamic nature of the task was primarily due to three elements: (a) roving enemy helicopters attempting to shoot down Apaches, (b) the unfamiliar and variable terrain (e.g., valleys, mountains, plains), and (c) unanticipated enemy surface-toair missiles. Successful performance depended on the ability of team members to coordinate their activities, primarily through the exchange of mission-critical information, so as to kill enemy targets and avoid being killed by enemy forces. Teams received real-time verbal feedback as to whether they had killed a particular target, and they had access to a computer screen indicator of weapon supply levels.

Reference(s):

Article: Marks MA, Sabella MJ, Burke CS, et al. The impact of cross-training on team effectiveness. J Appl Psychol 2002;87:3–13.
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=11916213&dopt=Abstract

No.10

Scenario name: Radar monitoring task

Platform name (asterisk if reviewed in platform report)**:** *Team Event-Based Adaptive Multilevel Simulation (TEAMSim)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☑	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☑	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☑	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☑	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☑	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: As a team, participants were responsible for working interdependently to identify contacts, make decisions, and prevent perimeter intrusions. The task incorporated both additive and discretionary interdependencies that compiled to team performance. Workload was equalized across sectors. However, the task was designed to unpredictably—but systematically— overload team members. This interdependence created discretionary opportunities for other members to shift their priorities and strategies, coordinate effort, and contribute to team performance. Although collective effort contributed to team performance, team members working outside their primary sector could not simultaneously work toward accomplishing individual goals. Thus, consistent with the multiple-goal model, overloads were designed to prompt resource allocation choices toward team or individual goals.

Reference(s):

DeShon, R.P., Kozlowski, S. W. J., Schmidt, A. M., Milner, K. R., Wiechmann, D. (2004). A multiple-goal, multilevel model of feedback effects on the regulation of individual and team performance. Journal of Applied Psychology, 89(6), 1035-1056. http://iopsych.msu.edu/DeShon/Papers/DeShon%20et%20al%20(2004)%20-%20Team%20regulatory%20processes.pdf

No.11

Scenario name: Reconnaissance

Platform name (asterisk if reviewed in platform report)**:**

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: Agent based modeling and Behavior Action Simulation Platform (BASP). Not a human-in-the-loop simulation platform.

Reference(s): http://www.leastsquares.com/papers/mws2001.pdf

No.12

Scenario name: Hostage Extraction

Platform name (asterisk if reviewed in platform report)**:** Team Performance Assessment Technology (TPAT)

Level of activity

Strategic	
Operational	✓
Tactical	

Relevance

Highly relevant	✓
Relevant	
Somewhat relevant	

Purpose

Training	
Research	✓

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	✓		
Medium			
Large			
Teams of teams	✓		
1.2 Team History			
Ad Hoc	✓		
Fixed			
1.3 Physical Distribution			
Distributed			
Co-located	✓		

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	✓		
2.2 Workload			
Physical			
Cognitive			
Time pressure			
2.3 Task Interdependence			
Additive	✓		
Conjunctive			
Disjunctive			
Discretionary	✓		
Pooled			
Sequential			
Reciprocal			

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model		✓	
Task mental model		✓	
3.2 Communication			
Implicit		✓	
Explicit		✓	
Centralized network			
Decentralized network			
Hierarchical network	✓		
3.3 Coordination			
Implicit		✓	
Explicit			
3.4 Team Adaptibility			
Monitoring			
Feedback			
Back-up behavior			
3.5 Planning			
Resource Allocation			

4 Team Measures

4.1 Outcome	
Automation	✓
Self-Report	
Observers	
4.2 Level of Analysis	
Individual Performance	✓
Team Performance	✓

Comments: Scoring is provided within time/event matrices (specifically, decisions are plotted by time), such that key factors such as planning, strategy formation, decision-making, and adaptation to change are demonstrated both graphically and tabularly. Fifty such dependent measures are included and scoring occurs on-line. 53 scores are provided at the end of a session, including ten measures of process-related, social psychological, and performance factors: decision-making, planning, strategy development, situational awareness, initiative, communication, cohesion, leadership, task difficulty, and task performance. In the graphic presentation of results, arrowed lines of various colors indicate various situations. For example, a participant who performed an action to facilitate future plans, a participant who planned an action but neglected to follow through, and a participant who planned an action but then followed a different course would all be illustrated. The patterns of arrows and colors that emerge reveal the type of planning that took place (e.g., successful or unsuccessful).

Reference(s):

Swezey, R. W., Hutcheson, T. D., Swezey, L. L. (2000). Development of a second-generation computer-based team performance assessment technology. International Journal of Cognitive Ergonomics, 4, 163-170.

No.13

Scenario name: Anti-submarine Warfare

Platform name (asterisk if reviewed in platform report)**:** Hierarchical Task Analysis (Teams) - HTA (T)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
Centralized network	☑	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☑	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☐
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: HTA(T) breaks down team goals into sub-goals and then determines which sub-goals can be reached only by teamwork. Assessment is facilitated by the presence of video and voice recordings of team and control room operators. Qualitative assessment is drawn solely from observation by a subject matter expert, and so requires much training on the part of the expert and is naturally rather subjective. Each episode, transcribed from the recordings, is listed and coded with a classification scheme consisting of five categories of behaviors (also introducing a small amount of subjectivity). Communication behaviors are composed of sending information and receiving information, and coordination behaviors are composed of discussion, collaboration, and synchronization. Points are then assigned based on whether each required behavior was performed correctly, partially correctly, or incorrectly/omitted.

Reference(s):

Annett, J., Cunningham, D., & Mathias-Jones, P. (2000). A method for measuring team skills. Ergonomics, 43, 1076-1094.

No.14

Scenario name: Dyads (a pilot and co-pilot)

Platform name (asterisk if reviewed in platform report)**:** Low-Fidelity Aviation Research Methodology

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: N/A

Reference(s):

Bowers, C. A., Salas, E., Prince, C., & Brannick, M. (1992). Games teams play: A method for investigating team coordination and performance. Behavior Research Methods, Instruments, & Computers, 24, 503-506.

No.15

Scenario name: C3 environment - monitoring & prosecuting of incoming targets on a radar screen

Platform name (asterisk if reviewed in platform report)**:** Team Performance Assessment Battery (TPAB)

Level of activity		**Relevance**	
Strategic	☐	Highly relevant	☐
Operational	☐	Relevant	☐
Tactical	☑	Somewhat relevant	☑

Purpose	
Training	☐
Research	☑

Scenario evaluation:

1 Team Factors	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☐	☐	☑
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☑
Time pressure	☐	☐	☑
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures	
4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The primary process under study by this tool is team decision-making. The straightforward design of synthetic work allows for low cost, ease of measurement, and maximum experimental control, while still replicating realistic amounts of cognitive demand and workload – the vigilance required in TPAB is equivalent to that of real- life tasks. The primary dependent measure is reaction time, as state changes indicated within the monitoring component necessitate certain responses. A coordination component is also provided, as resources and actions must be synchronized properly to act against incoming targets and this must be done concurrently with the monitoring task. Because individual and team tasks must be performed simultaneously, as well, generalizability of the task to real-life is quite high. Task characteristics such as work load and time pressure and situational characteristics such as uncertainty can also be examined within TPAB. Lastly, further development has extended the original configuration to allow team size to vary.

Reference(s):

Bowers, C. A., Urban, J. M., & Morgan, B. B., Jr. (1992). The study of crew coordination and performance in hierarchical team decision making (Report No. TR-92-01). Orlando, FL: University of Central Florida, Team Performance Laboratory.

No.16

Scenario name:	Seeking to discover the intent of targets based on characteristics
Platform name (asterisk if reviewed in platform report)**:**	Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise (TIDE2)

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☑	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☑	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: TIDE2 is another alternative for the study of decision-making in complex, ambiguous environments in command and control.

Reference(s):

Hollenbeck, J. R., Sego, D. J., Ilgen, D. R., & Major, D. A. (1991). Team interactive decision exercise for teams incorporating distributed expertise (TIDE2): A program and paradigm for team research (Tech. Rep. No. 91-1). East Lansing: Michigan State University.

Hollenbeck, J. R., Ilgen, D. R., Sego, D. J., Hedlund, J., Major, D. A., & Phillips, J. (1995). The multi-level theory of team decision making: Decision performance in teams incorporating distributed expertise. Journal of Applied Psychology, 80, 292-316.

No.17

Scenario name:	a metropolis crisis control center.
Platform name (asterisk if reviewed in platform report)**:**	C3 Interactive Task for Identifying Emerging Situations (CITIES)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Purpose

Training	☐
Research	☑

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☑	☐
Cognitive	☐	☑	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	☐	☑	☐
Task mental model	☐	☑	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☑	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☑	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☑	☐
Feedback	☐	☑	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures	
4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: CITIES has received praise for imitating real- life environments successfully. Additional equipment can be purchased for more specific study of particular factors of interest (e.g., devices that determine which microphone is in use or measure heart rate of participants). NeoCITIES is an update and extension of the original CITIES task.

Reference(s):

Wellens, A. R., & Ergener, D. (1988). The C.I.T.I.E.S. game: A computer-based situation assessment task for studying distributed decision-making. Simulation & Games, 19, 304-327.

No.18

Scenario name:	A radar-like target classification task
Platform name (asterisk if reviewed in platform report)**:**	Team Argus

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☑	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: Argus simulates a radar-like target classification task. It was developed to support research in measuring and modeling cognitive work load. Argus is used in both single-subject and team modes. In Team Argus we are interested in what levels of task workload are required to make the team's decision making process and performance deteriorate and what types of communication protocols and decision aids can facilitate team performance at high levels of task workload.

Reference(s):

http://cat.mm.rpi.edu/cogworks/publications/131_Schoelles&Gray01_BRMIC.pdf

http://interruptions.net/literature/Miller-CHI01-p79-miller.pdf

http://www.rpi.edu/~grayw/pubs/papers/schoelles/ms-wdg.pdf

No.19

Scenario name: Recovering weapons from hidden caches

Platform name (asterisk if reviewed in platform report)**:** Neverwinter Night

Level of activity

Strategic	[ ]
Operational	[ ]
Tactical	[x]

Relevance

Highly relevant	[ ]
Relevant	[x]
Somewhat relevant	[ ]

Purpose

Training	[ ]
Research	[x]

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	[ ]	[ ]	[ ]
Medium	[ ]	[ ]	[ ]
Large	[ ]	[ ]	[ ]
Teams of teams	[x]	[ ]	[ ]
1.2 Team History			
Ad Hoc	[ ]	[ ]	[ ]
Fixed	[x]	[ ]	[ ]
1.3 Physical Distribution			
Distributed	[ ]	[ ]	[ ]
Co-located	[x]	[ ]	[ ]
2 Task Factors			
2.1 Task Complexity			
Uncertainty	[ ]	[ ]	[ ]
2.2 Workload			
Physical	[ ]	[ ]	[ ]
Cognitive	[ ]	[ ]	[ ]
Time pressure	[ ]	[ ]	[ ]
2.3 Task Interdependence			
Additive	[x]	[ ]	[ ]
Conjunctive	[ ]	[ ]	[ ]
Disjunctive	[ ]	[ ]	[ ]
Discretionary	[ ]	[ ]	[ ]
Pooled	[ ]	[ ]	[ ]
Sequential	[ ]	[ ]	[ ]
Reciprocal	[ ]	[ ]	[ ]

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	[ ]	[ ]	[ ]
Task mental model	[ ]	[ ]	[ ]
3.2 Communication			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
Centralized network	[x]	[ ]	[ ]
Decentralized network	[x]	[ ]	[ ]
Hierarchical network	[ ]	[ ]	[ ]
3.3 Coordination			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
3.4 Team Adaptibility			
Monitoring	[ ]	[ ]	[ ]
Feedback	[ ]	[ ]	[ ]
Back-up behavior	[ ]	[ ]	[ ]
3.5 Planning			
Resource Allocation	[ ]	[x]	[ ]

4 Team Measures

4.1 Outcome	
Automation	[x]
Self-Report	[ ]
Observers	[ ]
4.2 Level of Analysis	
Individual Performance	[ ]
Team Performance	[x]

Comments: This game was selected because it can be used to simulate cooperative team tasks and it facilitates scenario authoring and customization. The built-in game editor tools are designed to allow users to customize the size and contents of the game world, including synthetic character behavior and the creation of customized items. A range of elements were incorporated allowing for the examination of culture on (1) team organization, including designated leader and leaderless conditions, (2) preferences for negotiation styles, (3) willingness to engage in tasks not related to the primary mission and the impact of the requesting individual's status, and (4) response to insults as moderated by insulter social status. Performance is team-based, with participants able to increase the team score by completing tasks which have rewards while managing costs and penalties.

Reference(s):

http://nwn.bioware.com/

http://www.informs-cs.org/wsc05papers/134.pdf

http://www.dodsbir.net/sitis/view_pdf.asp?id=NATOWarren.doc

No.20

Scenario name: North African “insertion from the sea”

Platform name (asterisk if reviewed in platform report)**:** DDD-III simulator

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	☐	☐	☐
Medium	☑	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	☐	☐	☑
Task mental model	☐	☐	☑
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐
4 Team Measures			
4.1 Outcome			
Automation		☑	
Self-Report		☑	
Observers		☑	
4.2 Level of Analysis			
Individual Performance		☐	
Team Performance		☑	

Comments: The DDD-III is a distributed client-server simulation that provides a flexible framework in which to study team decision making and performance in complex situations.

Reference(s): http://www.dodccrp.org/events/1999/1999CCRTS/pdf_files/track_1/016entin.pdf

No.21

Scenario name: Capture-the-flag event at a “Platoon vs. Platoon” level.

Platform name (asterisk if reviewed in platform report)**:** Neverwinter Nights

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☑	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☑	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☑
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The NwN “engine” is very versatile and is capable of supporting a wide variety of activities. It therefore offers some of the versatility of a custom testbed. Indeed, the NwN engine is versatile enough to emulate or recreate many “simpler” games such as chess, Battleship, and Scudhunt.

Reference(s): http://openmap.bbn.com/~thussain/publications/2005_HFES_paper.pdf

No.22

Scenario name: Radar-based ATC Tasks

Platform name (asterisk if reviewed in platform report)**:** *ATC team training device

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures	
4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: N/A

Reference(s): http://www.hf.faa.gov/docs/508/docs/cami/00_25.pdf

No.23

Scenario name:	Ensuring that launching a space vehicle will not endanger the general populace
Platform name (asterisk if reviewed in platform report)**:**	Multi-agent Operation Range Simulation Environment (MORSE)

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☑
Observers	☐
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: MORSE (Multi-agent Operation Range Simulation Environment) is an environment for three team members, encompassing some of the challenges facing Range Operations at KSC (Kennedy Space Center).

Reference(s):

http://www.cs.cmu.edu/~softagents/papers/rectenwald_michael_2003.1.pdf

http://www.cs.cmu.edu/~softagents/morse/JohnSycaraMar03.ppt

http://www.cs.cmu.edu/~pscerri/papers/hcii_05.pdf

No.24

Scenario name:	working together to find Scud launchers
Platform name (asterisk if reviewed in platform report)**:**	SCUDHunt

Level of activity

Strategic	☐
Operational	☐
Tactical	☑

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☑	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☑	☐
Task mental model	☐	☑	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: SCUDHunt is an Internet-based game of command and control developed by the Center for Naval Analyses (CNA) and ThoughtLink, Inc.SCUDHunt was designed as an experimental test bed for SSA (Shared Situational Awareness) research, allowing us to obtain an objective measure of SSA, in the game context, and statistically analyze the data. The game appears deceptively simple. In fact, it enables the demonstration of very interesting team and individual behaviors, like leadership and decision-making, and yields a rich set of data.To play effectively, players need to collaborate and share information. No player can win by themselves – it takes a combined team effort to effectively deploy all sensors and correctly interpret the sensor results. This created an excellent environment for exploring a team's shared SSA, as well as for examining how the experimental conditions affect the team's overall decision quality (defined as their ability to locate all of the hidden SCUDs).

Reference(s):

http://www.scudhunt.com/

http://www.thoughtlink.com/publications.htm#SCUD

http://www.thoughtlink.com/files/pdf/MetaAnalysisWeb.pdf

No.25

Scenario name:	Naval Air Defense Warfare
Platform name (asterisk if reviewed in platform report)**:**	Wright State Aegis Simulation Platform (WASP)/Team Aegis Simulation Platform (TASP) (an extension of WASP)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☐	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☑	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☑	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The purpose of TASP is to extend the existing suite of tools known as WASP to better enable researchers to assess and model human performance in a team environment.The proposed effort will extend WASP by adding more tasks and responsibilities in a three-person team configuration, incorporate hooks for software models of each role to be able to interact with the simulation in real time, incorporate hooks for diagnostic algorithms and feedback algorithms, enable automatic collection of performance data to include automatic speech recognition, develop diagnostic algorithms consistent with the Team Dimensional Training methodology, design and develop software agents to identify and measure team time windows.

Reference(s):

http://www2.ie.psu.edu/Rothrock/Research/HPAM/hpam/tasp.htm

http://www2.ie.psu.edu/Rothrock/Research/HPAM/hpam/wasp.htm

No.26

Scenario name: Janus wargame

Platform name (asterisk if reviewed in platform report)**:** wargaming simulation

Level of activity

Strategic	[x]
Operational	[ ]
Tactical	[ ]

Relevance

Highly relevant	[ ]
Relevant	[x]
Somewhat relevant	[ ]

Purpose

Training	[ ]
Research	[x]

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	[x]	[ ]	[ ]
Medium	[ ]	[ ]	[ ]
Large	[ ]	[ ]	[ ]
Teams of teams	[ ]	[ ]	[ ]
1.2 Team History			
Ad Hoc	[ ]	[ ]	[ ]
Fixed	[x]	[ ]	[ ]
1.3 Physical Distribution			
Distributed	[x]	[ ]	[ ]
Co-located	[ ]	[ ]	[ ]

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	[x]	[ ]	[ ]
2.2 Workload			
Physical	[ ]	[ ]	[ ]
Cognitive	[ ]	[ ]	[ ]
Time pressure	[ ]	[ ]	[ ]
2.3 Task Interdependence			
Additive	[ ]	[ ]	[ ]
Conjunctive	[x]	[ ]	[ ]
Disjunctive	[ ]	[ ]	[ ]
Discretionary	[ ]	[ ]	[ ]
Pooled	[ ]	[ ]	[ ]
Sequential	[ ]	[ ]	[ ]
Reciprocal	[ ]	[ ]	[ ]

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	[ ]	[ ]	[ ]
Task mental model	[ ]	[ ]	[ ]
3.2 Communication			
Implicit	[ ]	[x]	[ ]
Explicit	[ ]	[x]	[ ]
Centralized network	[x]	[ ]	[ ]
Decentralized network	[x]	[ ]	[ ]
Hierarchical network	[ ]	[ ]	[ ]
3.3 Coordination			
Implicit	[ ]	[ ]	[ ]
Explicit	[ ]	[ ]	[ ]
3.4 Team Adaptibility			
Monitoring	[ ]	[ ]	[ ]
Feedback	[ ]	[x]	[ ]
Back-up behavior	[ ]	[ ]	[ ]
3.5 Planning			
Resource Allocation	[ ]	[ ]	[ ]

4 Team Measures

4.1 Outcome	
Automation	[ ]
Self-Report	[x]
Observers	[x]
4.2 Level of Analysis	
Individual Performance	[ ]
Team Performance	[x]

Comments: N/A

Reference(s): http://www.dsto.defence.gov.au/publications/2504/DSTO-TR-1372.pdf

No.27

Scenario name: Fire Fighting

Platform name (asterisk if reviewed in platform report)**:** Networked Fire Chief (NFC)

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☑
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☑	☐
Time pressure	☐	☑	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☑	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☑	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☐

Comments: It should be noted that NFC does not mirror everything that occurs in a military context. Rather, it is a tool used to investigate the NDM (Natural Decision Making) theory. It brings the sort of variables into play that would be involved in NDM such as uncertainty, complexity, and feedback loops.

Reference(s):

Chapman, T. (2000). The effect of management structure and communication architecture on naturalistic decision making performance, University of Adelaide: Unpublished Honours Thesis.

No.28

Scenario name: Fire fighting

Platform name (asterisk if reviewed in platform report)**:** C3Fire

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☑
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☑
Task mental model	☐	☐	☑
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☑
Observers	☑
4.2 Level of Analysis	
Individual Performance	☑
Team Performance	☑

Comments: C3Fire make it possible to configure and simulate different forms of organizations and ways of how the system allows the subjects to handle and to exchange information. Accordingly, it is possible to accomplish a command situation that have comparable similarities to current or envisioned where researchers can investigate as e.g. team performance from a predetermined and controlled situation, which in turn could have different levels of constraints in information flow.The C3Fire micro-world can be viewed as a command, control and communication simulation environment, which can be used for investigation, experimentation and training on TDM (team decision making) and TSA (team situation awareness).The C3Fire micro-world has shown to provide an excellent support for quantitative data retrieval, which in turn is supplemented with qualitative data retrieval from audio and video recordings, as well as questionnaires.

Reference(s):

http://www.c3fire.org/c3fire/home/home.en.shtml

http://www.dodccrp.org/events/2002/CCRTS_Monterey/Tracks/pdf/103.PDF

No.29

Scenario name: joint command and control

Platform name (asterisk if reviewed in platform report)**:** DDD-III

Level of activity

Strategic	[ ]
Operational	[x]
Tactical	[ ]

Relevance

Highly relevant	[x]
Relevant	[ ]
Somewhat relevant	[ ]

Purpose

Training	[ ]
Research	[x]

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	[ ]	[ ]	[ ]
Medium	[ ]	[ ]	[ ]
Large	[ ]	[ ]	[ ]
Teams of teams	[x]	[ ]	[ ]
1.2 Team History			
Ad Hoc	[x]	[ ]	[ ]
Fixed	[ ]	[ ]	[ ]
1.3 Physical Distribution			
Distributed	[x]	[ ]	[ ]
Co-located	[ ]	[ ]	[ ]

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	[x]	[ ]	[ ]
2.2 Workload			
Physical	[ ]	[ ]	[ ]
Cognitive	[ ]	[ ]	[ ]
Time pressure	[ ]	[ ]	[ ]
2.3 Task Interdependence			
Additive	[x]	[ ]	[ ]
Conjunctive	[ ]	[ ]	[ ]
Disjunctive	[ ]	[ ]	[ ]
Discretionary	[ ]	[ ]	[ ]
Pooled	[ ]	[ ]	[ ]
Sequential	[x]	[ ]	[ ]
Reciprocal	[ ]	[ ]	[ ]

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	[ ]	[ ]	[x]
Task mental model	[ ]	[ ]	[x]
3.2 Communication			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
Centralized network	[ ]	[ ]	[ ]
Decentralized network	[ ]	[ ]	[ ]
Hierarchical network	[ ]	[ ]	[ ]
3.3 Coordination			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
3.4 Team Adaptibility			
Monitoring	[ ]	[ ]	[ ]
Feedback	[ ]	[ ]	[ ]
Back-up behavior	[ ]	[ ]	[ ]
3.5 Planning			
Resource Allocation	[ ]	[ ]	[ ]

4 Team Measures

4.1 Outcome	
Automation	[x]
Self-Report	[x]
Observers	[x]
4.2 Level of Analysis	
Individual Performance	[ ]
Team Performance	[x]

Comments: Four categories of data were collected during each of the experiments: 1. DDD simulator-collected data or MTWS data files 2. Video and audio tapes 3. Observer-collected data 4. Player self-report data

Reference(s): http://www.dodccrp.org/events/1999/1999CCRTS/pdf_files/track_1/103wolle.pdf

No.30

Scenario name: Airborne Warning and Control System (AWACS) Weapons Director Teams

Platform name (asterisk if reviewed in platform report)**:** *DDDnet

Level of activity

Strategic	☑
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☑
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☑	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☐	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
Centralized network	☐	☐	☐
Decentralized network	☐	☑	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☑	☐
Explicit	☐	☑	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☑	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The DDDnet is an internet-ready version of a Linux-based collaborative gaming space that connects players to each other and to others, such as observers, confederates, trainers, or researchers. In the DDDnet observers at any location in the network are able to observe the scenario play in real time. They can view the screen display and electronic communications of any player, and communicate to one another via email or voice. In addition, the DDDnet can connect players to one another for interactive mission planning, debriefings and after-action reviews. DDD simulations in general are based on broad command and control (C2) functions and have been demonstrated to elicit important team-oriented cognitive processes such as communication and coordination, resource allocation and sharing, and decision making.

Reference(s):

Barnes, C., Elliott, L., & Entin, E. (2001). Employing Internet2 Technology to Enable Collaborative Research and Distributed Training in Complex Multi-Operation Settings. Webnet Journal, October-December.

http://dodccrp.org/events/2002/CCRTS_Monterey/Tracks/pdf/044.PDF

No.31

Scenario name:	Airborne Warning and Control System
Platform name (asterisk if reviewed in platform report)**:**	C3STARS

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☑
Research	☑

Scenario evaluation:

1 Team Factors	Indep	Dep	Unknown
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☐	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☐	☐	☐
Co-located	☑	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures	
4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: C3STARS facility offers the opportunity to investigate complex decision making among interdependent team members within a dynamic and realistic setting. Closed circuit video and audio stations permit experimenters to directly observe team interactions and remotely record all communications (computer, visual and audio) for later analysis. The unique simulations integrate hardware and software resources, data collection and analysis systems, verbal communication networks, command and control scenarios and team performance measures.

Reference(s): http://dodccrp.org/events/2002/CCRTS_Monterey/Tracks/pdf/044.PDF

No.32

Scenario name: Joint Task Force (JTF)

Platform name (asterisk if reviewed in platform report)**:** DDD-III

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☑	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☑
Decentralized network	☐	☐	☑
Hierarchical network	☐	☐	☑
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

	Dep
4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The focus of this study is on the relative effectiveness of three organizational structures in the conduct of a simulated Joint Task Force mission.Because of the focus in the paper on the role of coordination, the major mission tasks requiring multiple assets will be one focus of the analysis.

Reference(s): http://www.dodccrp.org/events/1999/1999CCRTS/pdf_files/track_1/102hocev.pdf

No.33

Scenario name: Pilots (ATC)

Platform name (asterisk if reviewed in platform report)**:** Microsoft Flight Simulator

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☑
Relevant	☐
Somewhat relevant	☐

Purpose

Training	☐
Research	☑

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	☑	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☐	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☐	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	☐	☐	☑
Task mental model	☐	☐	☑
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☐	☐	☐
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☐	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☐
Observers	☑
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: Military air crews flew two simulated missions. Independent judges provided evaluations of the same six team process variables in both scenarios.

Reference(s): Brannick, M. T., Prince, A., Prince, C., & Salas, E. (1995). The measurement of team process. Human Factors, 37, 641-651.

No.34

Scenario name:	Joint Task Force Group (JTFG)
Platform name (asterisk if reviewed in platform report)**:**	DDD III

Level of activity

Strategic	☑
Operational	☐
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☐
Research	☑

Scenario evaluation:

	Indep	Dep	Unknown
1 Team Factors			
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐
2 Task Factors			
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☑	☐	☐
Time pressure	☑	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

	Indep	Dep	Unknown
3 Team Processes			
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
Centralized network	☐	☐	☑
Decentralized network	☐	☐	☑
Hierarchical network	☐	☐	☑
3.3 Coordination			
Implicit	☐	☐	☐
Explicit	☐	☐	☐
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☑
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: The software environment allows one to perform a comparative analysis of different organizations for various (user-defined) performance measures, and to quantify the robustness of a given organizational design. The commander (CJTFG) sets out to devise a plan for the mission that will specify all the tasks to be completed, as well as analyze the decision-making involved and stipulate who completes what task, which resources are used to complete each specific task, and how JTFG will coordinate in order to guarantee the best performance.

Reference(s): http://dodccrp.org/events/1999/1999CCRTS/pdf_files/track_1/079patti.pdf

No.35

Scenario name: Team C2 Task under sustained operation environment

Platform name (asterisk if reviewed in platform report)**:** *AEDGE™ (Agent Enabled Decision Guide Environment)

Level of activity

Strategic	[x]
Operational	[x]
Tactical	[ ]

Relevance

Highly relevant	[x]
Relevant	[ ]
Somewhat relevant	[ ]

Purpose

Training	[ ]
Research	[x]

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	[x]	[ ]	[ ]
Medium	[ ]	[ ]	[ ]
Large	[ ]	[ ]	[ ]
Teams of teams	[ ]	[ ]	[ ]
1.2 Team History			
Ad Hoc	[ ]	[ ]	[ ]
Fixed	[x]	[ ]	[ ]
1.3 Physical Distribution			
Distributed	[ ]	[ ]	[ ]
Co-located	[ ]	[ ]	[ ]

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	[ ]	[ ]	[ ]
2.2 Workload			
Physical	[ ]	[ ]	[ ]
Cognitive	[x]	[ ]	[ ]
Time pressure	[ ]	[ ]	[ ]
2.3 Task Interdependence			
Additive	[x]	[ ]	[ ]
Conjunctive	[ ]	[ ]	[ ]
Disjunctive	[ ]	[ ]	[ ]
Discretionary	[ ]	[ ]	[ ]
Pooled	[ ]	[ ]	[ ]
Sequential	[ ]	[ ]	[ ]
Reciprocal	[ ]	[ ]	[ ]

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	[ ]	[ ]	[ ]
Task mental model	[ ]	[ ]	[ ]
3.2 Communication			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
Centralized network	[ ]	[ ]	[ ]
Decentralized network	[ ]	[ ]	[ ]
Hierarchical network	[ ]	[ ]	[ ]
3.3 Coordination			
Implicit	[ ]	[ ]	[x]
Explicit	[ ]	[ ]	[x]
3.4 Team Adaptibility			
Monitoring	[ ]	[ ]	[ ]
Feedback	[ ]	[ ]	[ ]
Back-up behavior	[ ]	[ ]	[ ]
3.5 Planning			
Resource Allocation	[ ]	[x]	[ ]

4 Team Measures

4.1 Outcome	
Automation	[x]
Self-Report	[ ]
Observers	[ ]
4.2 Level of Analysis	
Individual Performance	[x]
Team Performance	[x]

Comments: N/A

Reference(s):

http://dodccrp.org/events/2002/7th_ICCRTS/Tracks/pdf/113.pdf

Barnes, C., Whitmore, J., Elliott, L., & Harville, D. (2004) Assessing Complex Team Performance in a Sustained Operations Environment. Journal of the International Test and Evaluation Association, 25, 39-44.

Barnes, C., Elliott, L. R., Coovert, M. D., & Harville, D. (2004). Effects of Fatigue on Simulation-based Team Decision Making Performance. Ergometrika, 4, 2-12. http://www.ergometrika.org/volume4/BarnesEtAl.htm.

No.36

Scenario name: International humanitarian assistance

Platform name (asterisk if reviewed in platform report)**:** N/A

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☐	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☑	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: N/A

Reference(s): http://www.vcds.forces.gc.ca/dgsp/pubs/rep-pub/dda/scen/scen-3_e.asp

HUMANSYSTEMS Incorporated

No.37

Scenario name: PEACE SUPPORT OPERATIONS

Platform name (asterisk if reviewed in platform report)**:** N/A

Level of activity

Strategic	☐
Operational	☑
Tactical	☐

Relevance

Highly relevant	☐
Relevant	☐
Somewhat relevant	☑

Purpose

Training	☑
Research	☐

Scenario evaluation:

1 Team Factors

	Indep	Dep	Unknown
1.1 Team Size			
Small	☐	☐	☐
Medium	☐	☐	☐
Large	☐	☐	☐
Teams of teams	☑	☐	☐
1.2 Team History			
Ad Hoc	☑	☐	☐
Fixed	☑	☐	☐
1.3 Physical Distribution			
Distributed	☑	☐	☐
Co-located	☐	☐	☐

2 Task Factors

	Indep	Dep	Unknown
2.1 Task Complexity			
Uncertainty	☑	☐	☐
2.2 Workload			
Physical	☐	☐	☐
Cognitive	☐	☐	☐
Time pressure	☐	☐	☐
2.3 Task Interdependence			
Additive	☑	☐	☐
Conjunctive	☐	☐	☐
Disjunctive	☐	☐	☐
Discretionary	☐	☐	☐
Pooled	☐	☐	☐
Sequential	☐	☐	☐
Reciprocal	☐	☐	☐

3 Team Processes

	Indep	Dep	Unknown
3.1 Shared Knowledge			
Team mental model	☐	☐	☐
Task mental model	☐	☐	☐
3.2 Communication			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
Centralized network	☐	☐	☐
Decentralized network	☐	☐	☐
Hierarchical network	☑	☐	☐
3.3 Coordination			
Implicit	☐	☐	☑
Explicit	☐	☐	☑
3.4 Team Adaptibility			
Monitoring	☐	☐	☐
Feedback	☐	☐	☐
Back-up behavior	☐	☐	☐
3.5 Planning			
Resource Allocation	☐	☑	☐

4 Team Measures

4.1 Outcome	
Automation	☐
Self-Report	☐
Observers	☐
4.2 Level of Analysis	
Individual Performance	☐
Team Performance	☑

Comments: N/A

Reference(s): http://www.vcds.forces.gc.ca/dgsp/pubs/rep-pub/dda/scen/scen-9_e.asp

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Annex B: Scenario Plan Presented to Scientific Authority

B1. Introduction

This document outlines scenario requirements and two potential scenarios that can be used in conducting new human-systems integration (HSI) research on teams and to define the approaches for subsequent experimental and modelling work. Specifically, the document describes the general approach, assumptions, scenario requirements, factors that will allow experimental control, factors that may be manipulated, general categories of measures of performance (MOPs), and the identification of two scenarios that meet these requirements. This represents the first step in developing scenario(s) for team experiments and modelling that are representative of the targeted context.

B2. Method

B2.1 General approach

It was decided that the generation of a scenario for HSI research on teams should involve leveraging knowledge gained from the survey of team literature, the identification of team platforms, and knowledge of future requirements of the CF that are relevant to team research. This approach will allow the HSI® team to provide a starting point for the experimental and modelling work to be conducted in subsequent years of the Applied Research Project (ARP). Using concrete examples of scenarios based on a realistic context with identifiable units and personnel supports the development of a high fidelity experimental platform appropriate for team modelling.

B2.2 Assumptions

Based on direction provided by the Scientific Authority (SA), it was decided that the scenario will be at the operational level and comprise a Joint, Interagency and Interdisciplinary Task Force (TF), in which teams-of-teams can be ad hoc or fixed as well as distributed or co-located. To increase the face validity of teams-of-teams in a Joint, Interagency and Interdisciplinary setting, we suggest representing large size teams performing cognitive work to achieve common objectives.

B2.3 Generation of scenario requirements

Based on the results of the review of team literature, capabilities of relevant team research platforms and consideration of future requirements, the HSI® team identified factors that will define the scenario context, factors that will allow experimental control, factors that may be manipulated, and potential categories of MOPs. All of these will be integrated into the final scenario.

Scenario context

As a first step to developing a scenario, the Scientific Authority (SA) identified factors that are crucial to the vision of this project. The following factors are fundamental and will define the overall context of the scenario:

- Joint;
- Interagency;
- Interdisciplinary, and
- Operational level activity.

After careful examination, HSI® has identified other factors that emerge from accommodating these requirements. A team composed of Joint CF units, multiple agencies, and personnel performing distinct roles can be satisfied by selecting a scenario that allows for teams-of-teams. As a result of multiple small teams contributing to a single overarching team, the experiment can include both ad hoc and fixed teams, as well as distributed and co-located teams. Because of their nature, teams-of-teams will likely be ad hoc (because they are called together only as required for a particular operation) and distributed (because individual agencies work individually from different locations), while sub-teams are more likely to be fixed (e.g. Red Cross) and co-located. In addition, setting teams-of-teams as a requirement will presume a scenario/experiment that can support large scale teams (i.e. three teams of three). Lastly, to ensure relevance to operational CF activities, HSI® suggests focusing on cognitive team work in a Command and Control (C2) task.

Factors to be controlled in the Scenario

As noted above, preliminary discussion with the SA, a review of current literature on teams, and knowledge of future requirements of the CF, led to the identification of important concepts for developing a scenario for team research. The following team and task factors have been recognized by HSI® as important factors to be controlled within the scenario.

- Team heterogeneity;
- Task interdependence, and
- Primary as well as secondary events/tasks within the scenario.

Upon final selection of a scenario and agreement with the SA, the aforementioned factors will be explored to determine how they can be varied to pursue different research aims or whether they should be held static.

Factors that may be manipulated

Factors within the scenario that could be potentially manipulated during experimentation include:

- Time pressure;
- Workload (related to time pressure);
- Secondary tasks (i.e. noise);
- Resources available;
- Communication, and
- Level of uncertainty.

The factors that will ultimately be manipulated during experiments with teams will likely be determined when the experiment is defined, however, the scenario must be able to support manipulation of these factors.

Categories of MOPs

Although specific MOPs will be defined at a later point, three categories of MOPs that could be appropriate include shared knowledge (i.e. mental models), communication (e.g. number of missed communications) and team performance measures (e.g. quality of plan).

Summary of scenario requirements

Scenario context	Factors that allow experimental control	Factors that may be manipulated	Categories of MOPs
Joint	Team heterogeneity	Time pressure	Shared knowledge
Interagency	Task interdependence	Workload	Communication
Interdisciplinary	Primary and secondary events/tasks	Secondary tasks	Team performance measures
Operational level activity		Resources available	
		Communication	
		Level of uncertainty	

B2.4 Identification of potential scenarios

At this point two potential scenarios have been identified, however these scenarios can be tweaked or more scenarios can be generated depending on further direction from the SA. These two scenarios are described in detail below. The first scenario is a Domestic Operation (DOMOPS) to address the Winnipeg Floods. The second scenario is also based on a real-life operation that focuses on an international peace support operation involving non-combatant evacuation with a multinational joint forces headquarters (HQ) responsible for mission planning. It is believed that the use of scenarios based on real-life operations will prove more fruitful for modeling future Canadian Force (CF) activities and will also improve the face validity of the scenarios for CF personnel.

For each of the two potential scenarios, the following were identified:

1. What entities are involved? (i.e. military, navy, air force, OGD, NGO etc.) Who are the team member's?
2. How are teams organized?
3. At what level of activity does the team perform? What function does the team perform? (i.e. strategic, operational, tactical)
4. What are the team's goals and priorities?
5. What are the primary and secondary tasks?
6. What demands are imposed on the team in typical situations and in emergency situations?
7. What is the physical distribution of teams?
8. Is the scenario realistic?

It is anticipated that one of the scenarios presented in this report will be selected for the purpose of modelling teams, and that the scenario will provide the foundation for subsequent work to be conducted for this ARP. However, if either of these scenarios does not meet the requirements of the project, an alternative scenario can be created.

Table B1: Scenarios: domestic joint force operation & international peace support operation

Points of interest	Scenario: Domestic joint force operation – Winnipeg Floods (OP ASSISTANCE)	Scenario: International peace support operation
Entities involved (i.e. military, navy, air force, OGD, NGO etc.) and team members	**National and Provincial/Municipal:** *City Departments* – Ambulance, Fire, City of Winnipeg Police Service, Harbour Patrol, Social Services, Emergency Preparedness and Coordination Committee (EPCC) *National* – RCMP, Emergency Preparedness Canada (EPC) *Outside Agencies* – Media *Public Sector* – Emergency Public Information Team (EPIT), Public Health, Public Utilities, Public Works *Volunteer Groups* – United Way, Meals on Wheels, Red Cross, Salvation Army **Department of National Defence**: Joint Task Force, 8,500 CF personnel, 2,850 vehicles, 131 water craft and 34 aircraft	United Nations observers on the ground Canadian government officials at the Canadian Embassy Canada has been approached by the United States and Britain to lead a multi-national joint task force Joint
Organization of teams	Teams-of-teams led by Joint Task Force Headquarters (JTFHQ)	Teams-of-teams – Assigned units will operate under OPCON of the Canadian Task Force Commander but OPCOM will remain with the respective nations. Forces will act under national Rules of Engagement, coordinated through the Canadian Commander.
Level of activity/function of team (strategic, operational, tactical)	Strategic, Operational and Tactical	Operational and Tactical
Team goals and priorities	To evacuate and accommodate all those in danger and minimize property damage	Safe extraction of Canadian, American and British citizens from Caribba.
Primary and secondary tasks	**Primary Tasks**: Evacuate people in danger zones Ensure open lines of communication with citizens Accommodation for those evacuated Protection of high risk properties Dike construction	**Primary Tasks**: In cooperation with American and British military planners determine the optimal task force composition. Determine the operational command and control structure **Secondary Tasks**:

Points of interest	Scenario: Domestic joint force operation – Winnipeg Floods (OP ASSISTANCE)	Scenario: International peace support operation
	Sandbags **Secondary**: Deter crime Protection of properties at medium and low risk	The extent of human suffering due to instability following the election may be such that the United Nations would ask for assistance to secure the relative safety of major pockets of the population. It is Canada's current position that it will not interfere with the internal affairs of Caribba unless it can be clearly demonstrated that the government is systematically acting against its own population.
Demands imposed on the team in typical situations and in emergency situations	High time pressure Infrastructure (i.e. complimentary networks) Low level of uncertainty	High Time pressure **High Level of uncertainty**: It is impossible to predict what the authority of the regime will be following the election. The potential presence of larger numbers of Caribbanian civilians has to be considered in planning.
Physical distribution of teams	Distributed	Distributed
Realism of scenario	Based on a historical event that was successfully handled but could be improved	Fictitious, but comprising elements of real events

B3 Next steps

Once a decision has been reached regarding the factors to include in the final scenario, the following work must be performed to create a comprehensive scenario that will support HSI team research and modelling:

1. Identify clear and meaningful start and end points for the scenario;
2. Create of a representative timeline of relevant events and activities;
3. Highlight key decisions and/or action points for team members;
4. Define positive versus negative outcomes;
5. Support the identification of one or more HSI intervention(s) whose effectiveness may be explored in a future model or experiment;
6. Propose hardware and software requirements for an experimental platform appropriate for an experiment using the scenario;
7. Further develop MOPs and Measures of Effectiveness (MOEs), and
8. Propose one or more augmentation(s) or variation(s) to the scenario that can be used for training subjects for team experiment(s) or for testing the generalizability of the team model.

A final report encompassing the scenario development and tool evaluation will be submitted to the SA.

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Annex C: Modified Scenario Plan

Development of Team Scenario – Guidance on Next Steps

Target: Teams-of-teams in joint, interagency and distributed environment

- team 1: DND – higher level of command (e.g., CanadaCOM)
- team 2: DND – lower level of command (e.g., JTFA, JTFC, …)
- team 3: OGD (e.g., PSEPC)

Aim: To explore collaboration and coordination that takes place vertically (e.g., teams 1&2) and horizontally (e.g., teams 1&3), and possibly within- and across- teams. To support low to medium fidelity experiments and computational modelling, to examine factors such as: team structure, role assignment, communication, integration, leadership, common intent, readiness

Context: Domestic operations

Approach: Consider multiple scenarios that will require collaboration between the same 3 nodes, and where DND will play a substantial rather than peripheral role.

Action Items:

Define multiple (instead of one) scenarios, but with less granularity, sketched out rather than fully instantiated, for example:

- scenario 1: natural disaster (e.g., Winnipeg floods would be acceptable)
- scenario 2: terrorist (e.g., radiological threat)
- scenario 3: pandemic (e.g., avian flu, SARS)

Basically, for each scenario, answer a modified set of questions (cf., page 5 in your plan for team modelling scenario):

1. (edited) What 3 entities/teams are involved? Who are the team members within each entity?
2. (edited) How are teams organized?
3. How is responsibility shared/distributed?
4. How is authority shared/distributed?
5. (edited) What function does each team perform? (i.e. strategic, operational, tactical)?
6. (edited) What are the teams' goals and priorities? What are the team members' goals and priorities?
7. What are the teams' primary and secondary tasks? What are the team members' tasks?
8. What demands are imposed on the team in typical situations and in emergency situations?
9. What is the physical distribution of teams?
10. (omit)
11. (new) How do the teams communicate and coordinate? (i.e., main tools and processes)

In addition, answer the following questions by drawing from literature review:

- which factors on team performance or team effectiveness can each scenario explore?
- which factors are expected to be especially influential in which scenarios? would the influential factors be the same or different across scenarios?
- for each influential factor, what level of the factor does each scenario represent?
- How well does each scenario support team experiments?
- How well does each scenario support computational modelling of teams?
- Is there a conceptual model of team performance/effectiveness (from literature) that can be tested by experiments using these scenarios?
- Is there a computational model of team performance/effectiveness (from survey) that can be tested by experiments using these scenarios?
- To conduct experiments with low/medium fidelity and medium/high control, who should participate in the experiments (i.e., profile sketch)?
- What screening / training should be provided to the experiment participants?

In terms of Next Steps (cf., page 8 in your plan for team modelling scenario):

1. (de-emphasize) dentify clear and meaningful start and end points for the scenario; -> de-emphasize
2. (de-emphasize) Create of a representative timeline of relevant events and activities -> de-emphasize
3. (important) Highlight key decisions and/or action points for team members;
4. (important, relates to #7) Define positive versus negative outcomes;
5. (edited) identify one or more HSI intervention(s) whose effectiveness may be explored using these scenarios
6. (de-emphasize) Propose hardware and software requirements for an experimental platform appropriate for an experiment using the scenario;
7. (important) Further develop MOPs and Measures of Effectiveness (MOEs)
8. (omit)

Annex D: Questionnaire Sent to Computational Model Developer Organization

Dear Sir/Madam,

We are conducting an assessment on tools for modeling team processes (computational models) on behalf of DRDC (Defence Research, Defence Canada). We are very interested in Brahms. You are highly appreciated if you are kind enough to take a moment to clarify the following questions for us as to the Brahms:

Is the Brahms capable of doing/supporting the following functions?

*Generally, please answer YES or NO.

*Please also give a brief explanation when necessary.

*Some question maybe hard or not applicable to answer. You can just ignore them.

1. Measures Workload?

Brahms includes a full agent- (BDI) and object-oriented language; you can program any measurement you want to make during a simulation.

2. Compatible with IPME?

Brahms has an agent-based (BDI) language and a Java API. Any human-performance model could be interfaced with as an agent in Brahms.

3. Scenario Flexibility?

The Brahms language allows for initial-beliefs and creation of agents and objects dynamically. This way you can create scenarios for simulation. The language also allows the creation of new beliefs via conclude statements that can have certainty factors. This enables flexibility for Monte-Carlo sims.

4. Domain Independent?

Yes, Brahms is a domain independent BDI language.

5. Model Team as Entity?

Agents can represent any abstract user-defined role, including representing an entire team. Agents can have attributes to allow the creation of beliefs about the agent for any agent or object, and facts in the world about the agent. Furthermore, you can define inference rules (forward-chain reasoning and situation-action rules), activities and activity-rules (rules that execute activities, take time and thus allow for representing situated action. One can also define initial beliefs for the agent and world facts about the agent. Each agent has a belief-set that contains all the beliefs of the agent at any moment in time. Agents perform activities and situated action by the firing of inference and activity-rules by matching their preconditions to the current belief-set.

6. Model Team as Group of Individuals?

Yes, Brahms agents can be members of one or more Groups. Groups can represent any abstract user-defined role, including representing an entire team. A Brahms Group can define a functional, organizational, social group, or community of practice. Agents inherit everything defined in a Group. Anything that can be defined at the agent-level can be defined at the Group-level and is inherited by the agents that are a member of the Group.

7. Model Specified Team Tasks?

Any task can be modeled as a set of activities (or as a composite activities which is decomposed into a set of inference rules (called thoughtframes) and sub-activities and their activity-rules (called workframes). Team tasks can thus be modeled at the Group level, or at the Agent level. This is up to the modeler.

8. Model Specified Team Interactions?

A predefined type of activity is a "communicate activity". In communicate activity the agent can communicate and/or receive beliefs to/from other agents or objects. Using a combination of communicate activities we can model generic Team interactions (such as information exchange in a meeting), or a specific interaction with objects (e.g. Typing in your pin-code at an ATM machine), or a specific communication that always happens (e.g. I always say my name when I pick up the telephone).

9. Model HSI (Human System Integration) Interventions of Interest?

Since Brahms also models objects, we can model systems as objects (not just agents). We can model human-system interaction very easily and naturally. More specifically, since any agent can be modeled as a Java agent, we can easily create an interface to the actual system.

10. Analyze Team's Strategies?

Since Brahms is an agent language and you can easily model teams and team tasks, you can easily analyze team strategies by analyzing the creation, communication and changing of agent beliefs as they are performing work activities.

11. Analyze Team's Performance?

See answer for #10. Activities can easily be modeled as creation and work on objects, which can be easily used to calculate individual agent performance and aggregate this up to team performance.

12. Available in Public Domain?

Yes. Brahms can be downloaded and used for free. However, Brahms is not Open Source. Brahms includes an agent-based language, compiler, and virtual machine/simulation engine, Interactive Development Environment (the Composer and soon a Brahms plug-in for Eclipse).

13. Stable?

Brahms has been stable for more than five years, although we are continuing adding new features.

14. Real-Time Computer Generated Forces?

Brahms can easily be used for real-time applications, including CGF. Brahms has been used at NASA for the development of a multi-agent workflow environment, creating personal agents for astronauts and robots. We have integrated speech dialog, GUIs and planning systems as human-agent interfaces to Brahms agents

Annex E: Description of Reviewed Scenarios

No.	Scenario name	Platform Name	Relevance	Scenario
1	Search-and-Rescue Mission in Antarctica	NASA Ames Centre - Distributed Research Facilities (NASA)	Highly Relevant	Space mission: A computer-based simulated search and rescue mission set in Antarctica was developed to study team interaction and decision making performance. Four-member teams must work together to locate a lost party sent to repair a malfunctioning communication antenna. Teams must develop plans and strategies, share information, manage resources, and cope with unexpected problems under time pressure. Both task and team stressors are manipulated to induce cognitive and emotional arousal. Task performance, physiological measures (ECG, respiration, SCL, EMG, PPG), voice and email communication, personality, team dynamics, and facial affect measures are being analyzed to identify the relations between stress, team interaction, and team performance.
2	Team Resource Allocation Problem in Emergency Crisis Management	NeoCITIES (Pennsylvania State University and Purdue University)	Highly Relevant	The simulation is designed to conduct empirical research on team cognition and decision-making within a distributed environment. NEOCITIES is an interactive computer program designed to display information pertaining to events and occurrences in a virtual city space. The teams in the simulation represent three separate services (Police, Fire/EMS, and Hazmat) in which they must assess situations, interact and communicate according to their inter-team and intra-team roles, allocate resources in a timely manner, and make decisions within the context of emergency crisis management. Scenarios used could address isolated and mundane events, inclusive events that have the potential to escalate in complexity, potential terrorist activities (international or domestic).

No.	Scenario name	Platform Name	Relevance	Scenario
3	Uninhabited Air Vehicle (UAV) Ground Control Operations to Taking Reconnaissance Photos	Synthetic Task Environment (STE) in Cognitive Engineering Research on Team Tasks (CERTT) Lab	Relevant	Simulation of Uninhabited Air Vehicle (UAV). The task is based on the actual operations of the Air Force's Predator UAV (UAV for the purpose of taking reconnaissance photos). Teams of three members have distinct roles. The Air Vehicle Operator controls airspeed, altitude, heading, and monitors the UAV systems. The Payload Operator adjusts camera settings to take target photos and monitors camera equipment. The Data Exploitation, Mission Planning and Communications Operator oversees the mission, plans a route under various constraints, and reports locations and restrictions.
4	Command and Control Simulation - Defending a region against invasion from unfriendly entity	DDD	Highly Relevant	The DDD is a dynamic command and control simulation requiring team members to monitor activity in a geographic region and defend it against invasion from unfriendly ground or air tracks that enter that region. Participants were seated in close proximity to one another at four networked computer terminals. Verbal communication was the only method of communication allowed during the task. Team members were free to talk as much or as little as they wanted. The geographic region is partitioned into four quadrants of equal size. Each team member is assigned the responsibility for one of the four quadrants. The objective of the simulation is to identify tracks that enter the space, determine whether they are friendly or unfriendly, and if unfriendly, keep them out of the restricted zones.
5	Combat Information Center - Monitoring radar display for targets	Tactical Navy Decision Making System (TANDEM)	Relevant	In TANDEM, subjects perform a sequence of time critical information gathering and communications tasks to identify targets then decide whether to shoot or clear each target. TANDEM is a simulated radar display that spots a predetermined number of targets on the screen. The task, in essence, is to determine the type and intent of the target, and take appropriate action.

No.	Scenario name	Platform Name	Relevance	Scenario
6	Naval Surveillance and Threat Assessment Operation	Team and Individual Tactical Assessment Network (TITAN)	Relevant	Four team members are asked to imagine themselves as officers aboard a naval ship. Their mission is to evaluate the threat posed by the air, surface and subsurface traffic (aka. 'contacts') in their ship's vicinity. Their ship and the contacts surrounding it are displayed on the radar screen at each workstation. The team's task begins with the Leader selecting a contact for the subordinates to evaluate. The Leader waits for each subordinate to use the information gathered by the ship's sensors to evaluate the threat level of the contact. Upon reviewing their respective contact information the subordinates each submit a threat assessment to the Leader. Once the Leader receives all three threat assessments (s)he synthesizes the information and submits a final threat assessment on behalf of the team. The team will later be able to review feedback.
7	Tank Battle Game	Bolo	Somewhat Relevant	Team members were seated side by side at three computers, and each controlled an on-screen 'tank' and worked in a computerized alliance with fellow team members. Teams' targets in this exercise were sixteen enemy 'pillboxes' that would attack and attempt to destroy any tanks within their firing range. Members' tanks were armed and could fire at pillboxes, but they had to replenish supplies at one of twelve refueling bases when ammunition was depleted. Teamwork is required in Bolo, because while it is extremely difficult for a single task to destroy a pillbox, tanks working together can readily do so.
8	Naval Combat Experience	Dangerous Waters	Somewhat Relevant	The Multiplayer multi-station mode allows players to man a specific station aboard a ship, plane or submarine, with other players taking the role of other crewmembers on the same platform. As the commander of the platform the player can either relinquish control of various stations to the automated Autocrew or man all stations automatically. Upon selecting a platform and the mission difficulty level, the player will be provided with an entirely random and dynamic scenario that will be composed of an infinite combination of mission goals, enemy forces, and random locations.

No.	Scenario name	Platform Name	Relevance	Scenario
9	Helicopter flight simulator	Longbow 2	Somewhat Relevant	The three team members worked together as a pilot, gunner and radar specialist to operate the Apache helicopter and were charged with conducting attack missions in challenging battlefields. The goal of each mission was to fly into enemy territory, destroy enemy targets, and return safely to friendly territory. To accomplish the mission teams had to navigate a fixed course of waypoints, identify and destroy all enemy targets encountered, and, at the same time evade enemy attacks on their helicopter. Missions concluded in three different ways: a) when a team reached the last waypoint, b) when a team was destroyed by enemy fire, or c) when the 12 minute time limit expired.
10	Radar monitoring task	Team Event-Based Adaptive Multilevel Simulation (TEAMSim)	Somewhat Relevant	TEAMSim is a PC-based simulation of a radar-tracking task. Three-person teams were seated at simulated radar consoles where contacts with different priorities and patterns of movement appeared. Team members communicated freely with one another on a closed communication system. Participants needed to learn how to 'hook' contacts on the radar screen, collect information to classify their characteristics, and render an overall decision (take action or clear) for each contact. Each team member was primarily responsible for one of the three sectors designated on the display, but each had discretion to monitor and work in their teammates' sectors.

No.	Scenario name	Platform Name	Relevance	Scenario
11	Reconnaissance	The Archimedes Combat Modeling Platform	Somewhat Relevant	The scenario depicted is a reconnaissance scenario. The (very simple) playbox consists of a 10x10 grid, each element on the grid represents a distinct terrain element. Each terrain element is characterized by three quantities: trafficability, which affects movement; cover, which affects combat adjudication; and concealment, which affects detection. Blue represents water, yellow open terrain, green forest, grey mountain and dark grey mountainous forests. In this scenario, a recon team (blue Agents) traverses a series of recon checkpoints (black Agents), searching for an objective (turquoise Agent) that is under guard by the enemy (red Agents). The blue Agents' goal is to locate the objective without being detected by the red Agents. The blue Agents are endowed with behaviors designed by the analyst to enable them to achieve their goal. These behaviors are dependent upon an Agent Variable, discipline.
12	Hostage Extraction	Team Performance Assessment Technology (TPAT)	Highly Relevant	The basic scenario entails a hostage extraction situation in an invented country. A command structure exists, including subordinates, superiors, and lateral colleagues, composed of a total of nine personnel, each of which occupies a different role (TPAT simulates missing personnel if needed). Generally, three teams are formed (though the option to reorganize them exists): (1) command team, (2) air resources team, and (3) ground resources team. All personnel can communicate with one another. Most information (generally presented in the form of a message) given to a participant is specific to that participant's role. Based on such information, decisions are made – this is accomplished by choosing from over 1,000 decision alternatives. For each decision made (which may be in response to information, in response to a request made by another participant, or to self- initiate an action), four steps are taken: (1) the decision is made, (2) the prior events leading to the decision are named, (3) plans, if any, are stated, and (4) other participants are notified of the decision. TPAT also generates challenges (e.g., emergencies, sudden changes, missing information) which may alter the course of a decision.

No.	Scenario name	Platform Name	Relevance	Scenario
13	Anti-submarine Warfare	Hierarchical Task Analysis (Teams) - HTA (T)	Relevant	The scenario entails four ships (provided to operators) which are used to escort and prevent the attack of two highly- valued units (e.g., supply ships). Anti-submarine warfare teams are distributed with a central control unit. These teams must respond to specific events (e.g., a request, a torpedo report, failing sonar) by identifying threats (e.g., determining if a presence is a submarine or a whale), deciding threat location, and attacking if necessary. Each event is designed to elicit specific actions (typically information-sharing behaviors).
14	Dyads (a pilot and co-pilot)	Low-Fidelity Aviation Research Methodology	Relevant	This paradigm was designed to study dyads (a pilot and co-pilot) and is available commercially as a standard aviation simulation program. The hardware arrangement involves only one computer and two monitors, and is therefore a low-cost, relatively hassle-free assessment that successfully provides elements of task coordination, communication, interdependency of roles, and measurement of individual characteristics. However, it may difficult to alter some variables such as task and work characteristics. Additionally, the configuration cannot be adjusted and so team size cannot be varied. Reliability and validity have been found to be acceptable.
15	C3 environment - monitoring & prosecuting of incoming targets on a radar screen	Team Performance Assessment Battery (TPAB)	Somewhat Relevant	TPAB uses “synthetic work” – in this case the monitoring and prosecuting of incoming targets on a radar screen – to approximate a command, control, and communication environment.

No.	Scenario name	Platform Name	Relevance	Scenario
16	Seeking to discover the intent of targets based on characteristics	Team Interactive Decision Exercise for Teams Incorporating Distributed Expertise (TIDE2)	Highly Relevant	Four team members, each with a different area of "expertise," seek to discover the intent of targets based on nine characteristics. Five rules exist that describe various combinations of characteristics, which then dictate threat level, so participants must share information in order to glean threat level to take appropriate action. Participants must complete individual as well as team tasks. Similar to occupations found in real life, TIDE[2] contains a hierarchical organization – there is a designated leader. And, as in real life, this leader can receive input from subordinates, but may make a decision at any time – with or without the agreement or contribution of others. One advantage that is generated by this capability is that group conflict can be manipulated. Other task characteristics such as ambiguity, time pressure, and task complexity can also be modified, and this paradigm has been used to study the relationships between stress, uncertainty, conflict, coordination, and performance. TIDE[2] scenarios can be tailored to a variety of environments (e.g., naval, investment banking, personnel selection), and components for data collection, data sorting, and data analysis are included.
17	A metropolis crisis control center	C3 Interactive Task for Identifying Emerging Situations (CITIES)	Highly Relevant	CITIES is actually comprised of an entire simulation system – not just software – in an attempt to more closely approximate the constraints of the environment that is simulated: a metropolis crisis control center. Team decision-making under pressure is the primary process of interest; information is distributed among participants and may be ambiguous, and the task is timed. Operating the "crisis center" requires constant monitoring and assessment (situation awareness) of changing events, as well as shifting the allocation of resources as priorities change. Teams are geographically dispersed and composed of two members, but CITIES is unique in that two cooperative two-member teams (fire and police) work together, thereby introducing a communication pattern not often examined in most team process assessments. Communication between team members is by audio conferencing and two-way video, supplemented by monitors with interactive touch screens. The type, number, sequence, timing, location, and severity of events can be manipulated, as can information richness and resource availability. Most dependent measures are recorded electronically by the system.

No.	Scenario name	Platform Name	Relevance	Scenario
18	A radar-like target classification task	Team Argus	Somewhat Relevant	Team Argus is solely a decision task. In the decision task, information is displayed to the subject about possible targets in the air space and on the ground. Based on this information and criteria given to the subject, he or she is to make a decision about what action to take (e.g., monitor, warn, engage etc.). In Team Argus access to the exact values of target attributes (cues) is distributed among the members. Members can send their cue data to other team members and can request data from other members. In team Argus, communication between team members is accomplished through text and data messages sent between workstations.
19	Recovering weapons from hidden caches	Neverwinter Night	Relevant	The game-based testbed uses a "re-skinned" version of the commercial off-the-shelf medieval fantasy role-playing game Neverwinter Nights. The re-skinned version features a simulated modern cityscape with people wearing modern clothes and engaged in non-magical activities. Basically, team members are assigned roles (e.g., patrol leader, weapons specialist) depending on the experimental condition and the team is given the high level task of locating and acquiring caches of weapons hidden within a town. The team is provided with equipment to help with the task (sensors of varying capabilities designed to help locate weapons caches and tools for opening doors and crates) and must decide how to allocate those resources. Additionally, team members have collaboration tools, allowing information to be shared between individuals and locations flagged or marked within the virtual environment.
20	North African "insertion from the sea"	DDD-III simulator	Highly Relevant	The primary mission tasks include demining and taking two beaches, taking and holding a hill overlooking one of the beaches, identifying and destroying the correct bridge to prevent enemy forces from reinforcing enemy troops near the beach heads, taking and holding an air field, and taking and holding a sea port. In addition to the main mission tasks the team must contend with a number of additional tasks that arise at unexpected times during the scenario trial (e.g., suppressing enemy artillery, destroying FROG missile launchers, destroying enemy aircraft, destroying enemy armor).

No.	Scenario name	Platform Name	Relevance	Scenario
21	Capture-the-flag event at a "Platoon vs. Platoon" level.	Neverwinter Nights	Relevant	The exercise scenario was similar to a capture-the-flag event at a "Platoon vs. Platoon" level. The participants were separated into two competing platoons of size 20. Each platoon was comprised of 3 squads, each with a similar mix of player types. Each participant was assigned a specific avatar and a role (platoon leader, squad leader or squad member). The avatars varied in their individual capabilities in order to promote teamwork and collaboration between players as they had to cooperate to apply different combinations of capabilities in order to meet mission demands. In each of two camps, a flag was placed which indicated possession or ownership of that territory. Adjacent to the flag was a lever that was used to indicate a change in possession of that flag and surrounding territory. Once a lever was pulled, it would remain in the possession of the puller's platoon until a member of the opposing platoon gained access to the lever, thereby claiming it as their own. In addition to the levers in the two camps, a third flag and lever were located in a "Hidden Camp." Players were told that the hidden lever could be found somewhere in the environment, but were not given its specific location. The hidden camp was protected by NPCs who could inflict damage to the avatars. The stated goals of the game were to defend your flag while capturing the flag of the opposing team or of the hidden camp.
22	Radar-based ATC Tasks	ATC team training device	Somewhat Relevant	Three scenarios - low, medium, and high-density conditions - were developed and calibrated to create three levels of aircraft density based on the number of aircraft presented to the team over time. Aircraft originally appeared in an inactive state and were activated at the discretion of the participant in the originating sector. Once activated, the aircraft had to travel through three sectors before landing at an airport in the fourth sector. The tasks required that subjects use a point and click method with a mouse to issue changes in aircraft direction, speed, and altitude.

No.	Scenario name	Platform Name	Relevance	Scenario
23	Ensuring that launching a space vehicle will not endanger the general populace	Multi-agent Operation Range Simulation Environment (MORSE)	Highly Relevant	It is a distributed system that simulates a task performed by a team of three human operators, each being responsible for some aspect of ensuring that launching a space vehicle from KSC will not endanger the general populace. MORSE provides monitoring stations where human operators track the progress of the mission prior to launch, and decide whether to abort or go ahead with the launch. To make this decision, the team must monitor incursions (e.g., aircraft or boats) that have entered the exclusion zone, an area bounded by launch impact lines. The human team has at its disposal radars that allow the team members to see incursions in the areas covered by the radars, and interceptor vehicles that can be appointed to intercept incursions. Radars and interceptor vehicles are shared resources that team members must acquire through coordination with each other and utilize for the performance of the team task. The overall team objective is to effect a safe launch where no incursions are left within the impact lines at launch time and resource consumption over the course of the task is minimized.
24	Working together to find Scud launchers	SCUDHunt	Highly Relevant	SCUDHunt is an abstract game of command and control, implemented as a multi-player web-based game. Team members play via the Internet; they may be collocated or distributed. The goal of the game is for team members to correctly determine (within a specified number of turns) where three Scud launchers are located on a 5-by-5 grid. The three launchers are randomly placed at the start of each game and remain stationary. Once the players find them, they do not move. Each player is assigned a role as an asset manager and controls one or more sensor assets. Each sensor covers a different number of squares and has a different probability of detecting a launcher. Some assets can also return false information, requiring verification on a subsequent turn by a more reliable asset. Conceptually, each turn has three phases: 1) a search phase, in which players place their assets on the board and receive search results, 2) a phase in which players share results, and 3) a strike plan phase, in which players nominate those squares they feel most likely contain a SCUD launcher.

No.	Scenario name	Platform Name	Relevance	Scenario
25	Naval Air Defense Warfare	Wright State Aegis Simulation Platform (WASP)/Team Aegis Simulation Platform (TASP) (an extension of WASP)	Somewhat Relevant	WASP uses a simplified naval command and control team consisting of a Tactical Action Officer (TAO), an Identification Supervisor (IDS), and the Electronic Warfare Supervisor (EWS). We assume that each member of the team must accomplish specified tasks based on the tactical situation, rules of engagement, and commanding officer (CO) directives. The TAO supports the CO to command, maneuver the ship, and define operational parameters. The TAO also can give the order to deploy weapons and provide verbal feedback to team member requests. The IDS is responsible for the supervision and control of the identification function. The IDS controls the Identification Friend-Foe (IFF) functions, manages air tracks in the system, and issues verbal level warnings to perceived hostile aircraft. The EWS is responsible for supervising the operation of electronic support measures. Furthermore, the EWS is responsible for the proper characterization of tracks and association of sensors to tracks.
26	Janus wargame	Wargaming simulation	Relevant	Janus is an interactive simulation wargame that allows multi-sided combat, under realistic simulation conditions. The view on the screen is a two-dimensional map with grid lines. However, to the weapon systems the terrain is three-dimensional (with elevation and contour lines). This affects maneuverability and line of sight. Unless the enemy is in the line of sight, each player can only see their own forces. When an enemy enters the line of sight of a friendly unit, it is spotted and identified. The units then automatically engage with the enemy, making decisions about what type of ammunition they will use (this decision is programmed into the computer's database). Janus models real world phenomena, including natural and man made obstacles, the requirement for route planning, direct and indirect fire engagements, planned fire missions, and tactical decision-making as the game progresses. The tasks require the coordination and co-operation of a team of people. Janus allows a team of three or more participants. One participant can act as a battle commander, while others can act as sub-unit leaders. This sets up a requirement for distributed decision-making. A communication system can also be used between the team members.

No.	Scenario name	Platform Name	Relevance	Scenario
27	Fire Fighting	Networked Fire Chief (NFC)	Relevant	It requires the operator to make decisions under continually changing conditions. Participants are required to fight fires that spontaneously break out on a map, thus providing an element of uncertainty. Also, the tasks involved in successfully fighting a fire require the co-ordination and co-operation of a team of people. An advantage of the NFC program is that it can be networked, so that hierarchical organization structures can be examined. Variations in weather are represented by wind direction and wind speed. The participants are required to use the appliances to extinguish the fires. The appliances have some of the same limitations as their real world equivalents. The decision-maker is also required to prioritize areas when allocating resources to fight the fires. The order of priority established on NFC is: 1) residences, 2) pastures, 3) national park, and 4) grassland. The purpose of this variety in landscape is to create a more complex and realistic goal. Performance scores show the percentage of landscape left after a designated period of time had elapsed, taking land priority into consideration.

No.	Scenario name	Platform Name	Relevance	Scenario
28	Fire fighting	C3Fire	Highly Relevant	The environmental domain, which is forest fire fighting, is of subsidiary interest and has been chosen because it generates a good dynamic target system. The system generates a task environment in which a group of people cooperate to extinguish a forest fire. The simulation includes forest fire(s), different kinds of vegetation, infrastructure (“villages” and “cities” – that are represented as houses), computer-simulated agents (fire-fighting units and reconnaissance personnel). The user interface consists of three basic elements; (1) a Geographic Information System (GIS); (2) a diary; and (3) an e-mail system. The GIS can be manually or automatically updated, as well as shared with other users. During a session, the simulator updates the GIS around the simulated units for the actors who are controlling these units. The players who run the system are part of a firefighting organization and can take on the roles of decision-team members or fire-fighting unit chiefs. The task of the decision-team is to have an overview of the situation, and to co-ordinate and schedule the fire-fighting units so that they can extinguish the fire and save the infrastructure. Communication among the different organizational parts is mainly conducted through mail and GIS updates
29	Joint command and control	DDD-III	Highly Relevant	Basically, a country friendly to the United States has been invaded by a neighboring state and has asked the United States for help. In response, a Joint Task Force (JTF) is tasked to conduct expeditionary amphibious operations to seize a seaport, an airport and a key bridge to facilitate the introduction of follow-on forces. The forces must accomplish a set of approximately 50 tasks, some known and some surprise, and some with temporal interdependencies, to achieve the overall mission. Developing concepts and methods to design architectures optimally matched to such a set of tasks, and comparing the performance of these architectures against that of more traditional architectures have been key foci of the A2C2 research. “Trigger” events that dramatically alter the task set or resources available have also been introduced during the scenario in two of the experiments (two and three) to examine structural and process adaptation.

No.	Scenario name	Platform Name	Relevance	Scenario
30	Airborne Warning and Control System (AWACS) Weapons Director Teams	DDDnet	Highly Relevant	This version of the DDDnet was developed to represent the underlying cognitive and decision making task demands of Airborne Warning and Control System (AWACS) Weapons Director Teams, based on multiple investigations of cognitive and functional aspects of this performance domain (Coovert, et al., 2001). Further development resulted in a scenario that emulates three military C2 teams: the USAF AWACS team, another USAF ground-based C2 team, and a third Navy airborne C2 team. The AWACS DDD-Net was implemented and demonstrated, allowing distributed simulations over the Internet. It linked the different locations, allowed multi-role missions, data collection, and feedback. Different parts of the network included I-2 connections for improved speed and performance. The DDDnet achieved and maintained a synchronized connection for an AWACS simulation involving 16 participants. Simultaneously, observers at each location rated performance using web-based tools that allowed immediate data pooling, analysis, and feedback, within 10 minutes after data input was complete.
31	Airborne Warning and Control System	C3STARS	Somewhat Relevant	The crew stations and scenarios simulate the air defense mission of an AWACS (Airborne Warning and Control System) platform. Realism is achieved through the functional representation of equipment and displays, experienced personnel playing the role of simulation pilots, and the use of operational scenarios.

No.	Scenario name	Platform Name	Relevance	Scenario
32	Joint Task Force (JTF)	DDD-III	Highly Relevant	The U.S. is taking action in support of an ally, Country Green, that has been invaded by neighboring Country Orange. The ultimate objectives of this mission are to secure Country Green's Airport and Port. A mission briefing document that outlined a specific chronology of mission tasks to be undertaken by the JTF was distributed to all participants. A greatly simplified version is listed below. 1. Amphibious forces will land and take North and South Beach after clearing mines. 2. Prior to taking N. Beach, infantry (INF) and air support will seize and hold the overlooking the beach. 3. Infantry will move down roads from S. Beach toward airport and from N. Beach to Port clearing mines and enemy tanks. 4. Special Operations Force (SOF) and satellite (SAT) must determine which of two roads the enemy plans to use for insertion of forces by assessing traffic. Once the enemy "lead vehicle" is identified, it should be destroyed as well as the bridge being used by that vehicle, while retaining second bridge for friendly traffic. 5. Armored counterattack forces are believed to be at the Airport and Port. If present, the must be identified and destroyed. 6. Both the Port and Airport must be captured and held. The attack on the Airport has priority and should occur first if they cannot be attacked simultaneously.

No.	Scenario name	Platform Name	Relevance	Scenario
33	Pilots (ATC)	Microsoft Flight Simulator	Highly Relevant	Two scenarios were developed following National Aviation and Space Administration (NASA) and Naval Training Systems Center (NTSC) guidelines for air crew coordination skills scenario design. Pilots began each scenario on the runway of an airport in Florida. In both cases, they were told that their mission was to fly an admiral from one airport to another. In both cases various things went wrong during the flight which required the teams to cope in various ways. In Scenario A, the pilots flew from Orlando to Daytona Beach. The airport at Daytona was closed, so that the pilots had to land at their alternative landing site, Ormand Beach. Pilots also lost communication with the air traffic controller temporarily. In Scenario B the pilots flew from St. Augustine to Malcolm McKinnon in Georgia. Near the state line, the admiral had a heart attack, and the pilots had to fly to the nearest emergency medical facility, Jacksonville International, to land. As they were descending, the runway was closed, forcing them to land on another runway at Jacksonville. An actual air traffic controller participated during the scenarios. He also played the other two roles needed during the flights: that of Chief Jones, who accompanied the admiral during the flight, and the contact person for Command Net, to whom the pilots reported during flight.

No.	Scenario name	Platform Name	Relevance	Scenario
34	Joint Task Force Group (JTFG)	DDD III	Somewhat Relevant	In a bellicose interstellar realm of the Third Millennium, a Joint Task Force Group (JTFG) is given a set of resources and is assigned to conduct a multi-faceted operation aimed at attacking and destroying three strategic enemy objects: a Geothermal Power-Plant, a Radar Tower, and a Sonar Station. From intelligence sources, it is known that the enemy units used to protect the above objects include missile towers (named Pulverisers), stationary plasma batteries (Punishers), and Light Laser batteries. It is also known that, due to a significant energy consumption while in their active mode, the Punisher and Light Laser battery units (the exact number of which is unknown) are not activated until they receive an alarm message from appropriate enemy intelligence units. Until their activation, the Punisher and Light Laser battery units are invisible to energy sensors (which is another reason for keeping them inactive until the battle commences). It is estimated that it takes the enemy one minute to activate each additional unit. On the other hand, the Pulverisers remain in constant readiness and can fire at any given time. In addition to the above information, friendly intelligence reports that the enemy is using five hovercraft air scouts (termed Peepers) for land recognizance. While Peepers' main function is to spot any land warfare advancing toward the Power-Plant, Radar Tower, and Sonar Station, and to send the alarm message to all enemy units tasked to protect these objects, Peepers can also carry various air-to-ground missiles and can be used to destroy the land warfare units. The composition of friendly assets (with versatile capabilities) available for the operation is as follows: (i) an air-fighter (Avenger); (ii) a stealth airfighter (Hawk); (iii) a fast attack vehicle (Jeffy); (iv) a mobile rocket launcher (Merl); (v) a very heavy assault tank (named Goliath); (vi) an amphibious tank (Triton); (vii) a mobile radar (Informer); and (viii) a heavy assault tank (Reaper). The friendly forces are initially located in the middle bottom portion of the map. The enemy objects are located in the upper section of the map in a dormant volcanic area, and Peeper units are scattered across the map, hovering over the no-flight zone that separates the friendly forces from the enemy objects.

No.	Scenario name	Platform Name	Relevance	Scenario
35	Team C2 Task under sustained operation environment	AEDGE™ (Agent Enabled Decision Guide Environment)	Highly Relevant	A typical scenario include a pre-mission planning section, the scenario itself, and a post-mission debrief section. Within scenarios, three different roles were utilized, consisting of ISR (Intelligence, Surveillance, and Reconnaissance, Strike, and Sweep. They participate as a three person teams. They own assets related to their functions respectively. Scenarios were constructed to require high amounts of interdependence coordination among the functions.
36	International humanitarian assistance	N/A	Somewhat Relevant	A situation has arisen in a Central African country that has placed a large number of lives at risk. The UN has asked for a Canadian contribution. The Government has agreed, Parliament has been consulted and an appropriate Order-in-Council has been enacted. The CF contingent mission is to transport UN humanitarian supplies from a UN forward staging area to local (NGO) staging areas for further dissemination by NGOs and local relief agencies. The CF will also command one of the UN forward staging areas and supply the NGOs with support services at the staging area. CF faces uncertainty as to unexpected situations and tasks.
37	Peace support operations	N/A	Somewhat Relevant	Tension between two non-NATO bordering states has escalated to include armed conflict. One state is likely to attain an overwhelming victory over its opponent. UN Security Council passed a resolution that a multinational force under UN command will be formed and deployed to restore the previous situation. Canada has agreed to deploy maritime, land and air force personnel abroad. CF Mission is to achieve, as part of a coalition operation, the withdrawal of Swasian forces from Weston territory through the contribution of land, sea and air forces.

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Annex F: Comparison of Computational Models

(Note: Model labelled with '*' represents email questionnaire responses are available for it and therefore the judgements for the model is mostly based on the questionnaire responses.)

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
1	**IPME*** (Integrated Performance Modelling Environment)	Micro Analysis &Design (MA&D) http://www.maad.com (full-featured discrete-event simulation environment)	Yes	N/A	Yes	Yes	Yes	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
2	**IMPRINT*** (Improved Performance Research INtegration Tool)	Micro Analysis &Design (MA&D) for Army Research Laboratory (ARL) http://www.arl.army.mil/ARL-Directorates/HRED/imb/imprint/Imprint7.htm (event-based task network)	Yes (evaluate operator & crew workload)	- It does not automatically import/export data to IPME. However, IMPRINT shares the same task network modeling simulation engine with IPME. - IPME is part of IMPRINT - IMPRINT/ACT-R Integration (Ref 3, 4, 5) - **CART** (Combat Automation Requirements Testbed), another example of Computational Task Simulation, is built on IMPRINT.	Yes	Yes	Yes	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
3	**ACT-R/PM** (Adaptive Control or Atomic Components of Thought – Rational/Perceptual-Motor)	Carnegie Mellon University (CMU) http://act-r.psy.cmu.edu/ (a "hybrid" cognitive architecture that aspires to provide an integrated account of many aspects of human cognition)	No	No	Yes	Yes	No	No
4	**MIDAS*** (Man-machine Integration Design and Analysis System)	NASA Ames Research Center San Jose State University and QSS Group, Inc. http://human-factors.arc.nasa.gov/dev/www-midas/ (Generalized its predictive capability to areas of design outside of the original application - helicopter application domain. For example operations in commercial aviation, space shuttle design, Crew Exploration Vehicle design and even to scope experimental timing for glovebox experiments conducted in microgravity conditions aboard the International Space Station.	Yes (Measures it using Wicken's multiple resource theory.)	Will be (Originally is a standalone constructive simulation system that has not been used to interact with other models or military simulations. Now is collaborating with MA&D to develop a new version that probably will be compatible with IPME.	Yes	Yes (geared towards human operators interacting with and within a crewstation of any kind, which may be contained in a vehicle, moving within an outdoor environment)	No	Yes (“Multi-Agent”, capable to model multiple crewmembers and crewstations)

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
5	**D-OMAR*** (Distributed - Operator Model Architecture)	BBN Technologies under sponsorship from the ARL. http://omar.bbn.com/ (The multiagent architecture of OMAR is especially suited to model social interactions. For the ATC model, OMAR models in-person interactions among aircrew members, "party-line" radio communications among aircrews, and telephone communication between ATC centers in adjacent sectors.)	No (Very detailed trace of model goal and procedure execution from which workload can be computed according to requirements.)	Probably (was successfully linked with Air Force's DCOG, ACT-R, COGNET/iGEN and EPIC-Soar and used to control Jack®, an animated, interactive virtual simulation of a human) (also providing synthetic team members for DDD)	Yes (Simply a set of software tools for building real-time or fast-time simulations with no constraints on the domain simulated or the scenarios that may be constructed.) (Primarily to simulate behaviour related to ATC)		Yes (Not usual ways been used. Could readily be done, if one is interested in large organizational modeling problems.)	Yes (Way of regularly being used with great attention to the interactions of individuals within the team.)
6	**SAMPLE** (Situation Awareness Model for Pilot-in-the-loop Evaluation)	Charles River Analytics (CRA) Inc. http://mentalmodels.mitre.org/cog_eng/reference_documents/sample%20model%20for%20pilot-in-the-loop%20evaluation.pdf	No (model SA)	Has not been interfaced with other cognitive models (Developed in C++)	Yes	Yes (expanded to model SA in other types of performance environment, other than original purpose: air combat)	No	Yes (modeling individual and crew SA)

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
7	**GLEAN*** [GOMS (Goals, Operators, Methods, Selection Rules) Language Evaluation and Analysis]	The Artificial Intelligence (AI) program at the University of Michigan http://www.eecs.umich.edu/~kieras/goms.html [A software tool for constructing simulation of a human user (programmed with GOMS) interacting with a simulated device or system.] Ref 6	Yes (workload profiles)	Probably (Recent version of GLEAN3 is grounded in EPIC) (Would need work to integrate.)	Yes	Yes	No	Yes (model human performance of a team of operators)
8	**APEX*** (Architecture for Procedure Execution)	NASA Ames Research Center http://ti.arc.nasa.gov/projects/apex/	No (No with Apex alone. Yes in conjunction with MIDAS which uses Apex as its behaviour engine.)	No. (However, Micro Analysis and Design has recently acquired a copy of Apex (as part of MIDAS) and is planning to build tools for it. They may have plans to use it with IPME in some way.)	Yes	Yes (published research has been limited to a single application: air traffic control)	Probably No (At least no one seems to have attempted it.)	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
9	**COGNET** (Cognitive as a Network of Tasks) [Integration of **COGNET/BATON** (Blackboard Architecture for Task-Oriented Networks) supports cooperative and teamwork behaviors. Ref 7]	CHI Systems http://www.chisystems.com/	Yes (Metacognitive functions permit to model self-awareness phenomena, e.g. subjective workload)	No (Written in C/C++)	Yes	Yes	No	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
10	**Soar*** (Historically, Soar stood for State, Operator And Result) [Soar is an architecture for building real-time cognitive systems, is domain independent, and has been integrated with various simulation environments. The development of a Soar system is generally done by developing agents by writing rules.]	Under active development at several sites around the world U of Michigan: http://sitemaker.umich.edu/soar CMU:http://www.cs.cmu.edu/afs/cs/project/soar/public/www/home-page.html USC: http://www.isi.edu/soar/soar-homepage.html U of Nottingham: http://www.nottingham.ac.uk/pub/soar/ U of Hertfordshire: http://phoenix.herts.ac.uk/~rmy/cogarch.seminar/soar.html U of Portsmouth: http://www.port.ac.uk/departments/academic/ct/research/soarasanagent/ Soar Technology Inc: http://www.soartechnology.com Explore Reasoning System Inc.: http://www.ers.com	No (There's nothing in the architecture to prevent this, but it hasn't been done much in practice.)	Yes (It has not yet been integrated with IPME, but could be done with a bit of work.)	Yes (Depending on how you engineer your Soar agent system.)	Yes (There is nothing in the architecture that ties it to a particular domain. Although new knowledge e.g. production rules, will need to be written for new domains.)	Yes "Multiple Interacting Agent" (This has been done in several projects.)	Yes (This has been done in several projects.)

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
11	**EPIC** (Executive Process-Interactive Control)	The Brain, Cognition, and Action Laboratory at the University of Michigan http://www.umich.edu/~bcalab/epic.html	No	Many of EPIC's features of are now embodies in the GLEAN model. EPIC has been successfully incorporated into Soar and ACT-R	Yes	Yes	No	No (It's a model of individual performance; it has no capability to model collective behaviour)
12	**PUMA** [Performance and Usability Modelling in ATM (Air Traffic Management)]	For National Air Traffic Services (NATS) by Roke Manor Research Limited. http://web.mit.edu/aeroastro/www/labs/AATT/reviews/puma.html	Yes (It is a toolset designed to enable the prediction and description of controller workload for ATC scenarios.)	Possible	Yes	Capable (Originally developed for air traffic scenario)	No	No
13	**A-SA** (Computational Model of Attention-Situation Awareness)	NASA & U of Illinois http://human-factors.arc.nasa.gov/ihi/hcsl/HPM_pubs/Wickens_AvSP_HPM.pdf http://www.humanfactors.uiuc.edu/Reports&PapersPDFs/TechReport/04-15.pdf	No, predicts errors	No (It's a Conceptual Model)	Capable	Yes	No	No

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
14	**Brahms*** (Business Redesign Agent-based Holistic Modeling System)	Agent iSolutions http://www.agentisolutions.com/home.htm (an agent-based simulation tool for modeling the activities of groups in different locations) (Brahms, which is strong on social interaction, but weak on individual cognition, would make a perfect match with Soar or ACT-R)	No (Brahms includes a full agent-(BDI) and object-oriented language, you can program any measurement you want to make during a simulation.)	Yes (Brahms has an agent-based (BDI) language and a Java API. Any human-performance model could be interfaced with as an agent in Brahms.)	Yes (The Brahms language allows for initial-beliefs and creation of agents and objects dynamically. This way you can create scenarios for simulation.) (The language also allows the creation of new beliefs via conclude statements that can have certainty factors. This enables flexibility for Monte-Carlo sims.) (Originally for modeling business work practice) (Brahms is a domain independent BDI language.)	Yes	Yes	

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
15	**CAST*** (Collaborative Agents for Simulating Teamwork)	The Pennsylvania State University http://ist.psu.edu/yen/publications/ijcai01.pdf (enables agents to anticipate potential information needs among teammates and to exchange information proactively)	No, however if other such tools are in use the CAST framework provides interfaces through which they can be readily incorporated.	Yes (a multi-agent architecture) (through plug-in modules)	Yes, agents use plans that describe their intended operation in the scenario.	Yes, CAST expects to have an API provided by the simulation environment in order to interact.	Yes	Yes
16	**STEAM** (A Shell for TEAMwork)	TEAMCORE Research Group at the University of Southern California http://www.isi.edu/soar/tambe/steam/steam.html (STEAM represents an integration of team with individual knowledge. see Ref 8) [**GRATE** - Generic Rules and Agent model Testbed Environment (see Ref 9) , **COLLAGEN -** Collaborative Agent (see Ref 10) and **RETSINA** (Reusable Environment for Task-Structured Intelligent Networked Agents) are examples of other computational models of teamwork which have been developed for producing cooperative behaviours among intelligent agents]	No	No (Based in Soar. STEAM is an explicit model of team goals and plans that are shared among team members. devised by Soar developers)	Yes	Yes	Yes (“team operators”)	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
17	**DDD*** (Distributed Dynamic Decision-Making)	Aptima http://www.aptima.com/Projects/Distributed_Dynamic_Decision_making.html (DDD is a synthetic task environment/simulation engine that allows researchers to prescript the actions of opposition forces. Though agents have been used in the past with the current version of the DDD this is challenging.)	No (Some researchers have used text based probes to determine workload. Inferential techniques are also a possibility.)	See Ref. 2 for integration of the domain independent multi-agent architecture CAST with the DDD. CAST-DDD is an architecture for human-agent missed teams in which agents can replace some or all of the players in a DDD simulation task.	Yes	Yes	Only for the opposition forces (OPFOR).	OPFOR again but dynamic capabilities are limited to spawning and branching.

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
18	**TOD*** (Team Optimal Design) (A new version of TOD is under development, and hence many answers are related to that new version.)	Aptima http://www.aptima.com/Projects/Team_Optimal_Design.html (TOD is a formal, algorithmic approach to team design that simultaneously optimizes team size, workload distribution, and mission tempo based on quantitative descriptions of task frequency, task workload, event-task flow, inter-task communication requirements, and task assignment constraints.)	Yes (In terms of "using" the notion of workload. TOD is optimization tool, and one of the variables it uses is the workload.)	No (Not designed to be)	Yes	Yes	No	Yes (Model individuals, or sub-teams - groups of individuals.)
19	**C3TRACE*** (Command, Control, and Communication-Techniques for Reliable Assessment of Concept Execution)	MA&D for ARL (Ref. 1, 11) http://www.dtic.mil/matris/ddsm/srch/ddsm0221.html (An example of integrating task and cognitive modeling: it takes the basic task network modeling approach and adds an information-weighted decision making algorithm)	Yes [(Visual, auditory, cognitive, psychomotor) VACP channels. Uses the McCracken/Aldrich 7-pt scale for each channel.]	No (Both tools use the Micro Saint Sharp engine. However, IPME runs on Linux and uses a database, C3TRACE runs on Windows and uses XML)	Yes (Communications can be developed to correspond to any scenario.)	No [Only in the (command and control) C2 domain.]	Yes	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
20	**KOGSIT** (Operator modelling using cognitive architectures)	Modelling of User Behaviour in Dynamic Systems (MoDyS) Research Group http://www.zmms.tu-berlin.de/modys/index.html (The goal of this project is to identify requirements and propose modifications to current cognitive architectures.)	No	Developed and applied enhancements to ACT-R/PM in order to make applied modelling more suited in complex and dynamic human-machine-systems for engineering purposes	Yes	Yes	No	No
21	**Cogitoid*** (an algorithmic model of the cognitive processes occurring in the mind of living organisms)	Institute of Computer Science at the Academy of Sciences of the Czech Republic. http://www.ercim.org/publication/Ercim_News/enw53/wiedermann.html	No	No	Yes	Yes	No	No

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
22	**Archimedes** Combat Modeling Platform	Least Squares Software http://www.leastsquares.com/papers/mws2001.pdf	No	No (Agent-based modeling)	Yes	Yes (military general)	Yes (Agents may represent individuals or units of any size, including heterogeneous collections)	Yes
23	**Wildfires** Fight Simulation for Training	Michigan Department of Natural Resources http://www.michigan.gov/dnr/0,1607,7-153-10369_36152-114699--,00.html (The multi-interactive, multimedia program uses audio and video that involves the use of role players while guiding a trainee through a scenario that addresses all the strategies, tactics and safety issues he or she might face in real fire incident.)	No	No	Yes	No	No	No
24	**RESA** (Research, Evaluation, and Systems Analysis)	Space and Naval Warfare Systems Command (SPAWAR) (RESA is the Navy model within the Joint Training Confederation (JTC) of Models. It provides Theatre Level Simulation encompassing all Naval Mission areas.)	No	No, written in Rational Fortran	Yes	No, models only Naval Activities (including Air)	Yes	Yes

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
25	**EADSIM*** (Extended Air Defense Simulation)	Teledyne Brown Engineering http://www.eadsim.com/ (A combat model - to model the performance and predict the effectiveness of ballistic missiles, surface-to-air missiles, aircraft, and cruise missiles in a variety of user-developed scenarios.)	Of the modeled entities.	No (Could be compatible in the future. However, it is likely it would require some modifications.)	Yes	No (models fixed- and rotary-wing aircraft, tactical ballistic missiles, cruise missiles, infrared and radar sensors, satellites, c2 structures, jammers, communications networks and devices, and fire support)	Depends (EADSIM normally models at an entity level, but has some ability to aggregate. For example, a flight of aircraft is modeled as each individual aircraft and the relationships between them.)	Depends (EADSIM normally models at an entity level, but has some ability to aggregate.)

No.	Constructive Simulation Platform Name	Developer Organization	Measure Workload	Compatible with IPME	Scenario Flexibility	Domain Independent	Model Team as Entity	Model Team as Group of Individuals
26	**JIMM*** (Joint Integrated Mission Model) [JIMM is a language-driven model. If you can describe it using the JIMM Conflict Language (JCL), you can model it. JCL is a reasonably general-purpose language with special support for the types of issues (passive and active sensing, weapons engagement, communications, human decision-making in the context of tactics, etc.) relevant to military conflict.]	Air Force Agency for Modelling and Simulation (AFAMS) http://afmsrr.afams.af.mil/index.cfm?RID=MDL_AF_1000053 https://www.msrr.dmso.mil/share/resourceitem/ViewDetails.jsp?resid=7707&schema=MSRR	No	Probably [The JIMM interface is compliant with both DIS (Distributed Interactive Simulation) and HLA (High-Level Architecture)]	Yes	Yes (JIMM is “general purpose” in that it is highly flexible and need not be restricted to military applications.)	Yes (JIMM executes the scenario based on the underlying player structures as defined by the scenario programmers, not via ‘canned’ entities.)	Yes (The specific system types modelled in the scenario are assembled into platform types. One or more platform types are assembled into a player type where tactics are programmed to move and otherwise employ underlying systems)

Comparison of Computational Models (Continued)

No.	Model Specified Team Tasks	Model Specified Team Interaction	Model HSI Interventions of interest	Analyze Team's Strategies	Analyze Team's Performance	Available in Public Domain	Stable	Real-Time Computer Generated Forces
1. IPME*	Yes	Yes	Yes	Yes	Yes	No (through a memorandu m of agreement)	Yes	Yes (Dependent upon the complexity of the model.)
2. IMPRINT*	Yes	Yes	Yes	Yes	Yes	No (Only available to US Government and their contractors)	Yes	Yes (through middlewar)
3. ACT-R	No	No	Capable	No	No	Yes	Yes	Yes
4. MIDAS*	Yes	Yes (able to model the interaction among crewmembers)	Yes [E.g. human interaction with new display techniques for CEV (crew exploration vehicle) ascent.]	Yes	Yes (Various relevant outputs, including task timelines, PERT charts and situation awareness)	Should be later this year, after the next version is complete (couldn't easily use the current version).	Yes (But is not yet ready for general public use.)	No (Strictly a discrete time-based simulation.)

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5. D-OMAR*	Yes (Usually model the tasks of individuals within a team in great detail and then examine team behaviours.)	Yes (simulates interactions among multiple performers) (Much work has been done on looking at human error, error sequences leading to incidents and accidents, and error mitigation.)	Yes (Among others, examined and evaluated alternate flight deck instrument configurations using D-OMAR.)	Yes	Yes (Detailed information on individual performance can be evaluated to assess team performance. If model a team as an entity, team behaviour is directly available for analysis.)	Yes (Open source. Lisp version for human performance modeling; Java version for agent-based system development)	Yes (The Lisp version is very stable. The full range of the Java version capabilities has not been as completely exercised.)	Not recently, but ever - the very first CGF tank crew to operate at Ft.Knox was a D-OMAR model-based four person per tank, tank platoon about 20 years ago.
6. SAMPLE	Yes	Yes (agent-based architecture; model interagent communication)	Yes	No	Yes	Yes	Yes	No

No.	Model Specified Team Tasks	Model Specified Team Interaction	Model HSI Interventions of interest	Analyze Team's Strategies	Analyze Team's Performance	Available in Public Domain	Stable	Real-Time Computer Generated Forces
7. GLEAN*	Yes	Yes	Yes (Can represent different system functionality and interface design decisions and get performance comparisons) (A methodology that is used to identify the goals that the operator faces when interacting with a technology or process in system design. GOMS is an attempt to formalize the collection of the activities that are performed by the operators in working environment. This can and often does include system interaction and performance.)	Yes (you can compare different team structures and processes)	Yes	No (IP is owned by University of Michigan, but kernel simulator is available for research purposes; commercial rights are reserved. Soar Technology, Inc. is developing a commercial-grade environment for the kernel simulation system.) (research license available)	Relatively (But research on good representation of human performance is on going, so GLEAN will continue to be upgraded. Past versions can still be used)	Potentially, but not currently used for this purpose.
8. APEX*	Yes	Yes (Within the capabilities of Apex's task specification language, PDL.)	Yes	No	No (Though there is support for flexible real-time and batched output to analysis tools.)	Yes (Through the NASA Open Source Agreement.)	Relatively Yes (is one of the newest and has not been subjected to the scrutiny of multiple application)	Yes (can be integrated with real-time systems)

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9. COGNET	No	Yes (The metacognitive control functions, together with the ability to model independent cognitive agents, provide the capability, at least in principle, to model coordination among multiple team members)	Yes	No	No	Yes (iGEM™ is a commercial software tool that refines and then execute COGNET)	Yes	No
10. Soar*	Yes (There's nothing in the architecture to prevent this)	Yes (Soar does not include any particular functions for teamwork. However, there have been several models of teamwork created in Soar, e.g. **Team-soar** http://ieeexplore.ieee.org/iel5/3468/21190/00983426.pdf?arnumber=983426 and **TacAir-Soar** http://www.soartech.com/projects/TacAir-Soar.pdf)	Yes	Yes (There's nothing in the architectur e to prevent this.)	Yes (There's nothing in the architecture to prevent this.)	Yes (Open source)	Yes (The current release is 8.6, and is used by researchers and corporations around the world. Soar has been under development for over 20 years and has been used in major military simulation exercise. Soar Technologies is a 40-50 person company that creates Soar models for customers.)	Yes (See www.soartech.com for multiple examples of this. In the STOW-97 and STOW-E exercises Soar controlled all fixed and rotary-wing aircraft fully autonomously.)

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11. EPIC	No	No	No (Primarily developed to model HCI)	No	No	Yes (source code and installation instruction are available online)	Yes	No
12. PUMA	No	No	Yes (PUMA is capable of assessing the effect on controller workload of various computer assistance tools.)	No	No	Yes (Licensed to third parties, as a fully supported product.)	Yes	No
13. A-SA	No	No	Yes	No	No	Yes	Yes	No
14. Brahms*	Yes	Yes	Yes	Yes	Yes (Brahms was specially designed to represent aspects of teamwork)	Yes	Yes	Yes
15 CAST*	Yes	Yes	No	No	Yes (By tracing available information flows between team members.)	Yes (Through AFOSR.)	Yes	No (could be added)

No.	Model Specified Team Tasks	Model Specified Team Interaction	Model HSI Interventions of interest	Analyze Team's Strategies	Analyze Team's Performance	Available in Public Domain	Stable	Real-Time Computer Generated Forces
16. STEAM	Yes	Yes (has been used to model coordination among team members in rotary-wing companies and used as the underlying method for improving teamwork in the Information Science Institute Synthetic (ISIS) team entered in RoboCup '97, an international competition to test multiagent systems using soccer as a simulation test bed. see Ref 12).	Yes	Yes	Yes	Yes	Yes	Yes
17. DDD*	Yes	Text based communications are captured as are all data surrounding actions requiring a coordinated action.	Yes (Allow to vary team structure, access to information, and control of resources)	Researchers using the DDD conduct analyses using various statistics and modeling packages after exporting the data from simulation runs in the DDD. Captures all data of any interactions that an individual, and by default the team, has with the DDD. This includes precise timing of when the event occurred and precisely where the entity was when the action was taken. DDD provides complete replay capability.		Yes	Usually	Not in the dynamic sense.
18. TOD*	Yes	Yes (helps to define how the team coordinates its execution of the mission's tasks)	Yes (helps to develop optimal team that achieves the desired balance of speed, individual workload, and distribution of workload within the team)	Yes (both optimizatio n of strategies and manual setting is available)	Yes	No (The new version will probably not be available in public domain, but will be distributed to their partners)	Yes (current version is stable; new version is designed to be)	Yes (TOD has a team dynamic adaptation component that can reconfigure the forces on-line based on changes in the mission.)

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19. C3TRACE*	Yes	Yes	Yes	Yes	Yes	No (in the process of developing a policy for foreign distribution)	Yes (with continual upgrading and enhancement)	No
20. KOGSIT	No	No	Capable	No	No	Yes	Unknown	Yes
21. Cogitoid*	No	No (A cogitoid presents a computational model designed with the aim to model basic cognitive abilities.)	No	No	No	Yes	No	No (A so-called 'computational bacterium' driven by a cogitoid has been designed, which was able to learn to move in one dimension towards a higher concentration of nutrients.)
22. Archimedes	Yes (The behavioural specification is extremely flexible and modular)	Yes (e.g. "IF attitude towards non-combatants IS friendly THEN attitude towards militia IS neutral. END IF)	Yes	Yes (roles of discipline, cohesion, moral and personalit y)	No	Yes	Yes	Yes

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23. Forest, Mineral, and Fire Management	No	No	No	Yes	Yes	Modified proprietary commercial product	Unknown	No
24. RESA	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
25. EADSIM*	Yes	Yes	No	Yes	Yes	No	Yes	Yes
26. JIMM*	Yes	Yes	Yes	Yes	Yes	DoD and DoD contractors only	Yes	Yes

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(U) Defence Research and Development Canada (DRDC) Toronto is in the process of developing team research scenarios aimed at supporting the Canadian Forces (CF) future integrated operations, and interoperability with allies, other government departments (OGDs) and non−government organizations (NGOs). This work falls within a 4−year Applied Research Project (ARP) to include a literature review of relevant team literature, the creation of a platform for conducting experiments on teams, the running of team experiments using a scenario involving one or more Human Systems Integration (HSI) intervention(s), the development of a computational model of team performance, and some preliminary validation of this model. Previous reports (Sartori, Waldherr and Adams, 2006; Go, Bos and Lamoureux, 2006) have reported the outcomes of exhaustive literature reviews on team research and team research platforms respectively.

This report describes the outcomes of two parallel streams of work. The first stream was the development of three team experimental scenarios, in a domestic operational context, appropriate for studying the targeted teamwork factors (i.e. teams−of−teams, joint, interagency, distributed environment). This was done by identifying and reviewing scenarios used previously in team research, leveraging concepts important to team research scenarios identified by the literature review, and incorporating knowledge of future CF requirements in new, composite team research scenarios. The second objective of this report was to evaluate a variety of computational modelling applications for their adequacy in modelling the targeted teams in the targeted scenarios, and to recommend one application as the most suitable.

This report provides detail regarding the different scenarios and computational models evaluated, and provides direction for the further development of scenarios to suit the detailed requirements of the ARP.

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(U) team modelling, team experiments, computational models, simulation, team performance, scenarios, IPME