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INFORMATION EXCHANGE IN JOINT, INTERAGENCY, MULTINATIONAL, AND PUBLIC (JIMP) OPERATIONS: FINAL REPORT

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Abstract

The intent of this project is to develop a paper-based and electronic questionnaire to assess information sharing within a team-of-teams operating in a Joint, Interagency, Multinational, and Public (JIMP) environment. This report includes information about the various stages of this project, including:

- A brief summary of the review of the literature relevant to information sharing and performance in a team-of-teams (presented in Taylor & Bruyn Martin, 2007);
- A description of the development of a draft questionnaire and subsequent review by scientific SMEs;
- A description of the electronic implementation and pilot test of a revised version of the questionnaire, and;
- A description of the final version of the questionnaire based on all of the feedback received.

Also included in this report are:

- A description of the modularity of the questionnaire;
- Documentation for analysts who wish to use the questionnaire;
- Suggestions for ways to analyse the questionnaire data, and;
- Recommendations for future iterations of, or use of, the questionnaire, including descriptions of how the questionnaire could be implemented in JIMP exercises, experiments, or operations, including several different ways to select items from the question pool depending on the goals of particular projects for which it will be used.

The main benefits of this questionnaire are that it is intended for and developed within a military context and for evaluating information sharing within a team-of-teams. Thus, this questionnaire is an instrument designed specifically to aid the investigation into information sharing in the JIMP environment.

Résumé

L'objectif de ce projet consiste à élaborer un questionnaire électronique et imprimé pour évaluer le partage d'information au sein d'un groupe d'équipes qui travaillent dans un cadre interarmées, interorganisationnel, multinational et public (IIMP). Ce rapport contient de l'information sur les diverses étapes de ce projet, notamment :

- un résumé concis de l'examen des documents associés au partage de l'information et au rendement au sein d'un groupe d'équipes (présenté dans Taylor & Bruyn Martin, 2007a);
- une description du processus d'élaboration d'une ébauche de questionnaire et l'examen subséquent réalisé par les experts scientifiques;
- une description de la mise en œuvre électronique et de l'essai d'une version révisée du questionnaire;
- une description de la version finale du questionnaire établie d'après l'ensemble des commentaires reçus.

Ce rapport comprend également :

- une description de la modularité du questionnaire;
- la documentation pour les analystes qui souhaitent utiliser le questionnaire;
- des suggestions de méthodes d'analyse des données du questionnaire;
- des recommandations relatives aux futures itérations ou à l'utilisation du questionnaire, incluant des descriptions des différents moyens pour intégrer le questionnaire aux exercices, expériences ou opérations IIMP ainsi que diverses méthodes de sélection d'éléments du questionnaire selon les buts des différents projets dans le cadre desquels il sera utilisé.

Le fait que ce questionnaire soit adapté au domaine militaire, qu'il a été élaboré au sein de ce domaine et qu'il permet d'évaluer le partage de l'information au sein d'un groupe d'équipes constitue son principal avantage. Par conséquent, ce questionnaire s'avère un instrument spécialement conçu pour faciliter l'évaluation du partage de l'information au sein de l'environnement IIMP.

Executive Summary

This report is the final deliverable for a questionnaire-development project. The questionnaire is intended to assess information sharing in today's operational environment, which involves military and non-military teams, organizations, and alliances; that is, Joint, Interagency, Multinational, and Public (JIMP) teams. One of the characteristics of operations in the 21st century is that the CF operate within a "team-of-teams"; this requires an expansion of current team-effectiveness theories, which are typically limited to the level of single teams. A multiple team structure would require more demanding coordination processes than a single team. Additional issues that must be considered include the multinational aspect of this team-of-teams where large cultural differences between team members are likely to exist.

This report describes the various stages of this project, including:

- A brief summary of the review of the literature relevant to information sharing and performance in a team-of-teams (presented in Taylor & Bruyn Martin, 2007a);
- A description of the development of a draft questionnaire and subsequent review by scientific SMEs;
- A description of the electronic implementation and pilot test of a revised version of the questionnaire, and;
- A description of the final version of the questionnaire based on all of the feedback received.

Also included in this report are:

- A description of the modularity of the questionnaire;
- Documentation for analysts who wish to use the questionnaire;
- Suggestions for ways to analyse the questionnaire data, and;
- Recommendations for future iterations of, or use of, the questionnaire, including descriptions of how the questionnaire could be implemented in JIMP exercises, experiments, or operations, including several different ways to select items from the question pool depending on the goals of particular projects for which it will be used.

A model of team information processing and effectiveness, the Command Team Effectiveness (CTEF) model by Essens, Vogelaar, Mylle, Blendell, Paris, Halpin, and Baranski (2005) was used as a framework for the issues affecting information sharing within a team environment. This model has been expanded to apply to JIMP operations with additional factors, including consideration of the impact of a team-of-teams structure on coordination processes, language, national cultural differences, and other work-culture factors. The expanded Essens et al. (2005) model and the additional factors important in a JIMP context were used to support the development of information-sharing question categories for the questionnaire. The categories developed were as follows:

1) Information-sharing performance (i.e., whether data were actually transmitted and understood);

2) Information-sharing effectiveness (i.e., actual data transmission / understanding relative to the required or expected transmission / understanding);
3) Information-sharing efficiency (i.e., time and effort needed for data transmission / understanding);
4) Information-sharing conditions;
5) Information-sharing processes, and;
6) Information-sharing products.

These question categories were used as a basis for development of specific questions related to information sharing within JIMP operations, and the creation of a first iteration of the questionnaire. The first iteration of the questionnaire was reviewed by scientific Subject-Matter Experts (SMEs) who were experienced in JIMP concepts, questionnaire development, or both. SMEs were asked to provide specific feedback on the selection of question categories, wording of the questions and the overall approach. They were also asked to rate all questions in terms of importance in order to help prioritize individual questions (these ratings are provided in this report). The feedback submitted by the scientific SMEs was used to refine the questionnaire.

The revised questionnaire was implemented in SurveyPro, a software application that allows surveys to be administered electronically using a basic web browser, and data to be gathered remotely. Using the electronic version of the questionnaire, a pilot test was conducted in which four military operators and two human factors analysts responded to the online JIMP Information-Sharing Questionnaire (given their own understanding and experience of what would happen in a JIMP operation) as well as additional questions about the usability of the questionnaire itself.

Overall, feedback was very favourable in terms of appearance and ease of navigation, but some ease of use and clarity issues were noted. Recommendations included providing additional definitions to increase question clarity. Further, pilot-test participants had particular difficulty understanding questions regarding the amount of information that is exchanged and the frequency with which information is exchanged, and therefore these questions were eliminated from the questionnaire. It is recommended that the amount and frequency of information be assessed directly with monitoring tools and observation. Pilot-test feedback also strongly reinforced the necessity for context-specific information to be provided by the analysts before administering the questionnaire. It is assumed that the questionnaire would be used in situations where the context is fully known by the respondents. The questionnaire was revised based on the feedback provided by the pilot-test participants, and the final version is included as an appendix to this report.

The report goes on to discuss possible approaches for investigating information sharing, and outlines ways in which the questionnaire can be modified to be appropriate for these different approaches. Examples include selecting only some of the question categories, selecting the most important questions from within each category, or selecting the most important questions overall.

Also included in the report is documentation for the questionnaire. The documentation includes a brief overview of the project, a summary of the questionnaire categories, a discussion of how the questionnaire categories were chosen, an outline of how the questionnaire can be modified, and sample analyses.

Recommendations for future work include the need to validate the current form of the questionnaire and determine how best to include performance and effectiveness measures.

Sommaire

Ce rapport constitue le produit livrable final d'un projet d'élaboration d'un questionnaire. Ce questionnaire vise à évaluer le partage de l'information au sein de l'environnement opérationnel actuel, lequel suppose la participation d'équipes, d'organisations et d'alliances militaires et civiles, c.-à-d. d'équipes interarmées, interorganisationnelles, multinationales et publiques (IIMP). L'une des caractéristiques des opérations du XXI^{e} siècle est que les FC doivent maintenant composer avec un « groupe d'équipes », ce qui exige d'élargir la portée des théories actuelles en matière d'efficacité des équipes, théories qui s'appliquent habituellement à une seule équipe. La coordination d'une structure à équipes multiples est plus exigeante que la coordination d'une seule équipe. Parmi les autres aspects à prendre en considération, il convient de mentionner la dimension multinationale de ce groupe d'équipes qui se traduit par des différences culturelles importantes entre les membres du groupe.

Ce rapport décrit les diverses étapes du projet, notamment :

- un résumé concis de l'examen des documents associés au partage de l'information et au rendement au sein d'un groupe d'équipes (présenté dans Taylor & Bruyn Martin, 2007a);
- une description du processus d'élaboration d'une ébauche de questionnaire et l'examen subséquent réalisé par les experts scientifiques;
- une description de la mise en œuvre électronique et de l'essai d'une version révisée du questionnaire;
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Ce rapport comprend également :

- une description de la modularité du questionnaire;
- la documentation pour les analystes qui souhaitent utiliser le questionnaire;
- des suggestions de méthodes d'analyse des données du questionnaire;
- des recommandations relatives aux futures itérations ou à l'utilisation du questionnaire, incluant des descriptions des différents moyens pour intégrer le questionnaire aux exercices, expériences ou opérations IIMP ainsi que diverses méthodes de sélection d'éléments du questionnaire selon les buts des différents projets dans le cadre desquels il sera utilisé.

Un modèle d'efficacité des équipes et de traitement de l'information à l'intérieur de celle-ci, le *Command Team EFfectiveness (CTEF) model* (modèle de l'Efficacité des équipes de commandement) par Essens, Vogelaar, Mylle, Blendell, Paris, Halpin et Baranski (2005), a été utilisé comme cadre pour les questions qui concernent le partage d'information au sein d'équipes. Ce modèle a été élargi pour l'appliquer aux opérations IIMP avec des facteurs supplémentaires, y compris les incidences d'une structure de groupe d'équipes sur les processus de coordination, la langue, les différences culturelles nationales, et d'autres facteurs touchant la culture organisationnelle. Le modèle élargi d'Essens et autres (2005) et les facteurs supplémentaires importants dans un contexte IIMP ont été utilisés pour soutenir l'élaboration des catégories de questions de partage d'information pour le questionnaire. Les catégories élaborées étaient les suivantes :

1) le rendement du partage d'information (c.-à-d. si les données ont été véritablement transmises et comprises);
2) l'efficacité du partage d'information (c.-à-d. la transmission et la compréhension réelles des données comparativement à la transmission et la compréhension requises ou prévues);

3) l'efficience du partage d'information (c.-à-d. le temps et les efforts nécessaires pour la transmission et la compréhension des données);
4) les conditions de partage d'information;
5) les processus de partage d'information;
6) les produits de partage d'information.

Ces catégories de questions ont été utilisées comme fondement pour l'élaboration de questions spécifiques relatives au partage d'information dans le cadre des opérations IIMP, et à la création d'une première itération du questionnaire. Cette première itération du questionnaire a été examinée par les experts scientifiques qui possédaient une expérience des concepts IIMP ou de l'élaboration de questionnaires, ou les deux. On a demandé à ces experts de formuler des commentaires spécifiques sur la sélection des catégories de questions, la formulation des questions et l'approche globale. On leur a également demandé de classer toutes les questions selon leur importance pour les hiérarchiser (ces classements sont fournis dans le présent rapport). Les commentaires soumis par les experts scientifiques ont été utilisés pour peaufiner le questionnaire.

Le questionnaire révisé a été mis en œuvre dans SurveyPro, une application logicielle qui permet l'administration électronique de sondages avec un navigateur Web de base ainsi que la collecte de données à distance. Un essai pilote a été mené dans lequel quatre opérateurs militaires et deux analystes des facteurs humains ont répondu en ligne à la version électronique du questionnaire sur le partage d'information dans un cadre IIMP (en raison de leur compréhension et de leur expérience de ce qui arriverait dans une opération IIMP) de même qu'aux questions supplémentaires sur l'utilité du questionnaire lui-même.

Les commentaires ont été généralement très favorables en ce qui a trait à l'apparence et à la facilité de navigation, mais certains problèmes de convivialité et de clarté ont été relevés. Les recommandations mentionnaient la nécessité d'ajouter des définitions pour accroître la clarté des questions. De plus, les participants de l'essai pilote ont eu une difficulté particulière à comprendre les questions concernant la quantité de renseignements échangés et la fréquence à laquelle ils sont échangés. Par conséquent, ces questions ont été éliminées du questionnaire. Il est recommandé d'évaluer directement la quantité et la fréquence d'information à l'aide d'outils de surveillance et d'observations. Les commentaires sur l'essai pilote ont également confirmé l'idée que les analystes doivent fournir des renseignements spécifiques au contexte avant d'administrer le questionnaire. Le questionnaire devrait être utilisé dans des situations où les répondants sont très familiers avec le contexte. Le questionnaire a été révisé selon les commentaires soumis par les participants de l'essai pilote, et la version finale est fournie dans une annexe jointe au présent rapport.

Le rapport aborde les approches possibles pour examiner le partage d'information et décrit les façons possibles de modifier le questionnaire afin qu'il corresponde à ces approches différentes. Cela pourrait se traduire par la sélection de certaines catégories de questions, la sélection des questions les plus importantes dans chacune des catégories ou la sélection des questions les plus importantes dans l'ensemble.

La documentation relative au questionnaire est également jointe au rapport. Cette documentation comprend un bref aperçu du projet, un sommaire des catégories du questionnaire, une discussion sur la façon dont les catégories du questionnaire ont été choisies, une description de la façon dont le questionnaire peut être modifié et des exemples d'analyses.

Les recommandations concernant le travail qui reste à accomplir comprennent la nécessité de valider le questionnaire dans sa forme actuelle et de déterminer la façon la plus appropriée d'inclure des mesures de rendement et d'efficacité dans la démarche.

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1. Introduction

1.1 Background

The Joint Command Decision Support for the 21st Century is a project under the Defence Research and Development Canada (DRDC) Technology Demonstration Program (TDP). The main goal of the JCDS 21 project is to demonstrate a joint, net-enabled collaborative environment to achieve decision superiority. This contract will support the overall JCDS 21 project by designing, implementing, validating, and applying a questionnaire tool to study information sharing, with a focus on the Joint, Interagency, Multinational, and Public (JIMP) context.

It is important to understand information sharing in JIMP operations because information sharing is both an important task in and of itself (e.g., sharing intelligence), and an important prerequisite for other important tasks (e.g., maintaining situational awareness). Important aspects of information sharing that are to be assessed include identifying perceived problem areas through self-report, having operators identify their own perceived or actual performance, and evaluating others' performance. A questionnaire is the most efficient way of identifying perceptions of performance and problems encountered related to information sharing.

For this current project, the most critical aspect of operating in a JIMP environment is that multiple organizations (both military and non-military) are working together, and they must collaborate, coordinate, and de-conflict to achieve the mission objectives. This is necessary in many types of circumstances, including natural disasters occurring within Canada as well as abroad, in peace-making or peace-keeping missions, and for regular peacetime activities such as monitoring our national borders and maintaining national security during significant events such as the Olympic Games. Achieving an adequate degree of coordination, particularly during complex operations, is likely to require a great deal of information sharing between the participating organizations. However, this type of "team-of-teams" structure creates challenges for information transmission and communication in general, including technological interoperability, differences in technical language (i.e., a single term may have multiple meanings depending on the organization and context within which the term is used), organizational and cultural differences, and goal conflicts. A questionnaire to address information sharing in a team-of-teams is needed because there is currently a lack of information about how information sharing is affected by this team-of-teams structure which underlies JIMP operations.

1.2 Scope

The goal of this JIMP information-sharing project was to create and evaluate a questionnaire that can be used to assess information-sharing, and also identify needs for and barriers to effective and efficient information sharing in JIMP operations. This report details the various stages of this project, including:

- A brief summary of the review of the literature relevant to information sharing and performance in a team-of-teams (chapter 2);
- A discussion of the development of a draft questionnaire (chapter 3);
- A review of the draft questionnaire by scientific SMEs (chapter 4);

- A discussion of the creation and electronic implementation of a complete questionnaire (chapter 5),
- A description of the pilot study of the electronic questionnaire (chapter 6), and;
- A description of the final version of the questionnaire based on all of the feedback received (chapter 7 and Annex A).

Also included in this report are:

- A description of the modularity of the questionnaire (section 7.3.1 and Annex F);
- Documentation for analysts who wish to use the questionnaire (Annex B);
- Suggestions for ways to analyse the questionnaire data (section 7.4), and;
- Recommendations for future iterations of, or use of, the questionnaire, including descriptions of how the questionnaire could be implemented in JIMP exercises, experiments, or operations, including several different ways to select items from the question pool depending on the goals of particular projects for which it will be used (section 7).

2. Literature Review Summary and Selection of Question Categories

The first phase of this project was a literature review of team and CF literature related to information sharing and team effectiveness. This review enabled the creation of definitions for important terms, and identification of categories and subcategories of factors which are important for evaluating information sharing within a JIMP context.

2.1 Definitions

Definitions of important concepts related to this project, including definitions for information sharing, performance, effectiveness, and efficiency related to information sharing, and JIMP operations are provided in this section to facilitate understanding of the principal concepts underlying our approach.

Information sharing can be conceptualized as communication between team members as well as information distribution from external sources to team members (Tremblay, Jobidon et al., 2006). As pointed out by Tremblay, Jobidon et al., any communication involves information sharing, but information sharing also includes instances such as a team member looking up information in an external database (which might not traditionally be considered communication). Tremblay, Lafond et al. (2006) indicate that information sharing is not simply the transmission of data: "An underlying assumption of information-sharing is that the latter translates into a shared situational awareness and self-synchronization through shared mental models of the current situation and of the desired end-state…" (Tremblay, Lafond et al., 2006, p. 33, citing Wesensten, Belenky, & Balkin, 2005). Thus, information-sharing involves the transmission of information which results in a change in the recipient's understanding, rather than just the transmission of raw data.

Performance can be defined as the behaviour of a system. As mentioned by Farrell (2005), performance must be measurable. Measures of performance can be subjective, depending on the type of system for which performance is being measured. Thus, information-sharing performance would be determined by characteristics of the transmission of information (amount, frequency, accuracy, etc.) as well as how the information affected the recipient's understanding.

Effectiveness is the extent to which goals are achieved (e.g., Tremblay, Lafond et al., 2006; Farrell et al., 2006). If a task was performed and its goal was achieved then the task was effective. Effectiveness is always measured relative to an expectation. Effectiveness can be defined globally in terms of the impact of a lower level variable on a higher level variable (i.e., task outcomes). For example, the goal of information sharing (lower level) may be shared situation awareness (higher level) Therefore information sharing is effective if the expected level of shared situation awareness is achieved. Effectiveness can also be defined locally in terms of the actual value of a variable relative to its expected value. For example, if the goal of information sharing is to transfer a specific amount of information, if this expected amount of information is transferred, then the goal is achieved, and information sharing is effective. To assess local effectiveness, assessments of expectations can be made, and then these can be compared with the measures of actual performance to calculate local effectiveness (e.g., performance/expected = level of local effectiveness). In cases such as experiments when the expected (or optimal) performance is known, this can be used to calculate local effectiveness if actual performance is known.

Efficiency refers to the number of benefits one receives per unit cost. That is, "In everyday language, something is highly efficient if it performs the desired function with very little effort wasted on things that do not matter to the immediate task" (Farrell, 2005, p.3). For this report, information-sharing efficiency must be evaluated by determining the relative cost-to-benefit ratio of the information-sharing that occurs. The cost could be measured in terms of time, effort, equipment used, money, energy, etc.

JIMP operations refer to operations that are Joint, Interagency, Multinational, and Public. Because the current project is geared toward increasing our understanding of information sharing within the JIMP operational environment, it is important to understand the various components of JIMP operations. The Joint aspect of JIMP operations means that more than one service of the same nation is participating. In reference to the Canadian Forces (CF), this typically means at least two of the army, navy, and air force are involved in the operation. The fact that JIMP operations are Interagency means that Other Government Departments (OGDs) and/or Other Government Agencies (OGAs), domestic and/or from other nations, are involved. Such departments and agencies can include Public Safety Canada (PSC), Royal Canadian Mounted Police (RCMP), Canadian Security Intelligence Agency (CSIS) and Health Canada, to name a few. As indicated by the fact that agencies and departments from other nations may be involved, JIMP operations are Multinational, and often include the host nation as well as other supporting nations and the UN. JIMP operations are also Public, meaning that the operations are open to scrutiny by oversight committees, commercial interests, and the media. Particularly through the media, these operations are also often open to the general population of the host nation and other nations (Gizewski & Rostek, 2007).

2.2 Questionnaire categories

The literature review revealed that the most pertinent factors closely follow those described in the Command Team Effectiveness (CTEF) model (Essens et al., 2005), which describes factors relevant to team information-sharing, including pre-existing team conditions, relevant team tasks, and team outcomes. The Command Team Effectiveness (CTEF) model presented by Essens et al. (2005) was chosen as a basis for deriving categories of questions relating to information sharing in JIMP operations. This model is an appropriate choice as it combines information processing in teams with other factors such as operational context and outcomes which are also important for the current project. In addition, it was designed in the context of military teams, which are the focus of the current project. As well, direct measures of information-sharing performance, effectiveness, and efficiency were developed by the authors and the SA team.

Three overall categories of questions, derived from the CTEF model, that are relevant to information sharing in JIMP operations were proposed:

- Conditions for information sharing;
- Information-sharing processes, and;
- Information-sharing products (i.e., what processes depend upon effective information sharing).

There were a number of question categories and subcategories which needed to be included in the current questionnaire that were not explicitly included in the CTEF model. It is important to emphasize the importance of information-sharing processes, as these processes are a focus of the current work but were not emphasized in the CTEF model. To this group of categories, we added

overall performance, effectiveness and efficiency questions based on input from the Scientific Authority (SA) team. As well, a review of the CF literature was performed to identify barriers to and enablers of information sharing (see Taylor & Bruyn Martin, 2007a). This review revealed that, although the majority of barriers and enablers related to information sharing would likely be identified by using factors derived from the CTEF model, there was also a need to include tools and cultural factors in the questionnaire. See Table 1 for the final list of question categories.

In addition to the three categories derived from the CTEF model, the authors and the SA team proposed the following question categories that are intended to be direct measures of information sharing in JIMP operations:

- Information-sharing performance;
- Information-sharing effectiveness; and,
- Information-sharing efficiency.

Additional factors that may impact information sharing in a team-of-teams, as well as factors important to JIMP operations (e.g., cultural differences) were also added.

Each of these overall question categories includes a number of subcategories that are listed in Table 1.

Table 1: Summary of initial questionnaire categories, sub-categories, and potential hypotheses

Overall Categories	Conditions	Information-Sharing Processes	Information-Sharing Products	Performance	Effectiveness	Efficiency
Sub-Categories	Constraints Workload Stress Autonomy Organizational support Leader factors Team member factors Team factors Tools Cultural factors	Information quality Information management Knowledge of relevant practices and procedures	Assessing the situation Making decisions Planning Directing and controlling Liaising with other teams Creating goals Providing and maintaining vision Maintaining common intent Interacting within the team Motivating Adapting to changes Providing team maintenance Mutual trust and respect Collective confidence in success Shared vision	Data transmission Understanding	Global Local	Time Effort
Example Potential Hypotheses	Workload and information-sharing effectiveness are negatively related	Information quality is positively related to information-sharing efficiency	Effective information sharing is positively related to the maintenance of situation awareness.	Certain formats are used to share information more than others	Information sharing adequately supports the development of situation awareness	Information sharing was efficient in terms of the amount of effort required

For a comprehensive review of the literature relating to information sharing and team effectiveness as well as a detailed description of the way in which question categories were derived, see Taylor and Bruyn Martin (2007a).

3. Initial Questionnaire Development

3.1 Method

This section describes the method used to develop the first iteration of the questionnaire as well as the SME feedback that led to a refinement of the questionnaire.

A first iteration of the questionnaire containing sample questions was developed by taking a subset of factors from each main category (6 in total; see Tables 1 and 2) and creating sample questions that reflected different levels of assessment of each individual factor. For example, environmental constraints were identified as a factor in the conditions category. There are a number of ways in which environmental constraints can be assessed that are relevant to the current research on information sharing in JIMP operations. First, one could make an overall assessment of environmental constraints (i.e. did environment constraints exist that affected the mission?). Second, one could assess the impact of environmental constraints on information sharing in general. Conversely, if the relationship is bidirectional, one could assess the impact of information sharing (in general) on environmental constraints. Finally, one could evaluate the impact of environmental constraints on information sharing within and between teams.

Table 2 shows the overall question categories, individual factors related to each category and the levels or type of assessment that can be evaluated with respect to each factor. As previously described, the question categories are:

- Conditions
- Products
- Processes
- Performance
- Effectiveness
- Efficiency

For each category, there exist individual factors. For example, individual factors within the conditions category may include:

- Time pressure
- Environmental constraints
- Stress
- Cultural factors
- etc.

For each factor within each category of questions, a number of questions were formulated. First, an overall assessment of the factor (i.e., was the factor present and did it affect the mission?) was developed. Second, assessments were developed to evaluate the impact of the factor on information sharing and, if applicable, the impact of information sharing on the factor. Finally, assessments were developed to evaluate the impact of the factor on information sharing both within

and between teams. For example, the questions developed for time pressure (factor within the conditions category) were:

- Overall, was this mission time constrained?
- What was the impact of time pressure on information sharing?
- What was the impact of information sharing on time pressure?
- What was the impact of time pressure on information sharing within the team?
- What was the impact of time pressure on information sharing between teams?

Table 2: Question categories, factors, assessments, and sample questions

Category	Individual Factors	Assessments	Sample Question
Conditions	Time pressure, environmental constraints, stress, cultural factors, etc.	Overall assessment (i.e., was the condition present and did it affect the mission)	Overall this exercise was time constrained.
		Impact of condition on information sharing	The time pressure in this exercise impacted the effectiveness of information sharing
		Impact of information sharing on the condition	The effectiveness of information sharing affected the time pressure I was under
		Impact of the condition on information sharing within the team	The effectiveness of information sharing from within my team impacted the time pressure I was under
		Impact of the condition on information sharing between teams	The effectiveness of information sharing with other teams impacted the time pressure I was under
Products	Situational awareness, common intent, team maintenance, etc.	Overall assessment (i.e., was the product adequate for the respondents to perform their duties?)	During this exercise, my knowledge of the situation was good
		Adequacy of support for the product (i.e., was enough information shared so that the product was adequate)?	On average, the amount of information shared was adequate to support my knowledge of the situation
		Impact of the product on information sharing	My knowledge of the situation impacted the effectiveness of information sharing
		Impact of information sharing on the product	The effectiveness of information sharing impacted my knowledge of the situation

Category	Individual Factors	Assessments	Sample Question
		Impact of information sharing within the respondent's team on the product	The effectiveness of information sharing within my team impacted my knowledge of the situation
		Impact of information sharing between teams on the product	The effectiveness of information sharing between teams impacted my knowledge of the situation
Processes	Presence of practices and procedures, sharing information, processing information, tools used during information sharing, etc.	Overall assessment (i.e., was the process adequate for the respondents so they could perform their duties?)	Adequate information-sharing practices and procedures were available
		Within-team assessment (i.e., was the process within the team adequate)?	Practices and procedures for information sharing within my team were available
		Between-team assessment (i.e., was the process between teams adequate)?	Practices and procedures for information sharing between teams were available
Performance (data transmission)	Format of data transmission, frequency of data transmission, amount of data transmitted, etc.	Overall assessment (i.e., estimate of frequency, amount, etc.)	In which format do you most often send information?
Effectiveness	Local effectiveness	Assessment of expected (i.e., optimal) performance versus actual performance (local effectiveness)	How many scheduled SitReps did you receive per day (on average) during the exercise? How many scheduled SitReps did you expect to receive per day (on average) during the exercise?
	Global effectiveness:	Assessment of impact of information sharing on higher-level outcomes (global effectiveness)	On average, did you receive the amount of information you needed? Note: The products questions are also related to global effectiveness
Efficiency	Level of effort, time required	Overall acceptability of costs required	The amount of effort required to send information is acceptable
		Acceptability of costs required within team	The amount of effort required to send information to people within my team is acceptable
		Acceptability of costs required between teams	The amount of effort required to send information to people on other teams is acceptable
		Open-ended questions to determine where information sharing is inefficient	Please explain what it is that requires an unacceptable level of effort

Rating scales that were compatible with the assessment were developed for each question category, keeping the scales as consistent as possible while maintaining question clarity. Five-point ratings scales were used in all cases. The anchors for rating scales used for the overall assessment questions (e.g. overall, this exercise was time constrained) ranged from 1 to 5, where 1 = strongly disagree, 5 = strongly agree, and 3 = neutral. For the impact questions (e.g., time pressure impacted information sharing), the rating scale anchors were -2 (strong negative impact) to +2 (strong positive impact). See Annex C (information provided to scientific SMEs) for a list of all of the rating scales used in the first iteration of the questionnaire.

The first iteration of the questionnaire was created as an Excel spreadsheet and provided to the SA team. This spreadsheet contained a worksheet for each category of questions (e.g., team conditions) and a number of sample questions and the response options for each category of questions. Sample questions assessed the overall state of the factor, and addressed the relationship between specific factors and information sharing. For example, "leader's skills" was one of the conditions thought to influence information sharing. The overall status of the leader's skills was assessed by the question "My leader's skills were generally adequate for this exercise." The sample question addressing the impact of leader's skills on information sharing was "My leader's skills impacted the effectiveness of information sharing".

For some factors, a bi-directional relationship between the factor and information sharing was identified. That is, the factor is expected to have an effect on information sharing and information sharing is expected to impact the factor (e.g. workload). Sample questions addressing this bi-directional relationship were, for example:

- "My workload had an impact on the effectiveness of information sharing";
- "Information sharing had an impact on my workload".

A selection of questions was also designed to address information sharing between and within teams. That is, specific questions such as "Information sharing within my team had an impact on my workload" and "Information sharing between teams had an impact on my workload" allow an assessment of both within and between team information sharing.

The types of questions provided above can be considered multi-dimension questions in that they address both information sharing and another factor or dimension (e.g. leadership style or workload). Single dimension questions (referred to as "overall assessment" questions) were also provided for each factor. For example, with respect to stress, the following single dimension, or "overall assessment", question was created: "Overall, I experienced a high level of stress during the exercise". For examples of sample questions see Table 2.

The SA team reviewed the first iteration of the questionnaire prior to the scientific SMEs. Changes suggested by the SA team were incorporated into the questionnaire sent to the scientific SMEs for feedback. Changes included:

- Changing the definitions of performance, effectiveness, and efficiency (to definitions currently used, including separation of effectiveness into global and local effectiveness)
- Adding stress as a factor (under conditions)

3.2 Results

Initial feedback from the SA team resulted in the addition of a number of single-dimension questions addressing information-sharing performance, effectiveness, and efficiency. The first iteration of these single-dimension questions (i.e., directly measuring or evaluating information-sharing performance, effectiveness, or efficiency) is included in the Annex C. The addition of single-dimension questions relating to information-sharing performance, effectiveness, and efficiency facilitates statistical analyses to investigate the relationship between specific factors (e.g. stress) and information sharing performance (or effectiveness or efficiency). This is further described in the discussion of analyses in Section 5.

In total, 275 questions (155 multi-dimension and 120 single-dimension questions) were provided to scientific SMEs for review and feedback as described in Section 4.1

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4. Scientific SME Review

4.1 Objectives

The goal of this activity was to obtain feedback from scientific SMEs on the first iteration of the questionnaire. SMEs were experts in JIMP operations, questionnaire development, or both. Overall, SMEs were asked to provide feedback regarding:

- The question categories (e.g., are all important categories of questions included, are there categories which should be eliminated?);
- The sample questions (e.g., is the wording appropriate for operators in a JIMP environment, are the questions clear?);
- Question priority (i.e., which of the categories are critical, which are moderately important, and which are only slightly important?), and;
- Overall approach (e.g., are the definitions appropriate, are the types of questions being asked the most effective way of assessing information sharing?).

4.2 Method

4.2.1 Participants

Scientific SMEs were identified and initially contacted by the SA team. A total of nine scientific SMEs provided at least some feedback on the questionnaire. SMEs were Defence Scientists from Defence Research and Development Canada (DRDC) including DRDC Toronto, DRDC Ottawa, DRDC Atlantic, DRDC-CORA (specifically the Strategic Joint Staff and Defence Science Support Team [formerly EXORT]), and the Centre for Security Sciences, as well as one individual who had operational experience in JIMP environments.

4.2.2 Materials

The package of materials (Annex C) provided to SMEs included:

- Project introduction;
- Specific questions relating to the questionnaire;
- Excel spreadsheet containing list of categories (for rating);
- Mind Map document (and pdf version) that shows the question categories and subcategories in a “tree-diagram” format, and;
- First iteration of questionnaire as an Excel spreadsheet with question categories and sample questions.

4.2.3 Procedure

HSI® staff contacted potential scientific SMEs to introduce them to the project and determine their willingness to participate. All materials were sent to the SMEs in the introductory email. SMEs were then contacted by telephone. During the phone conversation, SMEs were given a walkthrough of the materials, and any questions they had were answered. SMEs were requested to provide feedback by a specific deadline, depending on the time of the initial email and telephone conversation.

SME feedback was sent to HSI® via email. HSI® staff compiled all SME comments into a single document and assessed the feedback in order to identify required or recommended changes to the questionnaire. Changes to the question categories and/or individual questions were incorporated into the next iteration of the questionnaire.

4.3 Results

This section provides a summary of comments from the scientific SMEs. Specific comments are provided in Annex D. The feedback submitted by the SMEs was compiled based on relevant issues and summarized, including our responses to the feedback (e.g., was the comment addressed, and if not, why?). It was reassuring to note that the feedback regarding the JIMP information-sharing questionnaire as a whole was positive, and most SMEs requested a copy of the final version of the questionnaire. Although most of the SMEs indicated that the questionnaire was well-designed overall, many had specific suggestions about how it could be improved. The recommended areas for improvement are discussed below.

4.3.1 Question categories

The only suggestion SMEs had with respect to the overall question categories was a further grouping of questions into direct and indirect measures. While local effectiveness, efficiency, and some performance questions can be considered direct measures of information sharing (i.e., they are attempts to measure information sharing directly; e.g., “In which format do you most often send information?”), most questions are indirect assessments of information sharing, in that they ask about the impact of other factors on information sharing, rather than about information sharing itself (for example, “My workload impacted the effectiveness of information sharing”). This is reflected in the revised Mind Map (see Annex F), but had no effect on the questionnaire design itself, as questions were already divided into categories consistent with separating direct from indirect questions (i.e., the performance, effectiveness, and efficiency questions were already presented separately from the condition, performance, and product questions).

4.3.2 Sample questions

SMEs provided a small number of relatively minor suggestions about the wording of specific sample questions. It was recommended that operators be provided with a clear definition for several of the concepts (e.g., a definition for effectiveness that an operator will easily understand), and these should be presented either within the questions or in a cover explanation. Overall, SME feedback suggested that our sample questions were appropriate and avoided unnecessary jargon.

4.3.3 Question importance ratings

SMEs were asked to rate the relative importance of the question categories related to information sharing. The possible ratings ranged from 0 (not important – delete from questionnaire) to 3 (critical). The importance ratings produced by the scientific SMEs were combined and the mean and mode ratings were calculated. As well, using the mean ratings, subcategories were ranked within each category. The higher the mean (and the lower the rank), the more important the SMEs thought the category was for information sharing (e.g., a rating of 3 and a rank of 1 would be the most important in the subcategory of question). Mean and mode ratings are included in the report, and were intended to serve two main functions. First, if scientific SMEs agreed that particular factors were unimportant for information sharing, these would be deleted from the questionnaire (no factors had a mean importance rating of less than one, and so none were considered unimportant enough to eliminate). Second, these ratings are intended to provide suggestions about the relative importance of questions to analysts, so that they can tailor the questionnaire to suit their needs by eliminating the least important questions.

Importance ratings for the questionnaire categories are presented by category in Annex D. The tables list the question categories and subcategories, their mean and mode importance ratings, the number of data points included in the mean ratings, the rank order, and the group (the grouping system is explained below). There are several things to note. First, additional factors recommended by SMEs are included in the tables, but there are no ratings, rankings or groups for these added factors because they were not provided to the SMEs for rating in the original set of factors. For a complete list of additional factors recommended by SMEs, see Table 3. Second, team outcomes were presented to scientific SMEs as a separate category, and so they are listed as a separate category in the tables, but these are being treated as part of the products category in the questionnaire.

The rank column represents the perceived order of importance of factors within each main question category. The relative level of importance decreases as the rank increases (i.e., the most important will be rank 1; the least important will be the rank with the highest number).

To facilitate the selection of factors by importance ratings, factors were divided into three groups based on the mean ratings provided by the SMEs. Note that these groupings were done separately for each category of questions (i.e., factors in the Conditions category were divided into groups separately from the groups created for the factors in the Products category, etc.). Group 3 items had the highest ranking (i.e. highest number, most important), and Group 1 items had the lowest ranking (i.e. lowest number, least important). Groups were formed first by sorting the items based on their mean importance rating, and dividing them into three groups as equally as possible. Then, the mean ratings within the group were examined to determine whether items with the same mean importance were divided into two groups. If this was found to be the case, then the number of items with that mean was counted, and the rest of the items with the same mean were moved to the group, which contained the most items with that mean. For example, the Condition category contained 48 items which could be ranked (at least 3 people rated 48 of the factors). Initially, 16 items were placed in each of the three groups. However, upon examination, there were 11 factors with the mean rating of 1.75. Since all of these 11 factors are rated of equal importance, they should all fall within the same importance category (any method of dividing them into 2 different importance categories would have to be arbitrary). However, 5 fell within Group 1 and 6 fell within Group 2. Therefore, all 11 factors with the mean importance rating of 1.75 were placed in Group 2.

Analysts can use these importance ratings in three main ways. First, for categories analysts know they wish to include, importance ratings can be used as a guide when trying to determine which

questions should be selected (assuming a limited number of questions can be used). It seems reasonable that analysts would want to include the most important questions in a category, and omit the least important ones. Second, analysts could set an importance cutoff (e.g., a mean importance rating of 2.5) and include all questions with that importance rating (or above) and exclude any question with an importance rating below 2.5). Third, an analyst could choose a set number of questions (e.g., maybe participants will only be able to answer 10 questions), and use the importance ratings to determine which 10 questions are the most important. Note that there are ratings done at several levels (i.e., multiple subcategories within each category may have their own ratings), and it is up to the analyst to decide at what level they wish to examine the rating information.

Although these importance ratings are intended to enable analysts to make sure that the most useful questions are included in any iteration of the questionnaire, it should be stressed that these ratings are generally estimates by the scientific SMEs based on their experience. As well, categories were rated by a total of eight SMEs. Therefore, these ratings should be interpreted with caution, and used as guideline only. Further research should be performed to gather evidence about which of these factors actually have the strongest impact on information sharing in the JIMP context, and these ratings should be considered as suggestions rather than definitive information about which factors are most important when attempting to understand information sharing.

4.3.4 Overall approach

The overall approach of asking both direct questions (i.e. asking the respondents directly about their information-sharing performance) and indirect questions (i.e. asking the respondents about their overall performance, so that these ratings can be correlated with information-sharing performance) was deemed to be appropriate by the SMEs. The main issue raised by the SMEs was that additional direct or objective measures were needed, particularly of products and performance (e.g., measures of how much data is transferred). This was also confirmed by means of a pilot test, as discussed in Chapter 5 of this report. It would be very useful if such objective measures could be gathered and correlated with the questionnaire results; however, discussing which other types of measures might be most appropriate is beyond the scope of the current project.

4.3.5 Other comments

In general, comments from the scientific SMEs were favourable. A main reaction of the SMEs was that the questionnaire was extremely long, which may pose a problem in terms of time to complete the questionnaire and respondents' motivation level. The modular design of the questionnaire (i.e., respondents will be administered specific categories of questions rather than the entire inventory of questions) as well as a matrix format (i.e., using a short form for questions [e.g., question section # 13 in Annex A]) for some of the questions are two ways in which this issue can be addressed. This will be further discussed in the following section.

4.4 Refinement of questionnaire based on scientific SME review

Based on SME feedback, a number of changes were made to the JIMP information-sharing questionnaire. These included the addition of factors, rewording of some questions, and modifying the response options for some of the questions. For a full list of SME recommendations as well as actions taken to refine the questionnaire, see Annex D.

4.4.1 Addition of factors

Table 3 presents the factors that were added based on SMEs' recommendations. Note that other SMEs did not have these factors available for rating, so ratings for these factors could not be included, although they are included in the tables (Annex D) for completeness.

Table 3: Factors added based on SME feedback

Added factors	Category	Subcategory
Operational skills, strategic skills	Conditions	Leader factors - skills
Operational skills, strategic skills	Conditions	Team member factors – skills
Nonverbal communication	Conditions	Cultural factors – language differences
Power distance	Conditions	Cultural factors
Assignment of roles and responsibilities	Conditions	Team factors
Perceived legitimacy of assignment of roles and responsibilities	Conditions	Team factors – assignment of roles and responsibilities
Power dynamics – within teams and between teams	Conditions	Team factors
Physical constraints – collocated versus distributed	Conditions	Constraints
Sharing information	Information-sharing processes	Information management [note – this was a reorganization of obtaining and sending information]
Organizational trust	Team-related outcomes	Mutual trust & respect
CIMIC (Civil Military Co-operation)	Information-sharing processes	Dedicated roles/resources (specific example)

4.4.2 Rewording of questions

Some of the feedback from the scientific SMEs required rewording some of the questions. In some cases these changes could be made in a general way in the current questionnaire. Some examples include the following:

- Information management was suggested as a more appropriate term than knowledge management, and so this has been changed;
- Situational awareness was suggested as the term used by the military, and so situation awareness was changed to situational awareness, and;
- It was suggested that a context needed to be added to some of the task-performance questions, and this was done. For example, "My knowledge of the strategic objectives of this exercise was adequate" was changed to "My knowledge of the strategic objectives of this exercise was adequate to perform my duties."

Notes have been made for analysts in cases where information will have to be added depending on the specific administration situation. For example, when participants are asked about who they communicate with, scientific SMEs noted that specific individuals or positions may need to be mentioned as options.

4.4.3 Modifying response options

There were a few suggestions regarding the response options in the questionnaire. As far as possible, response scales were made identical. Most questions could be answered using a scale which ranged from strongly disagree to strongly agree (e.g., when you received pushed information, that information was useful). A separate scale was still needed for the impact questions (e.g., what impact did environmental constraints have on information sharing? Response options: very negative impact to very positive impact). For the format of information sharing questions (in the performance section), SMEs recommended presenting options in a closed-ended manner. This was done by including the response options: Text, pictures, and verbal.

5. Creation of Complete Questionnaire and Electronic Implementation

5.1 Creation of complete questionnaire

Topics for the questionnaire were expanded from the original list of categories by separating categories by the main assessment types for that category (e.g., the "conditions" category was divided into an "overall condition assessment", "impact of conditions on information sharing", and "impact of information sharing on conditions" topics). See Table 4 for a full list of topics used in the questionnaire, along with the section number and number of questions (including separate counts for content and comment questions; explanation provided below).

Table 4: Question set numbers and topics in the full version of the questionnaire

Topic	Section number in electronic questionnaire	Total questions	Content (i.e. info sharing) questions	Comment questions
Performance	1-4	39	35	4
Local effectiveness	5	17	16	1
Efficiency	6 & 7	14	12	2
Overall task performance assessment	8	46	45	1
Global effectiveness	9-11	52	49	3
Overall condition assessment	12	63	62	1
Overall information-sharing processes assessment	13 & 14	42	40	2
Impact of conditions on information sharing	15	65	64	1
Impact of information sharing on conditions	16	16	15	1
Impact of task performance on information sharing	17	44	43	1
Impact of information sharing on task performance	18	44	43	1

Each section of the questionnaire includes at least one "comments" question (the exact wording is: "comments about this section") that was included to allow pilot-test participants the opportunity to provide feedback on the particular section. These questions were used during the pilot study, but it is also recommended that they be retained when administering the questionnaire during an exercise or experiment to allow participants to provide additional feedback about specific implementations

of the questionnaire. Additionally, given that there were often multiple types of questions (e.g., open-ended and closed-ended questions) for a specific topic, there was often more than one question set and comments section per topic.

Note that all questions about information sharing (424 including direct, indirect, single dimension and multi-dimension questions) are referred to as content questions in Table 4, as distinct from the comment questions (18) for a total of 442 questions. For each topic, a reference to the section number in the electronic questionnaire is also provided.

General instructions for pilot-study participants (e.g., providing the context for responding to the questions) and usability questions were added for the purpose of the pilot study. More specific instructions (e.g., explaining terms and response options used in that section) for pilot-study participants were also included at the beginning of each section. Annex E includes the entire questionnaire used in the pilot study. Usability questions designed for the pilot study are provided at the end of Annex E. Instructions developed for analysts are included in Annex B.

The questionnaire contains many sections where the specific context is needed to answer the question. These are marked in red throughout the electronic version of the questionnaire (and have been included in the Excel spreadsheet version of the questionnaire in Annex A). Before administering this survey, it is assumed that the experimental design makes clear to the participants 1) the context (i.e., the specific mission or experimental scenario), and 2) an understanding of what is meant by terms such as “team”, “team leader”, and “JIMP operations”.

5.2 Electronic implementation

The software used to implement the electronic version of the questionnaire was SurveyPro (version 4.0). The software is developed by Apian Software Inc., located in Seattle, WA. In general, this software is user-friendly and allows the user to cut and paste items from Excel (used to create the inventory of questions) into electronic questionnaire worksheets. The questionnaire software allows the production of both online (used for this pilot test) and paper-based versions of the questionnaire. In addition, this software allowed us to produce a large inventory of questions that can easily be edited by individual analysts who may want to remove particular questions or sections, given they have access to SurveyPro.

Implementing the questionnaire in electronic format using SurveyPro and uploading it to the HSI® server allowed multiple, distributed users to access the questionnaire remotely and respond online. The questionnaire was successfully uploaded to the HSI® server and accessed by participants. Survey activity logs were available online using a web browser, and provided information about the number of completed surveys, the number of surveys that were accessed, and approximately when (e.g., within the last six hours, within the last 48 hours) they were accessed. Summary reports were automatically produced by SurveyPro when data was entered into the software, and custom reports could be done fairly quickly and intuitively created within this software as well. Although this was not done for this contract, the data collected by SurveyPro can be exported from SurveyPro and can be saved in a comma-space delimited (CSV) format, allowing it to be imported into Excel and many other programs (e.g., Statistica, SPSS). It took approximately 20 hours to create the electronic version of the survey and input the entire inventory of questions (442 in total) into the survey software.

Snapshots of the survey webpages are archived in ANNEX E.

Creation of the electronic version of the questionnaire took place in several stages:

1. All of the questions and instructions from the paper-based questionnaire were entered into the survey software database. Questions were divided into 11 sections based on topic. Note that there may be multiple sections within a topic based on question type. For example, there are 4 different question groups in the Performance section, as there are different types of closed- and open-ended questions which must be entered into the survey software differently (see Table 4);
2. The questionnaire was previewed, and any formatting and other appearance modifications required were made;
3. The questionnaire was uploaded to the HSI® server;
4. Preliminary testing was done by the developers to ensure that the electronic version of the questionnaire was accessible, usable, and that the data was saved properly;
5. One version of the electronic questionnaire contained all of the questions to make it easier for review by the SA team (the "All" version). Due to the length of the questionnaire, separate versions were created so that subsets of questions, rather than the entire inventory of questions, could be presented to different participants during the pilot test. All questions were divided between 6 different versions of the questionnaire (1 through 6). See Table 5 for the questionnaire versions used for the pilot test.
6. The 7 versions of the questionnaire were uploaded to the server and made accessible to participants, and;
7. Military personnel were contacted to act as participants in the pilot test and were sent hyperlinks to one of the six parts of the questionnaire (i.e., one of Versions 1 to 6).

Table 5: Questionnaire versions used in pilot test

Questionnaire Version	Questions in All Versions	Unique Question Sets
1	Performance, local effectiveness, efficiency, usability questions	Overall condition assessment
2	Performance, local effectiveness, efficiency, usability questions	Overall task performance assessment
3	Performance, local effectiveness, efficiency, usability questions	Overall information-sharing process assessment
4	Performance, local effectiveness, efficiency, usability questions	Global effectiveness
5	Performance, local effectiveness, efficiency, usability questions	Impact of conditions on information sharing (and vice versa)
6	Performance, local effectiveness, efficiency, usability questions	Impact of task performance on information sharing (and vice versa)

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6. Pilot Study of Electronic Questionnaire

6.1 Method

The goal of the pilot test was to obtain feedback from military participants about the electronic implementation of the questionnaire. A total of 22 participants were contacted, and 4 completed the pilot study. The participants were military experts working at the Canadian Forces Experimentation Centre, and were familiar with JIMP operations, as they were involved in the study of the JIMP concept. Two human factor practitioners (in-house consultants at HSI®) also acted as pilot-study participants and reviewed the electronic version of the questionnaire (for a total of 6 participants). The human-factors practitioners provided valuable feedback on usability issues such as ease of navigation and ease of use, but were unable to provide detailed feedback about the appropriateness of individual questions as they lacked operational experience.

For the purpose of the pilot study, six versions of the questionnaire were used (see Table 5). Note that all questionnaire versions contained the performance, local effectiveness, efficiency, and usability question sets. Military participants reviewed questionnaire versions 1, 4, 5, and 6 (one each) while the two human factors practitioners reviewed questionnaire versions 2 and 3. Note that members of the SA team for this contract were quite pleased at the return given that these military officers were very busy and yet responded to this informal request for participation.

6.1.1 Usability questions

As previously noted, usability questions about the questionnaire itself were designed for the pilot study and placed at the end of all versions. Five aspects of usability were investigated: navigation, appearance, ease of use, clarity of instructions, and appropriateness of wording. For each aspect of usability, one closed-ended question and one open-ended question were created. Closed-ended questions all used a 5-point scale from Low [1] to High [5]. Note that in some cases “Low” indicated the participant was satisfied with the questionnaire, and in other cases “High” indicated that the participant was satisfied with the questionnaire. See the Results section for an overview of the closed-ended questions. Pilot-study participants were also asked what question format they preferred, full or matrix formats (full-question formats ask the entire question; for an example, see question set 1 in Annex A. Matrix formats have an introductory section and then list items; for an example, see question set 13 in Annex A [begins on row 805 in the spreadsheet]).

Pilot-study participants were also given the opportunity to comment on the overall questionnaire. For this a general open-ended question was included at the end of the questionnaire (for all six versions).

6.2 Results

Feedback provided by the pilot-study participants will be discussed in three sections. The first section will discuss usability questions that address navigation, appearance, ease of use, clarity of instructions and appropriateness of wording (presented to all participants). The second section reviews the performance, local effectiveness, and efficiency sections (presented to all participants). The third section reviews feedback provided by individual participants that is specific to the sections that were unique to them. Note that Section 6.3 includes a discussion of the best way to address the recommendations made by pilot-study participants.

One of the goals of the pilot study was to determine average questionnaire completion time. The range of completion times was 6 to 18 minutes for the performance, local effectiveness, and efficiency questions. However, the accuracy of this estimate is questionable, as only three of six participants provided enough information to determine how long it took them to complete their version of the questionnaire. As well, two of the three participants who did provide information about completion times were the HF specialists, and so did not actually complete the questionnaire with the depth that may be required by an actual participant in an operational setting (therefore completion times would likely have been under-estimated).

6.2.1 Closed-ended usability questions

The responses to the closed-ended usability questions are summarized in Table 6 (note that one of the six participants did not complete the usability questions):

Table 6: Closed-ended usability questions

Usability Aspect	Question	# responses	Ideal rating	Mean rating	Mode rating
Navigation	Please rate the level of difficulty you had navigating this questionnaire	5	1 (Low)	1.4	1
Appearance	Please rate the acceptability of the appearance of this questionnaire (consistent, readable, etc.)	5	5 (High)	4	5
Ease of use	Please rate the ease of use of this questionnaire	5	5 (High)	3.2	2
Clarity of instructions	Please rate the clarity of the instructions for this questionnaire	5	5 (High)	3.2	2
Appropriateness of wording	Please rate the appropriateness of the wording used in this questionnaire	5	5 (High)	3.4	3

In general, responses to the closed-ended usability questions suggest that the usability of the questionnaire was reasonably good. Navigation and appearance received very good ratings. The ease of use, clarity of instructions, and appropriateness of the wording received reasonable ratings. The issues raised in the open-ended comments section (discussed in the next section of the report) provided some information about why the ratings were not even higher, and some hints about how to address these issues.

6.2.2 Open-ended usability questions

The responses to the open-ended usability questions are discussed below.

Navigation: This issue refers to how easily the electronic questionnaire can be navigated (e.g. to move back and forth between questions and sections). In addition to rating the level of difficulty in navigating the questionnaire, participants in the pilot study were asked the open-ended question "If you had difficulty navigating this questionnaire, please elaborate (what was the problem, and do you have any ideas for improvement?)"

The only comment received was related to editing comments; specifically, that the width of the comment boxes was fixed and did not allow enough characters to be entered. It should be possible

to solve this issue by expanding the number of characters that participants can enter in the comment boxes.

Appearance: The second issue that was investigated was the appearance of the questionnaire. Aside from rating the acceptability of the appearance of the questionnaire, participants were asked, "If there were any problems with the appearance of this questionnaire, please elaborate." There were two comments, one relating to the minimal amount of text that can be entered in comment boxes (addressed in the previous section), and the other relating to the length and repetitiveness of the questionnaire (i.e., the questionnaire is too long and repetitive). It should be noted that the questionnaire was still perceived as long and repetitive even though the participants were presented with less than 1/3 of the total number of questions in the entire questionnaire. However, the overall questionnaire is intended to represent an inventory of questions, and it is likely that analysts will administer only a limited number of these questions at a given time.

Ease of Use: As previously mentioned, participants were asked to rate the ease of use of the questionnaire. In addition, they were asked, "If there were any problems with the usability of this questionnaire, please elaborate." One participant reiterated his dissatisfaction with the amount of text that could be entered into comment boxes. A military participant indicated that the questions did not make sense. This comment suggests that there may be issues with the clarity of the questions; however, there was no opportunity to follow up (i.e., the analysts were blind to which military participant responded to which questionnaire). This issue should be further investigated in field trials in which this questionnaire will be administered.

Clarity of instructions: The fourth issue investigated was the clarity of instructions for participants. In addition to rating the clarity of instructions, participants were asked: "If there were any problems with the clarity of the instructions used, please elaborate." One participant indicated that they responded in other comment sections, and did not elaborate here (these comments will therefore be addressed in another section). Another participant indicated that he/she had concerns with the clarity of instructions, but that it might be due to lack of experience. Unfortunately, there was no feedback provided in terms of which specific instructions were unclear. Potential issues relating to the clarity of instructions should be further investigated in field trials in which this questionnaire will be administered.

Appropriateness of wording: Participants were asked to rate the appropriateness of the wording used for the questionnaire. Participants were asked "If there were any problems with the wording used, please elaborate." Only one participant commented and that was to indicate that he/she was unclear about the definitions of some of the terms used, specifically "leader", "team", and "information". As indicated in the questionnaire, it is intended that analysts using this questionnaire will need to specify to what and to whom the terms "leader" and "team" refer. The participant's response presented above reveals that input by the analyst will be necessary in order to clarify those concepts. The concern about the definition of "information" should perhaps be further investigated in field trials in which this questionnaire will be administered.

Question style: Finally, the sixth issue to be investigated was question style. That is, participants were asked if they prefer questions presented as full questions (e.g., question set #3 in Annex A, starting on row 58), or questions which were presented in a matrix format (e.g., question set #13 in Annex A, starting on row 805). Only two participants replied to this question. Both indicated that a grid style was generally preferred, although one participant indicated that more specific answers would likely be obtained with the use of a full-question style.

Other comments: An additional open-ended question was asked to allow participants to make any other comments they might have about the survey. Three participants provided comments. The first comment identified the need to specify answers for the "how much information" questions, and specify the parameters for those questions. The second comment also reinforced the need to define the questions addressing the amounts of information, and specify what types of answers are expected. A third participant reemphasized the need to expand the comment boxes, and indicated that the survey seemed too long.

6.2.3 Performance, local effectiveness, and efficiency questions

All questionnaire versions included performance, local effectiveness, and efficiency questions and thus all participants received these questions. The comments provided by participants are reviewed below.

Performance: The performance section contains questions about the format in which information is typically shared. Several of these are closed-ended, and the format options provided were text, pictures, and verbal. One concern was that we may not have included enough format options in these closed-ended questions. We also included an open-ended question asking if there are additional formats that are commonly used, and other options provided by the participants were:

- Mixed text and photos
- Video
- Radar, Electronic Warfare, or sonar displays
- Graphics

There were several comments about the performance section. One participant mentioned that staff briefings are an important source of information, but it is unclear about how to classify this, as these are usually presented in groups, and the "briefers" are generally peers, but the actual target of those briefings is usually the General.

Participants tended to have difficulty with the "how often" questions in the performance section (e.g. how often information has to be translated). One participant mentioned that he did not know what was meant by these "how often" questions. He indicated that the issue isn't how often it has to be done but rather how much time it takes (note that this is addressed in the efficiency section, which the participant would have not yet seen at the time they wrote this comment). To the question "On average, how often did you have to spend time interpreting information" one participant commented that they are always interpreting information, and so the question didn't make sense to them. Although one participant suggested that it might be possible to answer the "amount of information" questions in terms of pages of information, as SitReps were typically sent in text and pictures (although there were also powerpoint briefings), another participant replied that asking for an amount will not result in valid answers, as he has no idea what the values would be nor where to acquire such information. It was also stated that even if participants could provide numbers for these questions, they are not likely to be meaningful.

Several participants indicated that the questions about information exchange require a better understanding of who is involved in the exchange of information. The participant mentioned that this could be done by requiring the analyst to create a specific list of superiors, subordinates, and peers. Unfortunately, because this questionnaire is likely to be sent simultaneously to a number of participants at different levels in the team hierarchy, it may not be possible to specify individuals

because individuals will be subordinates, superiors, and peers for different participants. However, we do state in the questionnaire instructions that the analyst will have to specify what is meant by superior, subordinate, and peer for the participants.

One participant did not understand what was meant by the impact of interpreting information, and a participant also noted that the term "critical error" needs to be defined, as he didn't know what it meant.

In summary, participants provided many comments on this section, and they thought that many of these questions (especially the "how often" and "amount" questions) could not be answered in an accurate way. On the other hand, the participant's comments are the type of thought process that experimental designers must go through with all the questions they choose from this inventory and then modify the survey accordingly.

Local effectiveness: In the local effectiveness section of the questionnaire, questions were asked about expectations for information sharing. Theoretically, local effectiveness is the ratio of actual to expected performance. Local effectiveness is calculated by dividing the actual performance (answers received as responses to the performance section) by the expected performance reported in this section.

Similar issues were raised in this section as were raised in the performance section. Again, participants raised issues with understanding what is meant by "amount of information". One participant indicated that they could not provide meaningful answers, and would not provide numbers unless the experimenter insisted.

One participant had issues with the question "On average, how often do you expect to have to translate information from one format to another", and indicated that they always have to and always expect to have to translate information.

In summary, participants' comments to the local effectiveness questions were similar to their comments in the performance section, indicating that they had difficulty understanding the meaning of these questions, and felt that they could not answer them accurately.

Efficiency: There were two comments related to the efficiency section of the questionnaire, and both had to do with the clarification of questions. To the question "The amount of effort required to send information is acceptable" participants commented that they were not sure if the question referred to process or workload. As with the local effectiveness questions, these responses suggest that the efficiency questions are not easily understood.

6.2.4 Other content questions

Overall assessment of information-sharing conditions: The participant who was asked to provide feedback on the overall assessment of conditions section of the questionnaire had a few comments about the questions in this section. First, the participant needed clarification about what was meant by environmental constraints. Also, this participant noted that questions about leaders need to be more specific about which leader is intended.

The participant also made comments about the use of the term "team", strongly objecting to referring to members of the CF as a team.

Other sections: The participant who was presented with the overall assessment of task performance indicated that he had no concerns with this section. Participants who were presented with the other sections (overall information-sharing process assessments, global effectiveness, and

impact of information sharing on conditions and vice versa) did not make any comments about these sections.

6.3 Refinement of questionnaire based on pilot study

Feedback from the pilot-study participants suggests that the ease of navigation and the appearance of the questionnaire were more than satisfactory. However, participants were less positive with respect to ease of use, clarity of instructions, and appropriateness of wording used in the questionnaire. Participants provided comments that were used to determine ways in which the questionnaire could be improved. The following sections outline ways in which issues identified by participants can be addressed. Table 7 summarizes the issues raised by participants as well as recommendations to address these issues.

Table 7: Summary of issues identified in pilot study and recommendations to address these issues

Issue	Recommendation or Action Taken
Inadequate space in comment boxes	Comment space checked and should generally be adequate; this should be taken into consideration in future implementations of the questionnaire
Questionnaire too long and repetitive	Analysts should carefully consider how many and which questions they will include in the questionnaire
Define: “leader”, “team”, “superior”, “subordinate”, and “peer”	This will have to be done by the analyst
Define “environmental constraints”	Included examples such as weather and topography to clarify
Define “information”	Recommend that the following definition (or another that the analyst finds suitable) be included in the questionnaire: Information is knowledge or data (e.g. documents, pictures, maps, speech) which changes your understanding of the situation (when you are interpreting or receiving it). In the case of sending information, you expect that the data you are sending will change the recipient’s understanding of their situation
Define “critical error”	Recommend that a specification that critical errors are errors that are important enough to have a detrimental effect on task performance or the mission in general be added – Note that this question was eliminated, so this is no longer an issue.
Problems interpreting and answering performance and expectation (local effectiveness) questions	Deleted many of the questions in this section as participants indicated that they could not accurately answer these questions. Recommend that data be collected regarding these factors based on observations or analysis of artifacts, rather than on questionnaire responses
Specific difficulty answering: “On average, how often did you have to spend time interpreting information”	Changed question to: “What tasks required the most information processing?”
Include more options for information format	Deleted picture format, added graphic, photo, display, video formats, and allowed participants to select more than one option

Issue	Recommendation or Action Taken
Lack of clarity in efficiency section related to what is meant by effort required to send information	Added a comment in the efficiency section introduction that all aspects of sending information are included, and that participants can provide more information about what is inefficient in the open-ended questions at the end of the section

One issue that was raised repeatedly (although by only one participant) was that the space allowed for text entries in the comments column was insufficient. This was investigated, and comment boxes which were used allowed up to 10,000 characters, which should be sufficient for most comments. Boxes that were intended for responses to the "amount of information" questions (e.g., "On average, how many scheduled SitReps did you expect to receive per day during the exercise?") allowed responses up to only 200 characters. The difficulty experienced by the participant who commented on the lack of space was likely the result of him attempting to enter comments in the shorter response boxes. This is not likely to be a significant issue with the current implementation of the questionnaire as the smaller boxes are not intended for comments, and separate comment sections are provided. Nonetheless, the issue of adequate space for comments should be kept in mind if the survey is implemented in other software.

Interpretability appeared to be an issue for several participants. There are three categories of items which require elaboration. The first are items which, as already noted, require elaboration by analysts (colour-coded red in the questionnaire). This includes explanations of who is meant by the "*leader*", "*team*", "*superior*", "*subordinate*", and "*peer*". These items require the analyst to define these terms according to the context in which the questionnaire will be administered (i.e., specifying which organizations are involved in the specific JIMP exercise, experiment or operation). Comments by participants reinforce that these items do indeed require such elaboration.

A second group of items require elaboration in the general version of the questionnaire. Terms such as "*environmental constraints*", "*information*", and "*critical error*" are better defined in the final version of the questionnaire (as noted in Table 7).

A third set of items which require elaboration are the performance questions, as participants had difficulty understanding these questions. The goal of the performance section was to gather quantitative data about information-sharing performance, but participants seemed unable to provide meaningful values. Furthermore, the questions do not seem intuitive to them. This portion of the questionnaire was particularly poorly received, and it was therefore recommended that parts of the performance section be eliminated (the problematic questions have been eliminated from the final version of the questionnaire presented in Annex A). Furthermore, given that the local effectiveness questions are based upon the performance questions (because local effectiveness is calculated using responses from performance and expected performance questions), there will be similar concerns with the validity of those questions. It is therefore recommended that the local effectiveness questions be eliminated as well (these are eliminated from the final version of the questionnaire presented in Annex A).

Performance and local effectiveness measures can be derived using techniques such as social network analysis; however, this type of measure falls outside of the scope of this survey development. Ongoing work for other projects, such as a social network analysis, will complement the development of this survey by providing other means to measure performance and local effectiveness directly.

Other statements made by pilot-study participants suggest potential problems in interpretability of the questionnaire, but unfortunately many of the comments were not sufficiently clear to allow

identification of the underlying problem (one military participant even indicated that he believed his difficulty understanding the questionnaire was due to his own lack of operational experience). Thus, it is difficult to know which aspects of the questionnaire are unclear and it is therefore not possible to directly address these comments. However, most of these issues are likely to be resolved when the analysts provide adequate context for actual participants involved in a JIMP exercise, experiment or operation (e.g. what is meant by "leader").

Only two participants answered the question regarding which question format (full-question or matrix format) they preferred, and both preferred the grid format. This supports the earlier decision to use the grid format in specific sections of the questionnaire, and therefore this question format will be retained.

The questionnaire includes several questions that ask about the format in which information is typically shared. The participants indicated that information is shared in formats other than just pictures, text, and verbally. Rather, it was suggested that people also share information by using mixed text and photos, video, radar, EW, or sonar displays, and graphics. These format options will therefore be added to the appropriate questions in the final questionnaire. It may be necessary either to show participants how these items fit into established categories (for example, the "pictures" category could explicitly be defined to include graphics), or add items (for example, video). The issue of mixed formats should also be addressed, perhaps by adding the number of possible responses (i.e., allowing the participants to select more than one format as the one they use "most often", by requiring participants to select only a single format, or by explicitly including options which are mixed (e.g., mixed text and photos). The recommendation is that pictures be removed from the options, and instead include photos, graphics, video, and sensor displays (e.g. radar, sonar; this has been done in the final version of the questionnaire presented in Annex A). Also, the issue of mixed formats should be addressed by allowing participants to select more than one option. As well, the analyst must consider which formats are most relevant for the specific context, and make sure that those are offered as response options.

With respect to the efficiency questions, pilot-study participant feedback indicated that it was unclear whether effort (the level of effort required) referred to process or workload. S/He indicated that the effort required in terms of workload was acceptable, but that the administration processes were extremely (and needlessly) time consuming. Therefore, this question should either be separated into multiple questions, or clarification should be provided in terms of whether effort refers to process or workload. Because these are intended to be very general questions, it seems most reasonable to indicate to participants that all aspects of sending, receiving, and interpreting information should be considered. It should also be noted that there are open-ended questions included which allow the participant to comment on what tasks or process takes too much time, effort, etc., which should allow the analyst to acquire information about what specific aspect of information sharing is inefficient.

Finally, one participant disagreed quite strongly with the notion that the CF is actually a team. This is more of a theoretical point than a methodological one, but it should be considered. If the participants do not agree that they are working as a team, then many of the questions may not apply based on their experience.

7. Final Version of Questionnaire

This section provides a description of the final version of the questionnaire. Annex A contains an Excel spreadsheet with the final version of the questionnaire (i.e. the entire inventory of questions) and it is recommended that readers refer to the questionnaire while reading this section of the report.

There are many sections in the questionnaire that require input by the analyst in order to customize the questionnaire for the specific context in which it is to be administered. These sections are noted in red font in the final version of the questionnaire.

The final version of the questionnaire includes multiple worksheets. These worksheets are titled as follows, and contain the indicated categories from the Mind Map (see section 7.1):

- All: contains all questions (Note: this is the only worksheet included in the hard copy of this report);
- Perf, Effect: contains the performance and efficiency questions;
- Overall Products (Task perf): contains the questions evaluating information-sharing products;
- Overall Process: contains the questions evaluating overall information-sharing processes;
- Overall Condition: contains the questions evaluating information-sharing conditions;
- Global Effect: contains the questions evaluating global effectiveness;
- Impact – Cond: contains the questions evaluating the impact of conditions on information sharing and vice versa, and;
- Impact – Task: contains the questions evaluating the impact of task performance on information sharing and vice versa.

Specific instructions for respondents are included with each section in the Excel spreadsheet, while overall instructions are provided in the questionnaire documentation (see Annex B).

In each section of the questionnaire, the importance ratings provided by the scientific SMEs are included on the left side of the page (note that importance ratings are not available for some variables as they were added after the scientific SME review). The columns relating to the importance ratings are as follows:

- The topic rated by the SMEs for importance;
- The mean importance rating (ratings range from 0 to 3, with 3 being the most important);
- The mode importance rating;
- The number of data points available;
- The overall rank for each subcategory within the category (e.g., conditions and processes were evaluated separately);
- The group. Topics were divided roughly into thirds, Group 3 contains the highest rated topics, and group 1 contains the lowest rated topics. For more information about groups,

see the next section on SME rankings. The ratings can be used as suggestions for the most important questions to include if some questions have to be eliminated, and;

- The next columns contain the question, and below each question is the response scale (or other response format used).

7.1 Mind Map

A mind map was created to show the questionnaire categories, subcategories, and factors within each category. Figure 1 shows the main categories and the way in which these categories were divided into direct and indirect measures of information sharing. Direct measures of information sharing include performance, effectiveness and efficiency. Indirect measures of information sharing include the evaluation of factors relevant to JIMP information sharing including information-sharing products, conditions and information-sharing processes. Figure 1 shows only the question categories and not the individual factors within each category, and Figures 2 through 9 show the layout of the Mind Map by category.

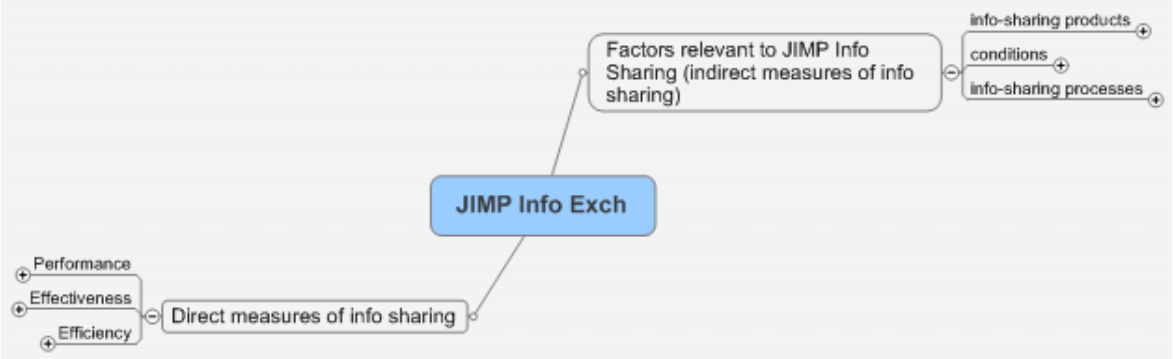

Figure 1: Mind Map showing main questionnaire categories

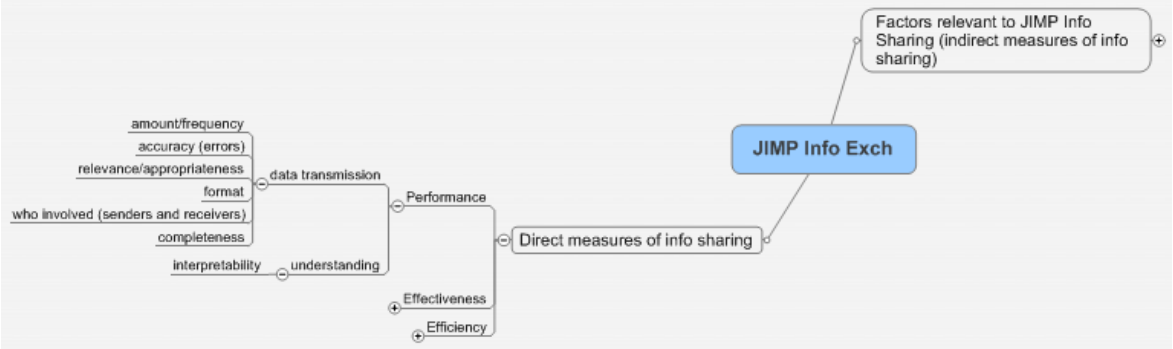

Figure 2: Mind Map showing subcategories and factors within performance

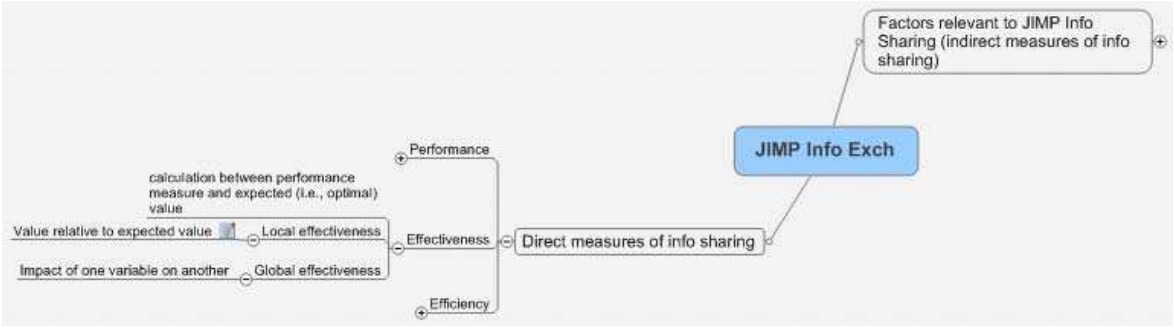

Figure 3: Mind Map showing subcategories and factors within effectiveness

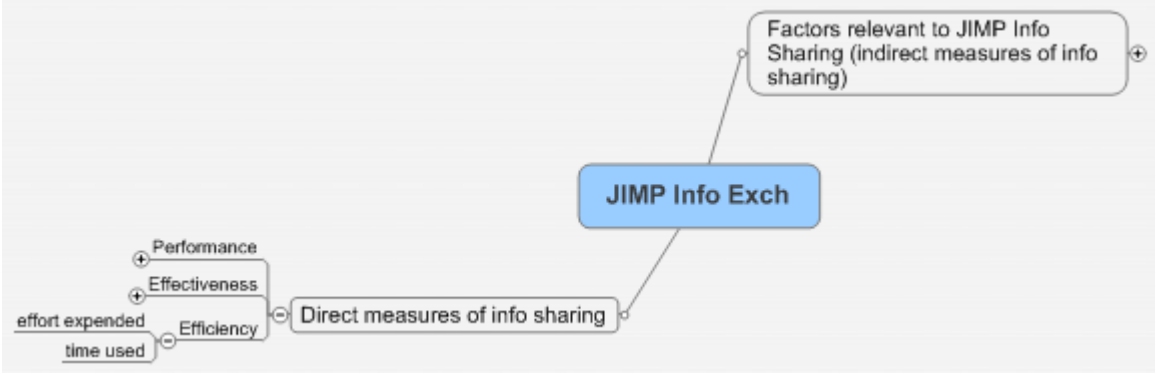

Figure 4: Mind Map showing factors within efficiency

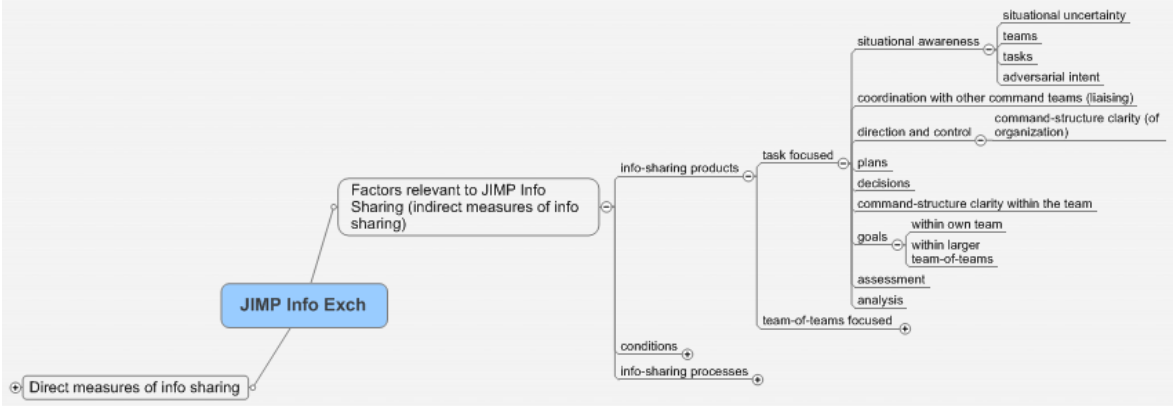

Figure 5: Mind Map showing subcategories and factors within information-sharing products (task-focused)

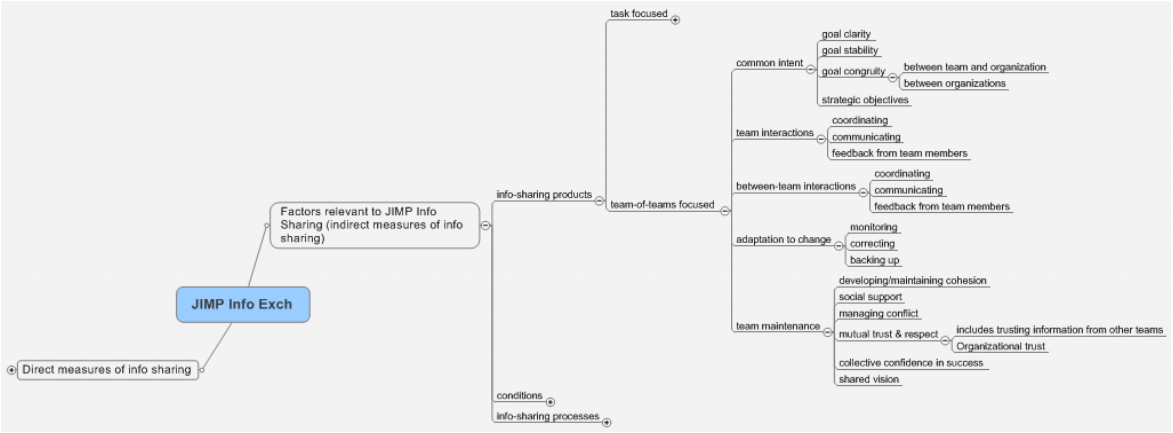

Figure 6: Mind Map showing subcategories and factors within information sharing products (Team-of-Teams-Focused)

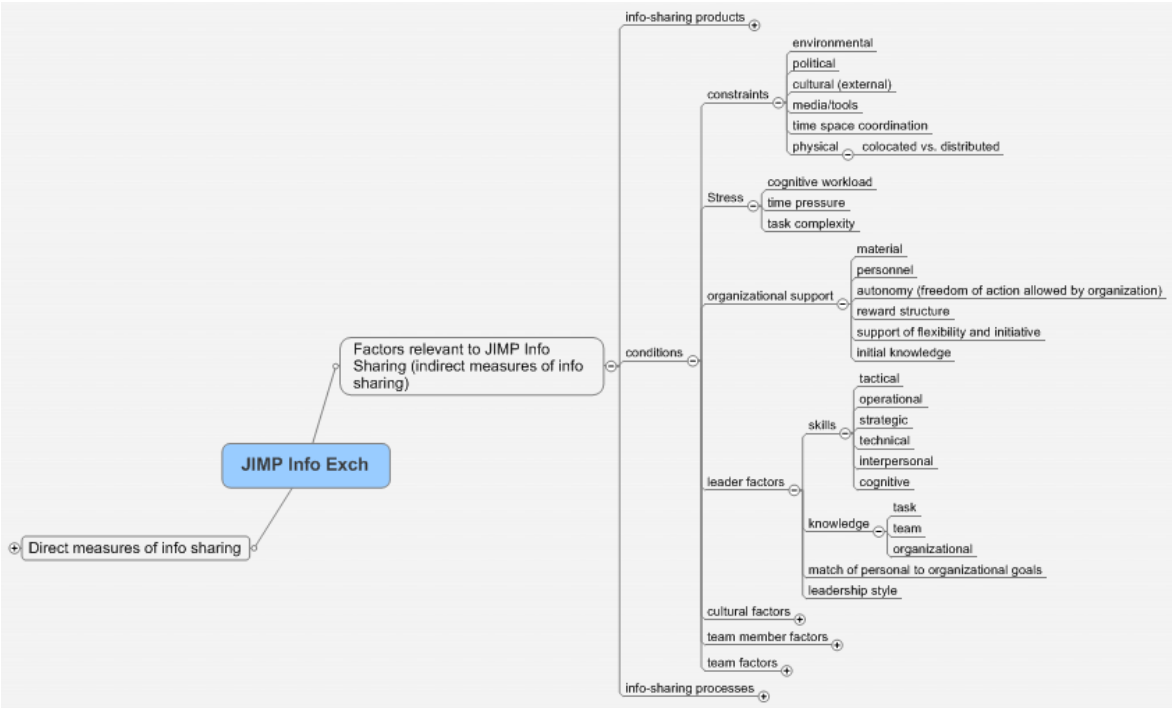

Figure 7: Mind Map showing subcategories and factors within conditions (Constraints, Stress, Organizational Support, and Leader Factors Only)

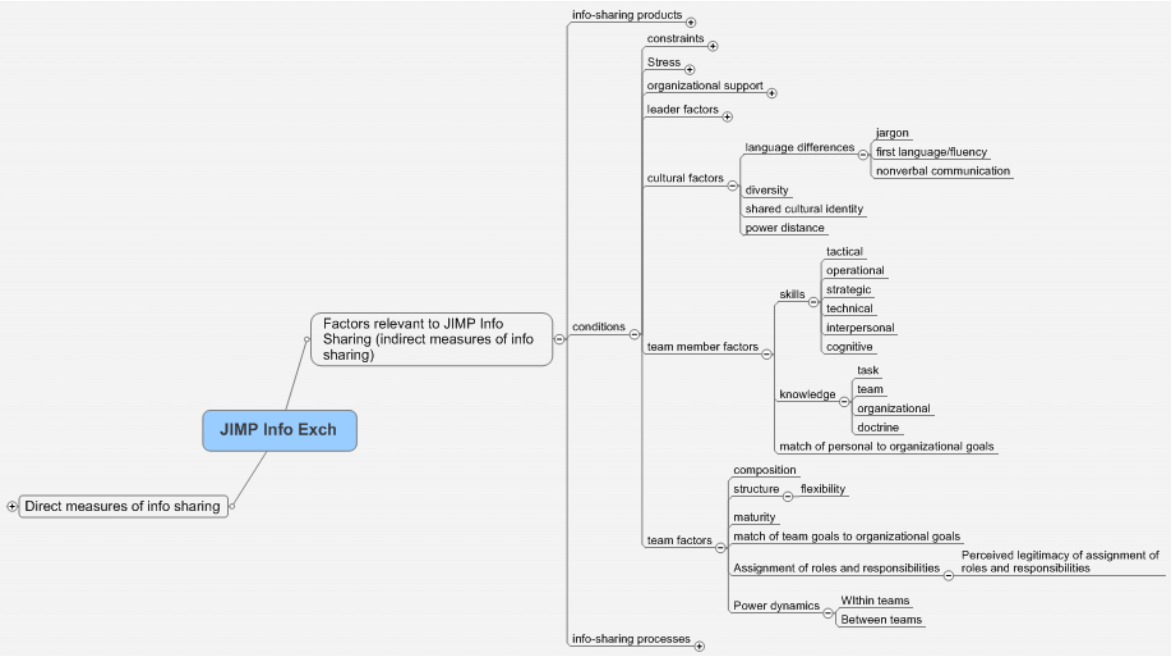

Figure 8: Mind Map showing subcategories and factors within conditions (Cultural Factors, Team-Member Factors, and Team Factors Only)

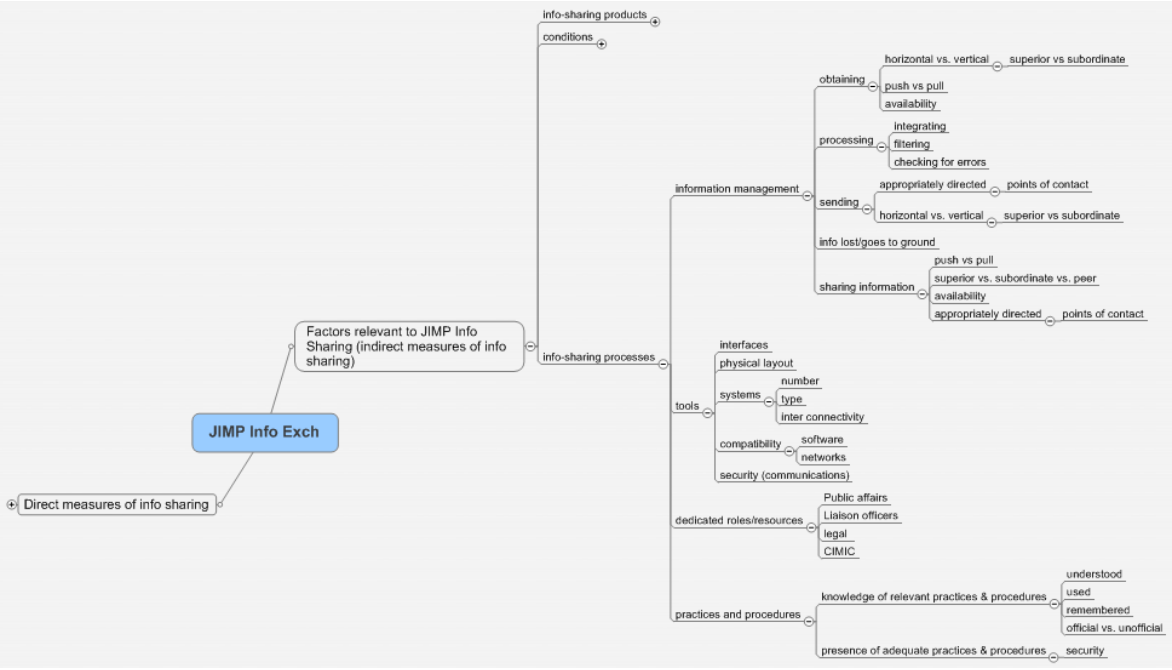

Figure 9: Mind Map showing subcategories and factors within information-sharing processes

7.2 Questionnaire documentation

Included in Annex B is documentation for the electronic questionnaire that should be provided to analysts. The documentation includes an introduction to the project, objectives of the questionnaire, a summary of the question categories, sample instructions for participants, instructions for adapting the questionnaire (e.g., how the questionnaire is modular and how the importance ratings can be used to select questions), and instructions for analysis of respondent data.

7.3 Questionnaire administration

One of the most persistent pieces of feedback we received from both scientific SMEs and pilot-study participants was that the questionnaire is currently too long. However, this questionnaire is intended to act as a repository for a wide variety of questions about information sharing related to JIMP operations and is not intended to be administered as a whole. Thus, in this section several ways in which the questions could be segmented and used to address different information-sharing research questions are presented, as well as other general suggestions about questionnaire administration.

There are several time frames in which the questionnaire could be administered. Within the time constraints imposed by the context of questionnaire administration, it was recommended that the questionnaire be administered at several different times. This is particularly important in the case of evaluating new equipment, procedures, etc., as a proper baseline should be obtained. It was also suggested that the questionnaire may best be administered with different sets of questions administered in different sessions, to help avoid participant reluctance and fatigue. But ultimately, the choice of questions to be administered and the frequency will depend on the hypothesis being tested.

7.3.1 Modularity of the questionnaire

In general, we expect that analysts interested in information sharing would wish to include, at the very least, questions directly related to information-sharing performance, effectiveness, and efficiency: that is, information transmission performance, effectiveness, and efficiency and understanding performance, effectiveness, and efficiency according to the definition of information sharing adopted in this study. Additional questions can then be used to further examine the impact of information sharing and other team-related factors and visa-versa. One approach to further examine this relationship is to obtain overall assessments of all of the categories (the overall assessments of conditions, information-sharing processes, and task performance) and then use those values to determine correlations between these and information sharing. For example, it could be determined whether political constraints (from the overall condition assessments) are correlated with the effectiveness of information sharing within a specific team. If the analysts wish to follow this approach, they would include the overall task-performance assessment, the overall conditions assessment, and the overall process assessment questions when administering the questionnaire.

If the interest of the analyst were to assess the perceptions of participants about the direction of the relationships between variables, for example, whether participants perceived that environmental constraints negatively impacted their information sharing, they would administer the impact questions. Depending on the specific research question, the analyst would administer the sets of questions on the impact of conditions on information sharing, the impact of information sharing on the conditions, the impact of task performance on information sharing, and/or the impact of information sharing on task performance.

A shorter version of the questionnaire can also be formed by eliminating certain questions within different sections of the questionnaire. Note that the survey was intentionally designed to assess information sharing in general but also to evaluate relationships between information sharing and specific factors (e.g. the impact of information sharing on workload). Therefore one strategy to shorten the questionnaire may be to focus on only one or two specific question categories and evaluate the relationship between information sharing and those factors. For example, a researcher might be very interested in global effectiveness of information sharing, but not interested in the impact of conditions on information sharing. Referring to Figure 1, this researcher would trim the "conditions" branch, but retain the "effectiveness" branch.

Another strategy to create an abbreviated version of the questionnaire would be to consider the importance ratings generated by SMEs during the scientific SME review of the questionnaire (discussed in Section 3.2.2.3). SMEs provided their assessments of the relative importance (in terms of information sharing in a JIMP environment) of the factors/questions included in each section of the questionnaire. The mean importance rating for each question/factor is provided in the Excel spreadsheet containing the final version of the questionnaire (Annex A), as well as in Annex D. The ratings may be considered by analysts to short-list questions in each section of the questionnaire as follows:

- Questions within each category were ranked according to importance based on mean importance rating, where the item ranked 1 was the least important, and importance increases with rank (the rank of the most important factor will equal the number of factors in the category). Individual analysts can use these rankings as a guide to determine which specific questions to include (e.g., use the five highest-ranked items). Note that these mean ratings are compiled from a relatively small number of data points, so they should only be used as suggestions.
- Questions within each category are grouped into thirds based on mean importance rating by the scientific SMEs. This information is contained in the "Group" column in the Excel spreadsheet (Annex A). The quickest way for an analyst to select the most important questions in each section (according to scientific SMEs) is to select all of the items which are in the top third in terms of importance rating (indicated as "Group 3"). Similarly, if the analyst wishes to eliminate the least important questions, then they can drop the items which fall into the least important category (i.e. bottom third in importance rating), and keep the items which fall into the most important (top third or "Group 3") and moderately important (middle third or "Group 2") categories. Group 1 contains the questions with the lowest importance ratings.
- Mean and mode importance ratings are provided for each question, and these can be used to compare the relative importance of question subcategories which do not fall into the same main question category. This might be required if an analyst wished to create a questionnaire version which included only the most important variables related to information sharing, without including a set number of items from each question category. For example, if an analyst could only ask questions about the 10 most critical factors, then according to the scientific SME rankings, this would include five products (situational awareness, goals, direction and control, decisions, and common intent), three processes (security of communications [subcategory of tools], interconnectivity [subcategory of tools], and information management), two outcomes (trusting information from other teams [subcategory of mutual trust and respect] and mutual trust and respect), and no conditions.

Thus, the modularity of the questionnaire as well as supplemental information about the relative importance of information-sharing factors facilitates tailoring the questionnaire to individual situations or projects with different research objectives. See the next section of this report for discussions of how the questions could be analysed for more ideas about which questions might be included in a version of the questionnaire to answer particular questions.

7.4 Analysis of questionnaire data

A number of different analyses[1] of the questionnaire data are possible depending on the research objectives. The current questionnaire is designed using multiple categories and subcategories of questions to address information-sharing issues. The categories and subcategories, along with possible assessments or evaluations that can be made for each category and subcategory, are shown in Table 8. Using correlations is particularly relevant for determining potential relationships between the information-sharing conditions and information-sharing performance as well as information-sharing products and the effectiveness of information sharing (i.e., global effectiveness). Of course, correlations can be performed between any sets of factors measured in the questionnaire. Other possible correlations of likely interest include correlations between information-sharing efficiency and information-sharing conditions as well as information-sharing efficiency and information-sharing products.

Table 8: Question categories, subcategories and possible assessment

Categories	Subcategories	Sub-subcategories	Possible assessment/evaluation
Performance	Data transmission		Estimates of actual performance (mean ratings), Open-ended data about information-sharing partners, Rating of the usefulness and understandability of information
Global effectiveness			Evaluation of whether information sharing was adequate for task performance (mean ratings
Efficiency			Evaluation of acceptability of effort required for information sharing (mean ratings, open-ended data)
Products	Task-focused	Situation awareness, command-structure clarity, goals	Overall assessment of adequacy of product Assessment of whether information sharing

[1] It should be noted that none of the questions contained in the questionnaire require reverse coding before analysis. That is, questions are not asked in opposite ways so that the responses have to be reversed.

Categories	Subcategories	Sub-subcategories	Possible assessment/evaluation
	Team focused	Common intent, team interactions, between-team interactions, adaptation to change, team maintenance	adequately supported product Impact of product on information sharing Impact of information sharing on product (mean ratings)
Conditions	Constraints		Overall assessment of whether condition affected the mission Impact of condition on information sharing Impact of information sharing on condition (mean ratings)
	Stress		
	Organizational support		
	Leader factors	Leader skills, leader knowledge	
	Cultural factors	Language differences	
	Team member factors	Team skills, team knowledge	
	Team factors		
Processes	Information management	Sharing information, processing information	Evaluation of adequacy of process
	Tools	Systems, dedicated roles/resources	
	Practices and procedures	Knowledge of relevant practices and procedures	

The general approach we recommend is to first average each participant's responses within each category and subcategory to which the questions belong. These scores can then be used to calculate the strength of the relationship(s) between the variables of interest across participants (i.e., perform correlations). Individual question means may be examined to determine which factors appear to be the strongest contributor to the relationship between the variables of interest, but the relationship between individual items should interpreted with caution and only taken as a guide. In many cases, mean scores are meaningful in and of themselves.

Overall, the JIMP information-sharing questionnaire allows an assessment of the following:

1) Information-sharing performance (i.e., whether the data were actually transmitted and understood);
2) Global effectiveness of information sharing (i.e., whether information sharing adequately supported information-sharing products, such as situational awareness);
3) Information-sharing efficiency (i.e., whether the time and effort required for data transmission / understanding was acceptable), and;
4) Information-sharing conditions (i.e., whether factors such as environmental constraints played a role in information sharing).

Explanations of how data can be analysed to assess these issues are discussed below.

7.4.1 Evaluation of information-sharing performance

An evaluation of individual operators' information-sharing performance is an intrinsically-important assessment for an experimenter interested in the status of information sharing. This measure is also an important component of other analyses, as it provides the information-sharing-performance data with which other data (e.g., quantitative information-sharing performance measures) can be correlated.

To analyse the data in order to assess the information-sharing performance of operators, the relevant questions are the three performance-estimate questions from the performance section (see list below), and the processes questions. Responses to all of these questions use a 5-point scale, with 1 representing poor information-sharing performance and 5 indicating good information-sharing performance. The three performance-estimate questions from the performance scale are:

1. When you received pushed information, that information was useful;
2. When you received information, you could immediately understand it, and;
3. When you sent information, you had to change its form so that the receiver could interpret it.

Examples of the processes questions are:

1. Overall, I obtained all of the information that I required to perform my duties;
2. Overall, I was alerted to critical information (no need to request it);
3. Overall, non-critical information was there when I requested it, and;
4. Overall, all of the information that I required to perform my duties was available.

An overall information-sharing performance score can be calculated by taking the mean score across all of the questions for each respondent. These scores can be interpreted by referring to the scale on which they are answered; the maximum value is 5, so values close to 5 indicate good performance. The minimum value is 1, so values close to 1 indicate poor performance.

7.4.2 Evaluation of global effectiveness

An evaluation of global effectiveness is likely to be a goal of an experimenter investigating information sharing in JIMP teams. To assess the global effectiveness of information sharing, we need to determine whether information sharing has adequately supported the information-sharing products for which it is being used. This is assessed using questions in the information-sharing product section of the questionnaire. Sample questions include:

1. On average, the information shared was adequate to support my knowledge of the situation
2. On average, the information shared was adequate to support my knowledge of my team
3. On average, the information shared was adequate to support my knowledge of our command structure

An overall global-effectiveness score (i.e., the degree to which information sharing supported the necessary tasks (or information-sharing products) that the respondent had to perform; also called global effectiveness) should be calculated by taking the mean for each respondent across all of the information-sharing product questions. The mean category (and, if applicable, subcategory) scores can be calculated for each participant.

Higher scores on these questions indicate more effective information sharing with respect to the products. That is, information sharing more adequately supports the tasks performed. Mean scores should range between 1 and 5.

7.4.3 Evaluation of information-sharing efficiency

Within the JIMP information-sharing questionnaire there is a section of questions related to information-sharing efficiency. To evaluate information-sharing efficiency, a mean for the six closed-ended efficiency questions (see example questions provided below) can be calculated for each respondent, and an overall mean calculated. Note that median scores could also be used. The response scale for these questions ranges from 1 to 5, so the higher the mean (or median) score, the higher the information-sharing efficiency rating (that is, the more efficient the respondent thought information sharing was).

Examples of the efficiency questions:

1. The amount of effort required to send information is acceptable, and;
2. The amount of time required to send information is acceptable.

7.4.4 Evaluation of impact of information sharing on task factors (i.e., products and conditions) and vice versa

Using data collected from the JIMP information-sharing questionnaire, the relationship between information sharing and products and conditions can be assessed in two ways. First, overall evaluations of products and conditions are included, and these evaluations can be correlated with evaluations of information-sharing processes, performance, effectiveness, and efficiency to understand the relationship between products and conditions and information sharing.

Overall scores could be calculated by taking the mean (or median) for each respondent across the overall condition-assessment questions, the overall product-assessment questions, the information-sharing process questions, and the performance questions.

Examples of overall condition-assessment questions include:

1. Overall, there were environmental constraints that strongly affected the exercise, and;
2. Overall, there were cultural differences with the host nation that strongly affected the exercise.

Examples of overall product-assessment questions include:

1. My knowledge of the situation was adequate, and;
2. Our team's coordination with other teams was adequate.

Examples of information-sharing process-assessment questions include:

1. Overall, I obtained all of the information that I required to perform my duties, and;
2. Overall, I was alerted to critical information (no need to request it).

The mean scale scores can be calculated for each participant. After mean scores have been calculated for each participant, correlations can be performed using the data across participants.

The mean scores can be interpreted by referring to the scale on which they are answered; the maximum value is 5, so values close to 5 indicate that the level of the condition was high (e.g., there were a lot of constraints that affected the mission), or that the level of the product was high (e.g., the level of situational awareness was high). The minimum value is 1, so values close to 1 indicate either that the level of the condition was low (e.g., there were few constraints that affected the mission), or that the level of the product was low (e.g., the level of situational awareness was low).

The second way to investigate the impact of information sharing on task factors (i.e., products and conditions) involves using impact questions. In the impact questions, respondents are asked to rate the impact of information sharing on specific task factors, and vice versa (as appropriate depending on the factor). For example, participants had to rate whether situational awareness had an impact on information sharing, and whether information sharing had an impact on situational awareness.

These questions are answered on a 5-point scale, ranging from -2 (very-negative impact) to +2 (very-positive impact), with 0 representing no influence. This scale is used because it assesses both the direction and strength of the relationship between the variables. It is necessary to ask these questions from both directions, as we hope to gain knowledge (even though it may be intuitive) about the direction of the relationship between information sharing and other factors. Although any conclusions about the direction of relationships would benefit from validation in future research.

The following separate scale scores can be calculated for each participant:

- Condition impact on information-sharing scores (e.g., rate the impact of time pressure on information sharing);
- Information-sharing impact on condition scores (e.g., rate the impact of information sharing on time pressure);
- Product impact on information-sharing scores (e.g., rate the impact of situational awareness on information sharing), and;
- Information-sharing impact on product scores (e.g., rate the impact of information sharing on situational awareness).

Scores can be interpreted in the following manner: scores close to zero indicate no relationship between the factors; a score close to -2 indicates a strong negative impact; and scores close to +2 indicate a strong positive impact. In interpreting these scores, one must consider which variable is the cause and which is considered the effect for that set of ratings. That is, these questions are asking about a cause-and-effect relationship, and which variable is the cause will influence how these questions are to be interpreted. Although it might seem as though these relationships should be equal (that is, if X has a strong, positive influence on Y, then Y should have a strong, positive influence on X), this is not always the case. For example, we expect that some conditions will have an impact on information sharing without the reverse being true (e.g., weather may affect information sharing but information sharing will not likely affect the weather).

The format of the impact questions is a matrix style. That is, there is one overall question asked for a list of specific factors (i.e., conditions or products). For example, “What is the impact of the factor on information sharing?” The response grid contains the list of factors on the left-hand side, and response options on the right. See the impact questions (e.g., question set #13) in Annex A for an example).

Sample conditions include:

1. Environmental constraints, and;
2. Political constraints.

Sample products include:

1. Your knowledge of the situation, and;
2. Your knowledge of other teams.

7.4.5 Open-ended questions

Based on suggestions by the scientific SMEs, several open-ended questions have been included in the JIMP information-sharing questionnaire. These questions allow further clarification of responses for a number of questions. These will have to be included on a case-by-case basis, depending on the goals of individual analysts. Individual analysts will have to determine how they wish to use open-ended responses, whether they wish to code these responses, and what types of analyses they wish to perform.

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8. Conclusions and Recommendations

The purpose of this contract was to create a questionnaire that can be used to evaluate information sharing (in particular information sharing performance, effectiveness, and efficiency) during JIMP operations. The questions are derived from the definition of information sharing as information transmission or exchange and increased understanding. Questions were developed that would measure information sharing both directly and indirectly. This questionnaire may be used to:

- assess the current levels of performance, effectiveness, and efficiency of information sharing;
- determine barriers to information sharing and possible means of surmounting them; and,
- assess the impact of new equipment, procedures, team composition, and other changes which may be made or proposed on information sharing within the CF.

This report summarizes the findings from previous components of the contract including: 1) the generation of question categories based on a review of team and CF literature, 2) the development and scientific review of a first iteration of the JIMP information sharing questionnaire, 3) the electronic implementation and pilot study of a revised version of the questionnaire, and 4) final revision and development of documentation to support use of the questionnaire.

In summary, the literature review, along with the CTEF model of team effectiveness (Essens et al., 2005), facilitated the identification of categories of issues to be examined in this questionnaire. These categories include the conditions surrounding the mission (including the technology used, organizational structure, team characteristics, etc.), information-sharing processes (including information quality, knowledge management, and knowledge of relevant practices and procedures), and information-sharing products relating to supported functions (e.g., is information sharing adequate to support situation awareness, planning, common intent, etc.). These categories guided the development of specific questions to be included in the questionnaire.

An initial version of the questionnaire was developed based on the literature review. Representative items from the selected question categories and subcategories were selected for SME review. Scientific SMEs provided important feedback about the question categories and factors included in the questionnaire as well as the wording of the questions. The SMEs had valuable suggestions about how the questionnaire could be improved but overall, feedback on the questionnaire was positive. This feedback received was used to revise the questionnaire which was then used as the basis for a pilot study.

Overall, the electronic implementation (in SurveyPro) and pilot test of the questionnaire was successful. In general, participants had favourable comments about the appearance and ease of navigation of the questionnaire. Thus, SurveyPro software appears to be an adequate software program for administering an online version of the questionnaire. Pilot study participants provided valuable feedback about several aspects of the questionnaire. The most prevalent feedback was concern over the validity of the information-sharing performance questions, specifically the "amount of information" and "how often" questions. Participants indicated that it would be quite difficult to provide meaningful answers for such questions. These performance questions were not included in the final version of the questionnaire. However, it is recommended that this type of information-sharing performance data (e.g. data transmission) is collected through other means (e.g., monitoring tools, human observers, and instructor criteria) and used as a necessary

complement to the data gathered by the JIMP information sharing questionnaire. In addition, in cases where the expected or optimal level of performance is known (e.g., during experiments), local effectiveness could be calculated using observed actual performance and these known expected values. Ongoing projects such as one investigating Social Network Analysis as a method of understanding and measuring information sharing could provide a means of assessing performance, and this questionnaire and that project could complement each other well.

Participant feedback from the pilot study also reinforced the need for analysts to provide context-specific information for participants, including definitions for “team”, “leader”, “superior”, etc. It has been clearly indicated where in the questionnaire this type of information is needed, and specific instructions for analysts have been provided. Additional feedback regarding the usability of the questionnaire was considered and changes were made to the questionnaire as appropriate.

Future research efforts with respect to the JIMP information sharing questionnaire should address a number of issues. First, further refinement and validation of the questionnaire (e.g. construct, content and external validity) should be pursued. Future iterations of the questionnaire could be used to address a number of issues including the extent to which respondents can accurately separate within- versus between-team factors and whether this is an important issue in the JIMP context. Second, future research should investigate the relative importance of the question categories. This could help analysts to choose a subset of the most important questions to evaluate information sharing in JIMP operations.

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10. Acronyms

CF	Canadian Forces
CTEF	Command Team Effectiveness
DRDC	Defence Research and Development Canada
JCDS 21 TD	Joint Command Decision Support for the 21st Century Technology Demonstration
JIMP	Joint, Interagency, Multinational, and Public
OGAs	Other Government Agencies
OGDs	Other Government Departments
SME	Subject-Matter Expert
SOW	Statement of Work
UN	United Nations

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Annex A:
Final Questionnaire

Annex B:
Questionnaire Documentation for Users

Annex C:
Materials Presented to Scientific SMEs

Annex D:
Scientific SME Feedback

Annex E:
Version of Questionnaire Used in Pilot Study

Annex F:
Final Mind Map

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(U) The intent of this project is to develop a paper–based and electronic questionnaire to assess information sharing within a team–of–teams operating in a Joint, Interagency, Multinational, and Public (JIMP) environment. This report includes information about the various stages of this project, including:

• A brief summary of the review of the literature relevant to information sharing and performance in a team–of–teams (presented in Taylor & Bruyn Martin, 2007a)

• A description of the development of a draft questionnaire and subsequent review by scientific SMEs

• A description of the electronic implementation and pilot test of a revised version of the questionnaire, and

• A description of the final version of the questionnaire based on all of the feedback received.

Also included in this report are:

• A description of the modularity of the questionnaire

• Documentation for analysts who wish to use the questionnaire

• Suggestions for ways to analyse the questionnaire data, and

• Recommendations for future iterations of, or use of, the questionnaire, including descriptions of how the questionnaire could be implemented in JIMP exercises, experiments, or operations, including several different ways to select items from the question pool depending on the goals of particular projects for which it will be used.

The main benefits of this questionnaire are that it is intended for and developed within a military context and for evaluating information sharing within a team–of–teams. Thus, this questionnaire is an instrument designed specifically to aid the investigation into information sharing in the JIMP environment.

(U) L'objectif de ce projet consiste à élaborer un questionnaire électronique et imprimé pour évaluer le partage d'information au sein d'un groupe d'équipes qui travaillent dans un cadre interarmées, interorganisationnel, multinational et public (IIMP). Ce rapport contient de l'information sur les diverses étapes de ce projet, notamment :

– un résumé concis de l'examen des documents associés au partage de l'information et au rendement au sein d'un groupe d'équipes (présenté dans Taylor & Bruyn Martin, 2007a)

– une description du processus d'élaboration d'une ébauche de questionnaire et l'examen subséquent réalisé par les experts scientifiques

– une description de la mise en œuvre électronique et de l'essai d'une version révisée du questionnaire

– une description de la version finale du questionnaire établie d'après l'ensemble des commentaires reçus.

Ce rapport comprend également :

– une description de la modularité du questionnaire

– la documentation pour les analystes qui souhaitent utiliser le questionnaire

– des suggestions de méthodes d'analyse des données du questionnaire

– des recommandations relatives aux futures itérations ou à l'utilisation du questionnaire, incluant des descriptions des différents moyens pour intégrer le questionnaire aux exercices, expériences ou opérations IIMP ainsi que diverses méthodes de sélection d'éléments du questionnaire selon les buts des différents projets dans le cadre desquels il sera utilisé.

Le fait que ce questionnaire soit adapté au domaine militaire, qu'il a été élaboré au sein de ce domaine et qu'il permet d'évaluer le partage de l'information au sein d'un groupe d'équipes constitue son principal avantage. Par conséquent, ce questionnaire s'avère un instrument spécialement conçu pour faciliter l'évaluation du partage de l'information au sein de l'environnement IIMP.

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