NORTH ATLANTIC TREATY ORGANIZATION

SCIENCE AND TECHNOLOGY ORGANIZATION

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STO TECHNICAL REPORT **TR-HFM-276**

Human Factors and ISR Concept Development and Evaluation

(Facteurs humains et élaboration et évaluation des concepts d'ISR)

This document is the final report of NATO RTG HFM-276.

Published February 2022

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The NATO Science and Technology Organization

Science & Technology (S&T) in the NATO context is defined as the selective and rigorous generation and application of state-of-the-art, validated knowledge for defence and security purposes. S&T activities embrace scientific research, technology development, transition, application and field-testing, experimentation and a range of related scientific activities that include systems engineering, operational research and analysis, synthesis, integration and validation of knowledge derived through the scientific method.

In NATO, S&T is addressed using different business models, namely a collaborative business model where NATO provides a forum where NATO Nations and partner Nations elect to use their national resources to define, conduct and promote cooperative research and information exchange, and secondly an in-house delivery business model where S&T activities are conducted in a NATO dedicated executive body, having its own personnel, capabilities and infrastructure.

The mission of the NATO Science & Technology Organization (STO) is to help position the Nations' and NATO's S&T investments as a strategic enabler of the knowledge and technology advantage for the defence and security posture of NATO Nations and partner Nations, by conducting and promoting S&T activities that augment and leverage the capabilities and programmes of the Alliance, of the NATO Nations and the partner Nations, in support of NATO's objectives, and contributing to NATO's ability to enable and influence security and defence related capability development and threat mitigation in NATO Nations and partner Nations, in accordance with NATO policies.

The total spectrum of this collaborative effort is addressed by six Technical Panels who manage a wide range of scientific research activities, a Group specialising in modelling and simulation, plus a Committee dedicated to supporting the information management needs of the organization.

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS System Analysis and Studies Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These Panels and Group are the power-house of the collaborative model and are made up of national representatives as well as recognised world-class scientists, engineers and information specialists. In addition to providing critical technical oversight, they also provide a communication link to military users and other NATO bodies.

The scientific and technological work is carried out by Technical Teams, created under one or more of these eight bodies, for specific research activities which have a defined duration. These research activities can take a variety of forms, including Task Groups, Workshops, Symposia, Specialists' Meetings, Lecture Series and Technical Courses.

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List of Acronyms

ACC	Air Component Command
AGS	Allied Ground Station
AI	Artificial Intelligence
AINTP-14	Joint Intelligence, Surveillance, and Reconnaissance Procedures in Support of NATO Operations
AoI	Area of Interest
AJP-2	Allied Joint Doctrine for Intelligence, Counterintelligence and Security
AJP-2-7	Allied Joint Doctrine for Intelligence, surveillance, and Reconnaissance
BCT18	Baltic CESMO 2018
BLUFOR	Blue Force
BQ19	Bold Quest 2019
C2	Command and Control
CD&E	Concept Development and Evaluation
CESMO	Cooperative Electronic Support and Measures Operations
CMRF	Centre for Maritime Research and Experimentation
CPED	Collection Processing, Exploitation, and Dissemination
CSD	Coalition Shared Data
CSO	Combat Systems Officer
CWIX	Coalition Warrior Interoperability Exercise
DOTMLPFL	Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Interoperability
DQ	Data Quality
DQM	Data Quality Management/Manager
DR	Data Relevance
DSA	Data Source Analysis
ED	Effectively and Manage Data
EMN	Enter and Manage Data Network
EO	Electro Optics
ET	Exploratory Team
EW	Electronic Warfare
EWCC	Electronic Warfare Coordination Cell
FFI	Norwegian Defence Research Establishment
FMV	Full Motion Video
IR	Intelligence Requirement
IRM&CM	Information Requirements Management and Communications Management
ISR	Intelligence Surveillance Reconnaissance
HF	Human Factors
HFM	Human Factors and Medicine
HQ	Headquarters
IM	Information Management
IOC	Initial Operational Capability

IPL	Integrated Priority List
IQ	Information Quality
JBM	Joint Battle Space Management
JCMS	Joint Collection Management Board
JISR	Joint Intelligence Surveillance Reconnaissance
JT	Joint Targeting
JTF	Joint Task Force
MCC	Maritime Component Command
MOS	Mean Opinion Score
NAGSF	NATO AGS Force
NAIs	Named Area of Interests
NATO	North Atlantic Treaty Organization
NFC	Need for Cognition
Nor Quest 18	Norwegian Quest 2018
OIS	Obstacles to Information Sharing
OLAP	On-Line Analytical Processing
ORBAT	Order of Battle
Org	Organization
PD	Power Distance
PSP	Product and Service Performance
PSSUQ	Post Study System Usability Questionnaire
QDS	Quality of Data at Source
QoE	Quality of Data and User Experience
QoS	Quality of Service
RFI	Request For Information
RTG	Research and Technology Group
RTO	Research and Technology Organization
SA	Situational Awareness
SME	Subject Matter Expert
SMO	Support to Military Operations
SNR	Senior National Representative
STANAGS	Standardization Agreements
SUMI	Software Usability Measurement Inventory
SW	Software
TAIs	Target Areas of Interest
TCPED	Tasking, Collection, Processing, Exploitation, and Dissemination
TRICOP	Trial Control
TTPs	Tactics, Techniques, and Processes
UA	Uncertainty Avoidance
USAFE	United States Air Force in Europe
UV16	Unified Vision 2016
UV18	Unified Vision 2018

WoG	Whole of Government
WL	Workload
WPC	Warrior Preparation Centre
XML	Extensible Markup Language

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Human Factors and ISR Concept Development and Evaluation

(STO-TR-HFM-276)

Executive Summary

The Issue

Intelligence, Surveillance, and Reconnaissance (ISR) operations are about collecting and providing information to human operators who in turn are required to make specific decisions regarding various courses of action in their theatre of operations. To be sure, ISR operations are technology intensive. However, at the same time, ISR operations are a very human-centric process. Despite this reality, little to no Human Factors (HF) research is included in the ISR Concept Development and Evaluations (CD&E) process. By studying the impact of new ISR technologies and concepts on operator performance across of variety of operational contexts, researchers can provide more scientifically rigorous advice to inform high-level policy and decision-makers on future ISR technologies and capabilities across all ISR environments: air, maritime surface, sub-surface, and space throughout domestic, allied, and Whole-of-Government (WoG) partnerships. To the extent that this is true, a HF research methodology should be an integral part of any ISR CD&E process to inform and advise policy and decision-makers at all levels of the ISR chain of command.

The Purpose

The North Atlantic Treaty Organization (NATO) Research and Technology Organization (RTO) Human Factors and Medicine (HFM) Panel Task Group (RTG) 276 (NATO RTG HFM-276) titled 'Human Factors and ISR Concept Development and Evaluation' was established to identify and understand HF issues critical to effective ISR operations. More precisely, the goals of this seminal work were:

1) To identify critical HF issues for effective ISR operations (e.g., situational awareness, workload, organizational structure, coordination and coordination mechanisms, visualization, trust, information sharing and management, leadership, and decision-making);
2) Use a theoretical model of behavior to develop our research methodology and understand our findings; and
3) To make recommendations regarding the use and implementation of HF research in ISR CD&E operations.

The Scope and Limitations

Based on and extending a model of military organizational effectiveness initially developed by the NATO HFM-163 RTO Group, the scope of the NATO HFM RTG-276 panel is to identify and understand HF issues critical to ISR operations. To do this, the panel decided to conduct its research on Joint ISR (JISR) operational effectiveness within the NATO United Vision 2018 (UV18) trial simulation at the United States Air Force Europe (USAFE) Warrior Preparation Centre (WPC), Einsiedlerhof, Germany June 11th to 26th, 2018. Also, the panel conducted similar research at the Bold Quest 2019 (BQ19) exercise conducted in Finland, May 2019.

Results, Significance to NATO, and Practical Implications

The NATO HFM-276 Task Group used a model of organizational effectiveness to develop a set of surveys to identify and understand the HF issues critical to effective ISR operations. The core of the model is the JISR process consisting of the Tasking, Collecting, Processing, Exploitation, and Dissemination (TCPED). The data collection plan derived from this model as well as other sources looks at the role of a number of HF issues across ISR operations: basic HF knowledge, situation assessment, workload, organizational structure, trust, information sharing, information management, leadership, culture, organizational process, organizational flexibility, shared awareness and responsibilities, coordination and coordination mechanisms, decision-making, competence, Intelligence Request Management (IRM), communications, meta data, and application system. All of these HF factors will influence ISR operational concepts and impact operator performance. In addition, the report summarizes some practical implications to improve the ISR CD&E process for NATO and non-NATO operations by focusing on developing a HF research methodology that should be included in the ISR CD&E process. This HF methodology would work like a quality control component for the technical and procedural ISR concept development. Research findings are expected to help inform and advise policy and decision-makers at all levels of the ISR chain of command in order to enhance information and decision advantage in NATO ISR planning, mission execution and capability development. It is also expected to help inform the integration of ISR with other joint processes such as joint targeting with regard to identifying current gaps HF related to ISR and integration with other processes.

Facteurs humains et élaboration et évaluation des concepts d'ISR

(STO-TR-HFM-276)

Synthèse

Problème

Les opérations de renseignement, surveillance et reconnaissance (ISR) consistent à recueillir et fournir des informations à des opérateurs humains qui doivent prendre des décisions spécifiques au sujet de divers plans d'action sur le théâtre des opérations. Précisons que les opérations d'ISR font un usage intensif des technologies. Cependant, il s'agit en même temps d'un processus très centré sur l'humain. Malgré cet état de fait, le processus d'élaboration et d'évaluation des concepts (CD&E) d'ISR inclut très peu de recherches sur les facteurs humains (FH), voire aucune. En étudiant l'effet des nouveaux concepts et nouvelles technologies d'ISR sur les performances des opérateurs dans divers contextes opérationnels, les chercheurs peuvent donner des conseils plus rigoureux sur le plan scientifique pour informer les décideurs de haut niveau quant aux futures technologies et capacités d'ISR dans tous les environnements d'ISR : air, surface maritime, environnement sous-marin et domaine spatial, dans tous les partenariats nationaux, alliés et pangouvernementaux. Si tel est bien le cas, la méthodologie de recherche sur les FH devrait faire partie intégrante de tout processus de CD&E d'ISR, afin d'informer et conseiller les décideurs à tous les niveaux de la chaîne de commandement d'ISR.

Objet

Le groupe de travail RTG-276 de la Commission sur les facteurs humains et la médecine (HFM) de l'Organisation pour la recherche et la technologie (RTO) au sein de l'Organisation du Traité de l'Atlantique Nord (OTAN), intitulé « Facteurs humains et élaboration et évaluation du concept d'ISR », a été créé dans le but d'identifier et comprendre les questions de FH vitales pour l'efficacité des opérations d'ISR. Plus précisément, les objectifs de ce travail précurseur étaient les suivants :

1) Identifier les questions de FH vitales pour l'efficacité des opérations d'ISR (par exemple, la connaissance de la situation, la charge de travail, la structure organisationnelle, la coordination et les mécanismes de coordination, la visualisation, la confiance, le partage d'information et la gestion, les qualités de chef et la prise de décision) ;
2) Utiliser un modèle théorique de comportement pour élaborer notre méthodologie de recherche et comprendre nos découvertes ; et
3) Émettre des recommandations concernant l'utilisation et la mise en œuvre des recherches sur les FH dans les opérations de CD&E d'ISR.

Portée et limites

Sur la base et dans le prolongement d'un modèle d'efficacité organisationnelle initialement élaboré par le groupe de la RTO HFM-163 au sein de l'OTAN, le RTG-276 HFM de l'OTAN a pour mission d'identifier et de comprendre les questions de FH vitales pour les opérations d'ISR. Dans ce but, le RTG a décidé de mener ses travaux sur l'efficacité opérationnelle de l'ISR interarmées (JISR) au sein de la simulation de l'essai OTAN United Vision 2018 (UV18) au Centre de préparation de la force (WPC)

des Forces aériennes des États-Unis en Europe (USAFE), à Einsiedlerhof, en Allemagne, du 11 au 26 juin 2018. Le RTG a également mené des recherches similaires pendant l'exercice Bold Quest 2019 (BQ19) en Finlande, en mai 2019.

Résultats, importance pour l'OTAN et implications pratiques

Le groupe de travail HFM-276 a utilisé un modèle d'efficacité opérationnelle afin d'élaborer un ensemble d'études visant à identifier et comprendre les questions de FH vitales pour l'efficacité des opérations d'ISR. Au cœur du modèle se trouve le processus de JISR composé de l'attribution des tâches, du recueil, du traitement, de l'exploitation et de la diffusion (TCPED). Le plan de recueil de données découlant de ce modèle et d'autres sources examine le rôle d'un certain nombre de questions de FH dans toutes les opérations d'ISR : connaissances de base sur les FH, évaluation des situations, charge de travail, structure organisationnelle, confiance, partage des informations, gestion des informations, qualités de chef, culture, processus organisationnel, souplesse organisationnelle, sensibilisation et responsabilités partagées, coordination et mécanismes de coordination, prise de décisions, compétences, gestion des demandes de renseignement (IRM), communications, métadonnées et système d'applications. Tous ces FH influencent les concepts opérationnels d'ISR et les performances des opérateurs. De plus, l'article résume quelques implications pratiques afin d'améliorer le processus de CD&E d'ISR pour les opérations de l'OTAN et hors OTAN, en se focalisant sur l'élaboration d'une méthodologie de recherche FH à inclure dans le processus de CD&E d'ISR. Cette méthodologie FH fonctionnerait comme un élément de contrôle de la qualité pour la mise au point des concepts d'ISR techniques et procéduraux. Les résultats de recherche devraient contribuer à informer les décideurs à tous les niveaux de la chaîne de commandement d'ISR, de façon à renforcer l'avantage de l'OTAN en matière d'information et de décision pendant la planification, l'exécution de la mission et le développement des capacités d'ISR. Les travaux devraient également éclairer l'intégration de l'ISR dans d'autres processus communs, tels que la désignation commune d'objectifs, concernant l'identification des lacunes actuelles de FH liées à l'ISR et l'intégration dans d'autres processus.

Chapter 1 – INTRODUCTION

**Fred Lichacz, Sigmund Valaker, Anne Lise Bjørnstad,
Stéphane Buffat, Rune Stensrud, and Daniel Zelik**

1.1 BACKGROUND

Intelligence, Surveillance, and Reconnaissance (ISR) is a term that encompasses collection operations, collection planning, collection mission management and the processing, analysis and dissemination of operational information [1]. The goal of the ISR process is to provide actionable intelligence to decision makers and action-takers. The mechanics by which intelligence is obtained involves a complex combination of technologies, systems and processes [2], [3]. Technologically, ISR relies on the use of many diverse sensors and sensor platform mixes across, air, ground, sea, and even space environments to provide a better situational awareness of what is happening on the ground, in the air or at sea. Joint ISR (JISR) operations involving allied forces, is vital for all military operations. JISR is about how to connect allied capabilities together, how to analyze the information collected, and how to share that information for maximum effect. This is an important capability that provides NATO decision makers with better situational awareness of what is happening in all theatres of operation: ground, sea, air, and space. JISR means that allies work together to collect, analyze and share information to maximum effect (from NATO Website, Sept. 27, 2018). JISR is at the core of information sharing in NATO. JISR expands the scope of interoperability to include multiple domains (air, land, maritime, and special operations) composed of multi-national forces, across the full spectrum of the NATO Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities, and Interoperability (DOTMLPFI) capability development paradigm. This makes JISR operations a unique example of cooperation and burden-sharing across the Alliance. Also, JISR operations are foundational for other key joint processes such as closing intelligence gaps in joint targeting, and are thus a critical research avenue.

To be sure, technology is a primary element in the ISR concept development and evaluation (CD&E) process. However, ISR technologies do not work in isolation. Instead of working in isolation, ISR technologies must interface with human operators. This is certainly the case in ISR operations where intelligence operations are fundamentally human centric since it is humans who are the ultimate decision makers in the ISR process [4]. Consequently, it seems imperative to include a Human Factors (HF) research methodology within the ISR CD&E process. A complete evaluation of an ISR concept's ability to improve operator decision making, in addition to improving higher-level policy and decision making cannot rely solely on the technology alone. Unfortunately, HF has not played prominently in ISR CD&E process thereby resulting in a large knowledge gap in the NATO ISR CD&E process [5] despite HF having been identified as an integral part of the ISR CD&E process [1], [4], [5]. In particular issues of interoperability among nations are still very much a human centric issue that needs to be tackled.

The developing and implementation of a HF research methodology in the ISR CD&E process would allow researchers to directly observe how the development of new ISR concepts impacts operator performance [3]. This information in turn can be used to inform and advice military and civilian policy and decision makers about the purchase and implementation of new ISR assets and crucially about changes to doctrine and procedures. As such, a complete evaluation of the ISR CD&E process must include an understanding of the HF issues required for effective and efficient decision making in order to ensure that new ISR technologies are developed around the capacities and needs of human operators. To this end, the NATO HFM RTG-276 panel is aiming to develop an understanding of the HF issues critical to JISR/ISR operations in order to support and enhance the ISR CD&E process. For ISR and JISR to remain an effective military capability, ISR concepts need to be continually updated and evaluated to ensure that they improve not only ISR operators ability to perform their duties, but also to inform policy and decision makers regarding new ISR concepts so that they can effectively shape future ISR enterprises in a rapidly changing world [1].

1.2 HUMAN FACTORS

The goal of HF is to improve performance (both operator and technical) and well-being through systems design [6]. As noted in Ref. [7], p 5, "...[human factors/ergonomics is] the study of how people and machines interact. It is a technology for creating designs that work well in human terms". As well, "The aim of human factors is the design of] machines that accommodate the limits of the human user..." "The goal of human factors...is to apply knowledge in designing systems that work, accommodating the limits of human performance and exploiting the advantages of the human operator in the process" ([8], p. 3). Finally, "human factors is about the role of humans in complex systems, the design of equipment and facilities for human use, and the development of environments for comfort and safety" ([9], p. xvii). Together, these definitions illustrate the notion that HF research is about making the machine, technology, or system, meet the needs of the user. Human factors research involves the study of how all aspects of the ways humans relate to the world around them, with the aim of improving operational performance [10]. This is typically accomplished by having the operators of the technology/system assess the various aspects of the technology/system regarding its ability to improve operator performance. A key element of HF research is that it helps to ensure that technologies/systems/concepts are not developed in isolation from the operators they are meant to help; you cannot properly evaluate systems without observing the interaction between the technology and the operator and input from the operators about the system itself which must be an iterative process between the operator and the technology. Unfortunately, little or no attention has been given to the role or impact of HF in the evaluation of technological architectures such as ISR systems [4].

The military has long recognized that a strong understanding of relevant HF issues is essential to improve the effectiveness of soldier performance and the relationship between humans and technology to meet the military challenges of today, tomorrow, and building for the future [11]. A great deal of military research has focused on improving operator SA and decision making across many different contexts. Understanding and improving human decision making has become increasingly important in military environments due to the continued development and use of increasingly complex technologies and distributed multi-national operations. To this end, much research has focused on discerning cognitive and non-cognitive variables that impact decision making and then designing systems and processes that meet the needs of human cognitive cognition. Systems, processes and technologies must be designed in such a way as to not over burden humans' limited cognitive capacity but rather, ensure that effective and efficient information processing in order to facilitate fast and accurate decision making [12]. In addition to, and related to the study of SA in operator decision making, HF researchers have evaluated the extent to which new systems, procedural and technological concepts improve cognitive workload [10], [13], [14], [15], [16], information sharing [17], decision making, and trust [16], [18], [19].

1.3 ET-143

A NATO Exploratory Team (ET) on HF and ISR CD&E for NATO operations was created in September 2015 to examine the role that HF play in the ISR operations with the goal of recommending the development of a HF framework and evaluation methodology to inform decisions in the ISR CD&E process. In February 2016, members of the ET met to explore the willingness and interest of nations to participate in a collaborative research program on HF and ISR CD&E for ISR operations and to share their knowledge and perspectives on the subject. The ET discussed the role of HF and ISR activities and the feasibility of a NATO Technical Group to study these issues.

The ET focused on discussions about the HF issues related to ISR CD&E in military operations [1], [2], [4]. The members of the ET were in agreement that the ISR CD&E process has a large gap when it comes to including HF analyses in the ISR CD&E process. In addition to this finding, panel members also discussed the identification of promising test beds and data collection opportunities, as well as the need for a HF centric end-to-end ISR process analysis. Accordingly, the members of the ET agreed that an RTG be created to address the findings and HF issues raised during the ET.

1.4 OBJECTIVES OF RTG-276

The NATO HFM RTG-276 panel was established at a meeting at the NATO CSO, Paris, France,

May 2017 to extend the work discussed during ET-143. RTG-276 was stood up to create a collaborative partnership with NATO members and partner nations to develop a deep and holistic understanding of the role of HF in ISR operations in order to make recommendations toward a HF evaluation methodology for the JISR CD&E process across the full range of alliance ISR military operations. A HF evaluation capability will enhance the current JISR CD&E process in order to provide evidence-based advice on how best to design and evaluate JISR sensor and procedural concepts to meet the needs of NATO and national decision makers and operators throughout the entire ISR environment.

During subsequent meetings, it was decided that the objective of RTG-276 would be to identify and understand HF issues critical to effective ISR operations with a particular focus on JISR operations within a NATO operational level HQ. Research findings are expected to help leaders and nations identify ISR CD&E research gaps as they pertain to HF that can be addressed in future JISR concept trials. Three main objectives from these meetings were developed:

- Apply a model of Organizational Effectiveness for understanding, explaining, and measuring different HF issues for effective operator performance in ISR operations.
- Identify critical HF for effective ISR operations from a current NATO JISR trial and using related data and research literature.
- Make recommendations regarding the development of a HF research and evaluation methodology for future ISR CD&E trials.

During the NATO HFM RTG-276 panel meeting, the members of the panel identified NATO's Unified Vision 2018 (UV18) trial as a relevant setting and opportunity to gather HF data on JISR operations. Unified Vision has become NATO's main trial to practice and evaluate new technical and operational concepts for conducting Joint Intelligence, Surveillance and Reconnaissance (JISR) in NATO operations. Accordingly, members of the RTG-276 participated in UV18 to collect HF data to achieve the objects of RTG-276. At the annual RTG-276 panel meeting at the Norwegian Defence Establishment (FFI) in Kjeller, Norway September 2018, the panel decided to augment the data gathered at UV18 with data collected from BoldQuest 2019 (BQ19). The plan to collect data from BoldQuest 2019 in May 2019 in was finalized at the annual meeting in Toronto, Canada, March 2019. Here, members of the panel developed a data collection plan to be included in the BQ19 trials (see Annex D).

1.5 METHOD OF WORK

The work of the HFM RTG-276 panel was founded upon the existing research platform of HFM RTG-146 (Key factors identified in a Theoretical Model of Organizational Effectiveness) and related ISR and organizational research from military contexts [1], [3], [5], [20], [21], [22], [23], [24], [25] as a basis for examining HF issues that enable or hinder JISR coalition operations. The goals of the panel's research are:

1) To determine if HF issues are important to ISR CD&E process;
2) To explore a model of organizational effectiveness for understanding, explaining, and measuring different aspect of HF issues in JISR operations;
3) Help define the HF issues to be studied in a JISR operational setting; and
4) Develop recommendations for improving JISR operations through the inclusion of a HF research methodology.

The HFM RTG-276 team planned, coordinated, multiple meetings, both in-person and virtually, between 2017 – 2019. The purpose of these meetings was to develop the data collection and analysis plans for UV18 and BQ19. The research methods used during UV18 were both quantitative and qualitative. The quantitative component took the form of rating surveys while the qualitative component took the form of observations and unstructured interviews with key personnel at UV18. The research methodology for BQ19 was the same as the post event survey used in UV18.

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Chapter 2 – THEORETICAL FRAMEWORK

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In this chapter we provide a high-level theoretical framework on human factors in JISR operations. A theory can be broadly conceived as a statement of relations among concepts within a boundary set of assumptions and constraints and so we delineate the general assumptions, constraints as well as concepts and their relation to our framework [1]. We see our theoretical framework as comprising three key concepts:

1) The JISR process;
2) Various human factors variables; and
3) Output factors.

It is how these concepts relate and what governs their relation broadly that is the concern of this chapter. The various sections present detailed theory and analysis of the JISR process, the influence of various human factors and their impact on output factors. The sections also give an in depth presentation of the methodology relevant for each section.

Different approaches to process in organization have been put forward such as the input-mediator-output framework, the input-mediator-output-input framework as well as structuration-inspired frameworks of process [2], [3]. In broad terms these can be seen as encompassing both teleological and sequential perspectives where there is the assumption that clear goals guide actions to produce certain results, as well as more emergent perspectives of change where the structure that humans work in impact and is impacted by humans in other structures [4].

We suggest as an underlying assumption that the JISR process, as carried out in an alliance context, does not easily subscribe to any of these models: rather it is a mix of a pre-planned and designed sequential processes, and emergent processes [5]. On the one hand there are formally defined procedures, doctrines Tactics, Techniques, and Processes (TTPs) such as Joint Intelligence, Surveillance, and Reconnaissance Procedures in Support of NATO Operations Orders of Battle (AintP ORBATs), on the other hand there are experimentation as to what working processes including specific nodes will actually look like. This suggests that our research keep an agnostic view as to the influence of TTPs on the one hand and the actions and perception of these within the execution of JISR. The theoretical framework thus contains two forces that we see as interacting: the planned actions and the emergent actions. The distinction between planned and enacted JISR is found both in the dichotomy between plans for experimentation and actual experiments/exercise execution, as well as the tension between planned and executed JISR operations, execution can sometimes even be dynamic. The tension between planning and the dynamics of execution is in our view essential to understand how human factors influence JISR. Mechanisms of human decision making and collaboration should be developed that ensure a smooth transitioning from pre-planned to dynamic JISR in NATO.

More specifically our model seeks to combine linear and non-linear trajectories of JISR collaboration. From a sequential planned point of view the core of the model is the JISR process where the Tasking, Collection, Processing, Exploitation, and Dissemination (TCPED) phases can be viewed as constituting different phases in the team adaptive model by Burke et al. [6]: situation assessment, plan formulation, plan execution and team learning (which could be the evaluation of whether CPED helped solve the task) (see Figure 2-1). This relatively linear team-process of single PED-Cells should also be seen in light of their collaboration with other teams (cells) in a multi-team system, i.e., multiple teams working integrated toward a common goal [7]. Federated PED, involving multiple PED-Cells, is particularly important to ensure the necessary data

gathering needed for actionable intelligence. We expect that the planned JISR process may for different reasons not always be feasible in the expected planned way. For example, from the point of view of the task: the actual workload of a PED-Cell during the execution of tasks may critically influence its ability to be part of the overall alliance JISR process. Prior planning for NATO may to a certain extent reduce this factor, but not completely remove the uncertainty. Several other factors may also contribute to challenging a pre-planned JISR process: such as the various PED-Cells motivation, experience, and the degree to which they understand the mission differently and so on. We thus see the influence of the human factors as not only sequentially related to fulfilling an overarching goal for the JISR process within single teams, but to a large part influencing the overall NATO JISR process in other unintentional ways. On the other hand, the stated process of JISR may not necessarily change as a consequence of these hindrances, as this could depend on the effectiveness of coordination and trust within and between multiple national PED-Cells.

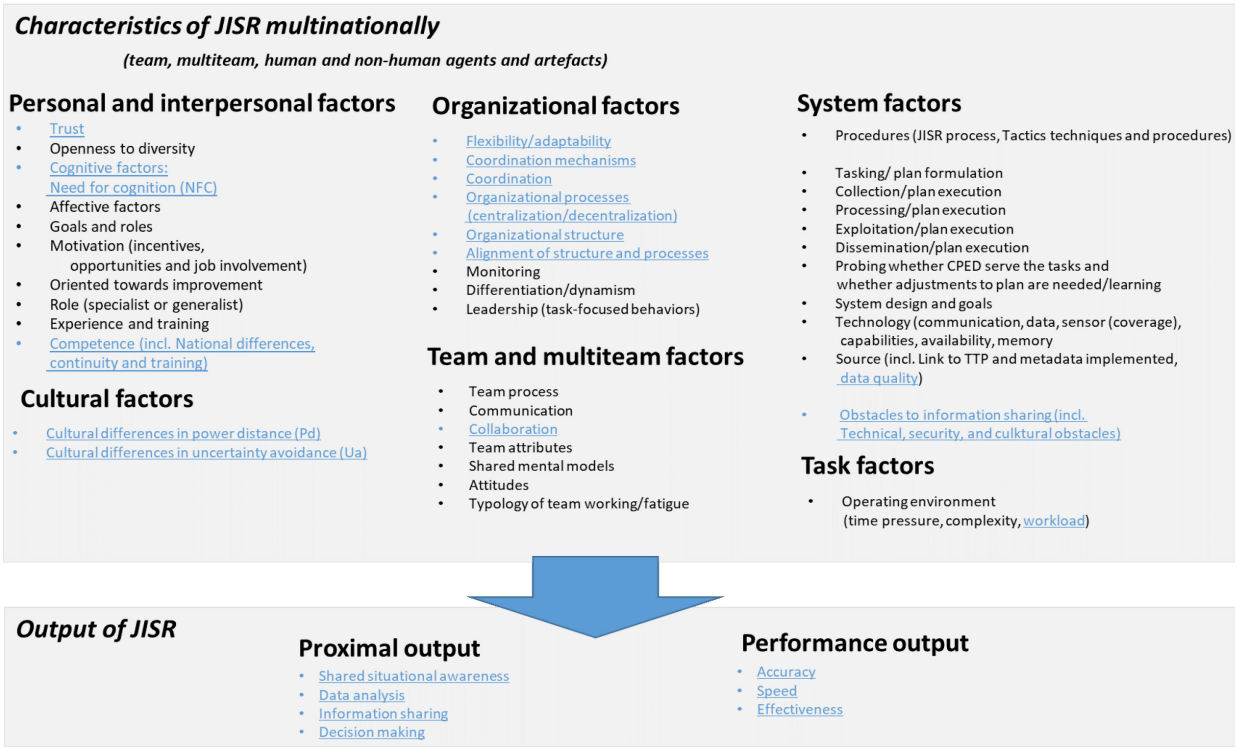

Figure 2-1: Human Factors Influencing JISR and Its Output Factors – Theoretical Framework.

In the different chapters we delineate how personal and interpersonal factors, organizational factors, cultural factors, task factors, system factors and team factors influence JISR. These input factors are expected to influence the JISR processes and their ability to deliver results usable in the JISR process internally as well as to external organizational elements (e.g., to Joint targeting or to the Intelligence community) and in turn output factors such as shared situation awareness, data analysis, information sharing and decision making as well as accuracy and speed of mission accomplishment. This proposed connection between input and output factors is portrayed in Figure 2-1; the figure provides an overview of all the factors studied in this report. The blue and underlined factors are those empirically examined. There are more detailed presentations of theory in the subsequent chapters, including also models that explain in more detail the proposed interrelationships between the factors presented in the general model.

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Chapter 3 – TEST BEDS: UNIFIED VISIONS 2018 AND BOLD QUEST 2019

Fred Lichacz, Sigmund Valaker, Anne Lise Bjørnstad, Stéphane Buffat, Rune Stensrud, and Daniel Zelik

3.1 UNIFIED VISION 2018

During an organizational meeting in Paris, May 2017, members of the NATO HFM RTG-276 panel identified NATO's Unified Vision 2018 (UV18) Trial as a unique setting and opportunity to gather HF data on JISR operations. Unified Vision has become NATO's main trial to practice and evaluate new technical and operational concepts for conducting JISR in NATO operations.

The overall aim of UV18 is to improve NATO's JISR TCPED interoperability and, where appropriate, continuing to pursue the interoperability improvement opportunities identified from previous UV series of trials. The outcomes from UV18 are intended to contribute to NATO's preparations for the delivery of the Allied Ground Surveillance (AGS) Initial Operational Capability (IOC) in 2018/19 and other related JISR Initiative capability packages. UV trials are considered to be the premier NATO event at which to practice and evaluate JISR across all of the DOTMLPFI lines of development. The results of the trials inform NATO bodies and nations of change recommendations to support NATO's development of an enduring JISR capability and support the Alliance's preparations for the delivery of NATO AGS, and assisted NATO and the nations to improve the interoperability of their JISR capabilities in support of future operational missions [1].

UV18 was conducted at the USAFE Warrior Preparation Centre (WPC), Einsiedlerhof, Germany June 11 – 26 2018. The primary goals of UV18 Trial Goals were to maximize the interoperability between NATO and National ISR capabilities and to further enhance the JISR TCPED process, with a particular focus on Federated PED. The main focus for NATO AGS Force (NAGSF) participation in UV18 was to exercise the Force's PED capability from a variety of sensor types, such as Electro Optics/ Infra-Red (EO/IR) and Full Motion Video (FMV). As well, UV18 was involved in testing advanced technologies to improve the speed and accuracy with which information is gathered and processed. UV18 used a combination of aerial, ground and maritime Surveillance and Reconnaissance platforms and sensors, from both Europe and North America, to test lessons learned by NATO nations over the course of the last decade of operating together [1].

3.1.1 UV18 Trial Organization

A Blue Force (BLUFOR) structure was staffed to support those functional areas necessary to support the trial goals. This included the relevant J2/J3 functions at the JTF HQ level and at the air, land, maritime and special operations component commands at the WPC. Italy hosted the Maritime Component Command (MCC) in Rome and France hosted elements of the Air Component Command (ACC) in Lyon. A number of participating nations provided PED nodes that made up the Trial PED Federation.

In addition to the Joint Task Force (JTF) Headquarters at WPC, the Trial included live activities at a number of locations. The Centre for Maritime Research and Experimentation (CMRE) led the execution of live maritime surveillance activities off the East coast of Iceland and North Norway. The Czech Republic executed live Electronic Warfare (EW) activities at one of their military training areas. The US executed live activities in Arizona and the NATO biometrics community executed the bulk of their activity at T' Harde in the Netherlands.

There was a remote UV18 Electronic Warfare Coordination Cell (EWCC) located at the Putlos Range in northern Germany that leveraged from the German Air Force BALTIC Cooperative Electronic Support

Measures Operations (CESMO) Trial 2018 (BCT18) that was running concurrently. Data from the BCT18 activity was used to support EW execution during UV18, with the EWCC ultimately reporting to the Signals Intelligence and Electronic Warfare Operations Cell (SEWOC) within the JTF. This Trial setup provided an opportunity to execute the tasking and reporting mechanisms in the EW processes, specifically between the tactical levels where EW assets are deployed, up to a joint level.

The trial execution phase was managed by the Trial Control (TRICON) and each day's activity was based on a number of vignettes, which involved a mix of simulated and live-fly operations. Some of these vignettes were of short duration but some extended over a five-day period in order to support the execution of a Joint Collection Management Board (JCMB) during the trial. The vignettes had been developed over a number of months by a small team comprising members from some of the participating nations, NATO agencies and industry. A federation of simulators was used to support the simulated trial vignettes. The main simulation effort was provided by the WPC. Some nations and agencies offered 'live-fly,' maritime and ground data collection also provided ground activity linked to the relevant vignette script [1].

On each trial execution day, focused debriefs, involving system engineers and operational users, were scheduled to discuss solutions to issues that had arisen during that day's trial execution. During UV18, these focus sessions were used very effectively to address Intelligence Requirements Management and Communications Management (IRM&CM) system related issues, including capabilities, procedures, and doctrine. The output from these debriefs provided useful insights as to the required future adaptation of IRM&CM systems and doctrine.

For all of the PED nodes, the manning of each was decided by the nation/organization offering that particular PED capability. There was a UV Assessment Team comprised of 38 SMEs and approximately 60 observers who participated at various times during Trial execution. As part of the Unified Vision 2018 exercise, there was a similar exercise conducted at the National Joint Headquarters in Norway. The purpose of this trial was the integration of JISR with Joint Targeting (JT), Joint Battle space Management (JBM), and utilizing federated PED-Cells. In this respect, the National Joint Headquarters in Norway was very similar in its functioning to the JTF headquarter in Enseidlerhof. Our panel collected some data for the chapter on coordination, from 13 respondents that worked in JISR, JT and JBM in the Norwegian Headquarters.

3.2 BOLD QUEST 2019

Bold Quest 2019 (BQ19) was a US led exercise that included coalition partners and took place in northern Finland in addition to other national PED nodes. A similar setup of PED-Cells was used in BQ19 as in UV18 so it made sense to collect extra data from this exercise for this research. The following information provides an overview of the exercise setting [2]:

Bold Quest is formally known as the Coalition Capability Demonstration and Assessment, in which Nations, Services and Programs pool their resources to improve interoperability and information sharing. Multiple command locations, systems and virtual simulators will take part in the event from outside Finland via established joint and coalition distributed networks.

The live fires portion of the demonstration will take place in the Rovajärvi Firing Range. Air operations will take place from the Rissala and Rovaniemi airfields and will be centered around the Rovajärvi area and Rissala environs. Also, other army, navy and air force training areas will be used, as well as the garrison areas of Sodankylä, Rissala, Riihimäki and Turku.

Approximately 700 Finnish soldiers will participate in the event. From abroad Finland is expecting approximately 1,500 participants from several countries. The participating units and systems will be confirmed in early 2019.

The goal of BQ is to demonstrate and assess the command and control interoperability of joint fires sensors and related systems in a multinational operating environment. The event tests and demonstrates the functional and technical interoperability of ground, sea and air-based ISR and joint fires systems. Some of the demonstration fires will be live-fire exercises and some simulated.

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Chapter 4 – METHODOLOGY

**Fred Lichacz, Sigmund Valaker, Anne Lise Bjørnstad,
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4.1 ASSESSMENT TASK

The purpose of the NATO HFM RTG-276 UV18 HF Assessment was exploratory in nature to get an understanding of the role and importance of HF issues during JISR operations. The UV18 HF assessment task was defined in line with the goals of HFM RTG-276:

1) To gauge current knowledge about HF research in the ISR CD&E process;
2) To identify critical HF issues for effective JISR operations within a simulated NATO JISR operation;
3) To further explore a model of organizational effectiveness for understanding, explaining, and measuring different aspects of HF issues in JISR operations; and
4) To make recommendations regarding improvement of education and training of NATO and partner countries' militaries for ISR CD&E coalition operations.

4.2 ASSESSMENT STRATEGY

The intent was to collect data from the JISR operators participating in UV18 at the WPC. Three of the research group members were present for parts or the whole of this exercise, one member of the panel was in France during UV18 and was able to collect HF data from the PED-Cell located in Bruz, France, and another member of the research group was also present at the NJHQ in Norway. A combination of surveys, observations, interviews, and experimentation were used to collect the HF data.

4.3 MATERIALS

This study employed a combination of quantitative (i.e., questionnaire) and qualitative (i.e., observations and semi-structured interviews) methodologies as described below.

4.3.1 Questionnaires

There were seven HF questionnaires developed for the UV18 (a modified version was used in BQ19) study: A pre-trial survey, a post-trial survey and five in-trial surveys. These surveys were selected developed on the basis of our HF model of JISR and its output factors (see Figure 2.1) in turn resting on relevant HF research [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12] that focused on HF issues for organizational effectiveness. The surveys used both bipolar semantic and Likert-scale ratings to capture quantitative responses about various HF issues. For numerical presentation of the analysis results, the participants rated each objective or assessment area using a 5-point scale. However, the qualitative free-text answers provided the anecdotal evidence against which more in-depth analysis was conducted. Each survey was populated with statements with the intent to capture relevant HF information about JISR operations. The surveys were presented to the participants on SharePoint hosted on the UV18 Portal.

4.3.1.1 Pre-Trial Survey

The main part of the pre-trial survey questionnaire in UV18 (Annex A) was developed to obtain a basic understanding of the participants' pre-existing knowledge of HF in JISR operations and their views on the importance of HF research for JISR operations. The HF variables in the pre-trial survey included basic HF knowledge, situational awareness, workload, importance of organization, visualization, the role of trust, obstacles to information sharing, information management, leadership, cognition, and culture. These HF issues were chosen as they are typical of the most basic HF issues studied in the research literature and that are prominent in the theoretical framework on HF in JISR operations [1], [2].

We measured need for cognition (NFC), using the NFC scale [13]. The cultural differences, Power distance (Pd) and Uncertainty avoidance (Ua), were measured using Hofstede's Values Survey Module [14], VSM 2013 (available at www.geerthofstede.com). There is research supporting that the Pd and Ua measures are valid also in military settings [15], [16]. Response categories were on five-point scales. Some items were re-coded in order to make high scores indicate the same across items and measures. The cultural measures were calculated using Hofstede's formulae (www.geerthofstede.com): Pd = 35(m07 – m02) + 25(m20 – m23) + C(pd) and Ua = 40(m18 – m15) + 25(m21 – m24) + C(ua), where "m" is the mean score on the numbered item and "C" is a constant that may be added to make the scores between 0 and 100. The trust measure was based on the measure from Bjørnstad et al. [7]. Trust was measured both pre and post exercise.

4.3.1.2 Post-Trial Survey

A post-trial survey was included to get the operators' feedback on how specific aspects of the trial impacted various HF issues in UV18 (Annex B and Annex C; Annex C shows the questions after on-site modifications were made). This survey was presented to the participants at the conclusion of the trials. The HF issues chosen for this survey are typical of the most basic HF issues studied in the research literature and that are prominent in the theoretical model of organizational effectiveness [1], [2]. The organizational variables, flat structure, decentralized processes, flexibility, alignment, obstacles to information sharing, trust, and the organizational effectiveness variables, shared awareness of tasks and responsibilities, information sharing, and decision making were all measured using scales developed for use in military contexts and whose psychometric properties were tested by Bjørnstad and Elstad [17]. These measures were based on earlier work by Bjørnstad, et.al. [7], Lichacz and Bjørnstad [18], Bjørnstad [6], [20], and Yanakiev and Horton [1]. Alignment is calculated and represents the absolute difference in scores between the flat structure and decentralized processes measures. Obstacles to information sharing were measured using an adaption of Bjørnstad's metric [17], [18], [19], [20].

Similar to the post-trial survey used in UV18, a post-trial HF survey was developed for the participants in BQ19 (see Annex D), consisting mainly of a selection from the UV18 questionnaires. This survey was used to examine the human factors in complex systems and the design of equipment, processes, and facilities to improve human performance with an understanding of the limits of human cognitive performance. Participants were asked to respond to questions about the organizational structure and processes, trust and competence, information sharing, management and quality, visualization capabilities, processes, workload, shared awareness, and decision making, personnel, and training within JISR operations.

4.3.1.3 Daily Surveys

There were five surveys: one for each day of the trials in UV18. The main focus of these surveys was to examine how HF issues were impacted by daily events during the trials. The daily surveys are located in Annex E.

4.3.1.4 Observations and Interviews

An Observations Capture Tool, also hosted on the UV18 Portal, provided a means to capture any ad hoc comments from participants that were not tasked to complete a survey following the vignette execution. This tool also presented a convenient means to capture trial conduct related Lessons Identified (LI).When required, the analysts had informal interviews/discussions with the operators to clarify any oddities in the data collected if need be.

4.4 PARTICIPANTS

The UV18 trial involved the participants from 18 NATO nations, two partner nations, two NATO commands and 10 agencies plus a number of other NATO/national bodies. For the entire UV18 trial, there were over 1200 personnel involved. For those participating at the WPC, there were 265 personnel who were part of one of TRICON, BLUFOR, SNRs, Assessment and Observers. With regard to the PED operators of whom the study was targeting, there were a total of 104 personnel [21].

The participating nations included: Belgium, Croatia, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Romania, Slovenia, Spain, Sweden, Turkey, United Kingdom, and United States.

Data was collected from military personnel from the WPC and the different land, maritime, air, and special operations component commands. A total of 48 (male (41) and female (7)) military JISR operators comprised of Lieutenant to Lieutenant Colonel from 11 countries responded to the questionnaires.: Belgium (2), Croatia (7), Czech Republic (5), France (1), Germany (4), Italy (2), Poland (2), Romania (1), Spain (8), Turkey (1), and US (15).

As part of the data collection for the study on coordination, some data was collected from a part of the UV18 exercise that took place at National Joint Headquarters in Norway. In total there were collected data from 13 officers who were all Norwegian and had a rank that ranged from captain to lieutenant colonel. No other demographic information was collected here due to classification.

For BQ19 there were collected data from ten respondents. There were respondents comprising ranks from lieutenant to colonel, and one officer of another rank, from 5 countries: Finland (4), France (2), Norway (1), Spain (1) and US (2).

Some constraints of the trials made it hard to collect data from all relevant participants. This was due to the fact that our study was not the main focus of the trials, although the experimental leaders tried their best to include our survey in the daily routine of the trial. As the trial was in progress there were some complaints on the length of the survey, which may have led to fewer responses than expected. We tried to accommodate such complaints and shortened the survey somewhat, but could not do this extensively as any changes would compromise the value of the survey. The experience we gained, which reflect common issues in field data collection, is lessons identified that can be useful for future survey collection: common and well known “rules” of survey collection should be carefully heeded: make sure the survey is completely integrated with the overall trial and make sure that the respondents have the time to complete the survey. In our case it should be emphasized that measures were taken to ensure this advance, but that any field trial case have the risks mentioned and we experienced some of them.

4.5 PROCEDURE

From June 13 – 26, 2018, members from NATO HFM RTG-276 carried out the assessment strategy plan for UV18 at the USAFE WPC, Einsiedlerhof, Germany. The following researchers participated in the field work: Dr. Fred Lichacz, Dr. Stéphane Buffat, Dr. Daniel Zelik, and Dr. Sigmund Valaker. The pre-study

survey was presented to all of the participants on-line during the practice phase of the trials and the post-trial survey was presented to all of the participants at the end of the trials. The five daily trials were presented to the participants at the end of each trial day in conjunction with other surveys from other interested NATO partners. The chair of NATO HFM RTG-276 provided an overview of the goals of NATO HFM RTG-276 and the HF surveys to the UV18 audience during the training sessions in the main theatre at the Einsiedlerhof base. He also informed the participants that the survey was completely anonymous and that their participation was entirely voluntary. The pre- and post-trial surveys required about 20 minutes to complete while the daily surveys required about 10 minutes to complete.

One member of the research panel collected HF data at the French PED-Cell in Bruz, France. He collected observational and interview data to compare the operations at the PED-Cell with the components of the theoretical model of organization used by this NATO panel. Also, he conducted a small experiment to examine how ISR operators switch between tasks given a variety of different information processing cues. Another member of the research panel made observations and collected data at the NJHQ in Norway.

In the BQ19 trials, questionnaire data was collected at the site in Finland at the end of the trial by way of paper surveys.

In both the Bruz and BQ19 data collections, the analysts provided participants with the same pre-trial data collection briefings as was done at the UV18 event site in Einsiedlerhof.

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Chapter 5 – PRE-TRIAL SURVEY RESULTS

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5.1 INTRODUCTION

The pre-trial survey questionnaire was designed to get an understanding of the operators' general understanding of the role of HF in JISR operations as well as related issues and is presented in Annex A. The survey consisted of eight sections with multiple statements about each respective HF issues. The eight sections were made up of questions pertaining to: basic human factors knowledge, situational awareness, workload, organization, trust, information sharing, information management, leadership, culture and cognition (the findings from the areas of culture and cognition are presented in Chapter 7). The participants were informed that their responses to the statements were to be based on their own experiences within ISR operations. All of the items in the pre-trial survey questionnaire are based on the general models of HF in JISR operations discussed in this report above.

All participants were requested to complete the pre-trial survey questionnaire during the one week training period prior to the start of the simulated JISR missions.

The HF section of the survey was included to gain insight into the participants' general knowledge about the extent to which HF plays a role in JISR operations and CD&E. The participants were informed that their responses were to be based on their experiences in JISR operations. The participants were asked to respond to a variety of statements about their knowledge of various HF in JISR operations. The ratings in each scale used were:

1) Strongly Disagree
2) Disagree
3) Neutral
4) Agree
5) Strongly Agree

The means, medians, and standard deviations from the data are reported in the corresponding tables. To determine if the average scores differed significantly from Neutral, a one-sample t-test was conducted comparing the observed mean against the midpoint of the scale (neutral value of 3) for each item [1].

5.2 HUMAN FACTORS

The section on HF was included to gain insight into the participants' general understanding of HF in ISR operations. The participants were asked eight Likert-type questions using a 5-point rating scale about their knowledge of HF in ISR operations. The means, medians, standard deviations, and t-statistics from the rating data are reported in Table 5-1.

In general, the participants indicated that HF issues are examined in the ISR CD&E process (Items 1 and 7) but did not know if a HF doctrine or a HF Lessons Learned capability exists for JISR operations (Items 2 and 3). However, the respondents did indicate that HF research is important to ISR CD&E and should be part of the ISR CD&E process (Items 4, 5, 6, and 8).

Table 5-1: Means, Medians, and Standard Deviations of General Knowledge of HF in ISR Operations.

Human Factors					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	3.44*	3.5	1.08	48	$t(47) = 2.78, p < .01$
2	3.19	3.0	0.77	46	$t(45) = 1.71, p < .09$
3	3.17	3.0	0.77	45	$t(44) = 1.53, p < .13$
4	4.13*	4.0	0.56	48	$t(47) = 13.68, p < .001$
5	4.03*	4.0	0.67	47	$t(46) = 10.84, p < .001$
6	3.94*	4.0	0.70	47	$t(46) = 9.12, p < .001$
7	3.28	3.0	0.81	48	$t(45) = 2.37, p < .02$
8	3.81*	4.0	0.68	47	$t(46) = 8.15, p < .001$

Note: Asterisked items are statistically significant at $p < .01$ and $p < .001$; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

5.3 SITUATIONAL AWARENESS

The section on SA was included to gain insight into the UV18 participants' views on SA in ISR operations and to ensure the continuity with previous research (see Chapter 1) on the role of SA in military operations. The participants were asked five Likert-type questions about SA in ISR operations. The means medians, standard deviations, and t-statistics are reported in Table 5-2.

Table 5-2: Means, Medians, and Standard Deviations of Views on Situational Awareness in ISR Operations.

Situational Awareness					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.56*	5.0	0.65	48	$t(47) = 16.67, p < .001$
2	4.38*	4.0	0.53	47	$t(46) = 17.76, p < .001$
3	3.51*	4.0	0.82	45	$t(44) = 4.21, p < .001$
4	4.21*	4.0	0.65	48	$t(47) = 12.86, p < .001$
5	3.97*	4.0	0.67	47	$t(46) = 9.94, p < .001$

Note: Asterisked items are statistically significant at $p < .001$; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

The results presented in Table 5-2 revealed, not surprisingly, that SA is an important issue for ISR operators and ISR operations. There was agreement across the operators that it is important to have an understanding of all of the issues that impact SA and that the ISR CD&E process should include a component that examines how new concepts impact operator SA.

5.4 WORKLOAD

Questions about WL were included to gauge the participants' views on how WL is impacted in ISR operations based on their own experiences. The participants were asked six Likert-type questions about their experiences about WL in ISR operations. The means, medians, standard deviations, and t-statistics are reported in Table 5-3.

Table 5-3: Means, Medians, and Standard Deviations of Views on Workload in ISR Operations.

Workload					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	3.25*	3.0	0.82	47	$t(46) = 2.13, p < .038$
2	2.58*	3.0	0.71	48	$t(47) = -4.01, p < .001$
3	2.76	3.0	0.88	47	$t(46) = -1.8, p < .078$
4	2.94	3.0	0.94	47	$t(46) = -.46, p < .644$
5	2.97	3.0	0.68	46	$t(45) = -.22, p < .83$
6	3.74*	4.0	0.68	46	$t(45) = 7.36, p < .001$

Note: Asterisked items are statistically significant at $p < .05$ and $p < .001$; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

Overall, the findings revealed that WL is not too much of an issue for the ISR operators. The operators indicated that they have to resources to mitigate high WL and are not frustrated by the amount of work they have to do but believe that issues pertaining to WL in ISR operations should be studied in the ISR CD&E process (Items 1, 2, and 6). Interestingly, the respondents were neutral about whether they have enough time or staff to do their tasks or whether WL is studied during ISR CD&E trials (Items 3, 4, and 5).

5.5 ORGANIZATION

The section on Organization (Org) was included to learn about the participants' views on the impact of Org on ISR operations. The participants were asked six Likert-type questions about their views about the impact of Org on ISR operations. The means, medians, standard deviations, and t-statistics are reported in Table 5-4.

Table 5-4: Means, Medians, and Standard Deviations of Views on Organization in ISR Operations.

Organization					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.36*	4.0	0.53	47	$t(46) = 17.66, p < .001$
2	4.36*	4.0	0.56	47	$t(46) = 16.43, p < .001$
3	4.29*	4.0	0.62	48	$t(47) = 14.94, p < .001$
4	4.00*	4.0	0.71	48	$t(47) = 9.69, p < .001$
5	3.31*	3.0	0.70	45	$t(44) = 2.97, p < 005$
6	3.64*	4.0	0.67	47	$t(46) = 6.50, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

The responses revealed that Org is critical to effective and efficient ISR operations. Moreover, the importance of this issue manifests itself in the operators' views that the impact of Org on ISR operations should be included in the ISR CD&E process.

5.6 VISUALIZATION

The section on Visualization was included to obtain a basic understanding of the participants' views on how information should be presented during ISR operations. The participants were asked seven Likert-type questions about their knowledge about HF in ISR operations. The means, medians, standard deviations, and *t*-statistics are also reported in Table 5-5.

Table 5-5: Means, Medians, and Standard Deviations of Views on Visualization in ISR Operations.

Visualization					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.21*	4.0	0.74	48	$t(47) = 11.27, p < .001$
2	4.17*	4.0	0.61	46	$t(46) = 13.11, p < .001$
3	4.33*	4.0	0.66	48	$t(47) = 13.93, p < .001$
4	4.24*	4.0	0.82	46	$t(45) = 10.23, p < .001$
5	4.44*	4.0	0.54	48	$t(47) = 18.37, p < .001$
6	3.30*	3.0	0.75	46	$t(45) = 2.73, p < .009$
7	4.08*	4.0	0.58	47	$t(46) = 12.75, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

Overall, the data revealed that the participants' view the manner in which data is presented is important to successful JISR operations. Moreover, the participants agree that the ISR CD&E process should experiment with different types of data visualization in order to improve JISR operations in the best way possible.

5.7 IMPORTANCE OF TRUST AND TRUST IN COLLEAGUES

The first measure was included to get insight into the participants' views on trust in ISR operations. The participants were asked 7 Likert-type questions about their knowledge about HF in ISR operations in the importance of trust measure. The seven questions were statements directly about the role that trust plays in JISR operations.

The second measure of trust, measured trust in colleagues within their own and other PED-Cells. These six questions were about the participants' views on how confident they were that colleagues from their own nation and other nations in their PED-Cells share information, assist each other, and fulfill their responsibilities during ISR operations. This second set of questions used a 5-point rating scale that consisted of the following ratings:

1) Very confident
2) Confident
3) Neutral
4) Doubtful
5) Very Doubtful

The means, medians, standard deviations, and t-statistics are reported in Table 5-6.

Table 5-6: Means, Medians, and Standard Deviations of Views of The Importance of Trust and Trust in Colleagues in ISR Operations.

Trust					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.19*	4.0	0.74	47	$t(46) = 13.33, p < .001$
2	4.15*	4.0	0.61	47	$t(46) = 14.29, p < .001$
3	4.17*	4.0	0.66	46	$t(45) = 11.76, p < .001$
4	4.28*	4.0	0.82	46	$t(45) = 11.34, p < .001$
5	4.36*	4.0	0.54	46	$t(45) = 15.24, p < .001$
6	3.43*	3.0	0.75	46	$t(45) = 3.93, p < .001$
7	3.97*	4.0	0.58	47	$t(46) = 11.04, p < .001$
8	2.11*	2.0	0.91	45	$t(44) = -6.55, p < .001$
9	1.93*	2.0	0.91	45	$t(44) = -7.82, p < .001$
10	2.00*	2.0	0.97	45	$t(44) = -6.86, p < .001$
11	2.37*	2.0	0.81	45	$t(44) = -5.17, p < .001$
12	2.26*	2.0	0.77	46	$t(45) = -6.48, p < .001$
13	2.33*	2.0	0.83	45	$t(44) = -5.42, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

Not surprisingly, trust is an important element of JISR operations. Items 1 – 7 revealed that the ISR operators believe that trust in one's colleagues and data analyses is important to successful JISR operations and that this aspect of JISR operations should be studied during JISR CD&E activities. In contrast to variables 1 – 7, low scores on variables 8 – 13 represent higher levels of trust. Accordingly, the data from variables 8 – 13 indicate that the operators are confident that their colleagues, both domestic and international, will share information with them, help them, and fulfill their responsibilities during ISR operations (compare these findings with the results from Chapter 7 where the data was coded differently).

5.8 VIEWS ON OBSTACLES TO INFORMATION SHARING IN ISR OPERATIONS

The section on Obstacles to Information Sharing (OIS) was included to determine what aspects of JISR operations hinder information sharing. The participants were asked 13 Likert-type questions about their knowledge about hindrances to information sharing in ISR operations. The means, medians, standard deviations, and t-statistics are reported in Table 5-7.

Table 5-7: Means, Medians, and Standard Deviations of Views on Obstacles to Information Sharing in ISR Operations.

Obstacles to Information Sharing					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.45*	5.0	0.89	48	$t(47) = 11.25, p < .001$
2	4.00*	4.0	0.85	47	$t(46) = 7.97, p < .001$
3	3.02	3.0	0.79	47	$t(46) = .18, p < .855$
4	3.91*	4.0	0.85	47	$t(46) = 7.33, p < .001$
5	3.89*	4.0	0.69	47	$t(46) = 8.76, p < .001$
6	3.72*	4.0	0.68	47	$t(46) = 7.27, p < .001$
7	3.95*	4.0	0.62	47	$t(46) = 10.52, p < .001$
8	3.68*	4.0	0.81	47	$t(46) = 5.75, p < .001$
9	3.95*	4.0	0.77	47	$t(46) = 8.43, p < .001$
10	3.55*	4.0	0.85	47	$t(46) = 4.44, p < .001$
11	3.21*	3.0	0.75	47	$t(46) = 1.95, p < .001$
12	3.36*	3.0	0.64	46	$t(45) = 3.88, p < .001$
13	4.04*	4.0	0.65	47	$t(46) = 10.86, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

In general, the data from the OIS section of the survey revealed that there are many elements within JISR operations that hinder information sharing. Accordingly, the participants indicated that OIS should be studied during the JISR CD&E process.

5.9 INFORMATION MANAGEMENT

The section on Information Management was included to insight into the participants' views on how IM operates within ISR operations. The participants were asked seven Likert-type questions about their knowledge about IM in ISR operations. The means, medians, standard t-statistics are reported in Table 5-8.

The participants revealed that they were unsure whether IM was run well or that Lessons Learned (Items 2 and 4, respectively) were integrated into the problem-solving process. Despite this, the participants indicated that IM is critical to JISR operations and should be studied within ISR CD&E activities.

Table 5-8: Means, Medians, and Standard Deviations of Views on Information Management in ISR Operations.

Information Management					
Item	*M*	*Md*	*SD*	*N*	*t-statistic*
1	4.25*	4.0	0.56	48	$t(47) = 15.33, p < .001$
2	2.95	3.0	0.93	47	$t(46) = -.31, p < .756$
3	3.46*	3.0	0.78	45	$t(44) = 3.98, p < .001$
4	3.19	3.0	0.95	46	$t(45) = 1.38, p < .173$
5	3.27*	3.0	0.79	47	$t(46) = 2.37, p < .022$
6	3.27*	3.0	0.61	47	$t(46) = 3.08, p < .003$
7	4.04*	4.0	0.65	47	$t(46) = 10.86, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

5.10 LEADERSHIP

The section on Leadership was included to insight into the participants' views on the impact of Leadership in ISR operations. The participants were asked six Likert-type questions about Leadership in ISR operations. The means, medians, standard deviations and the t-statistics are reported in Table 5.9.

Table 5.9: Means, Medians, and Standard Deviations of Views on Leadership in ISR Operations.

Leadership					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	4.15*	4.0	0.78	48	$t(47) = 9.92, p < .001$
2	4.14*	4.0	0.77	47	$t(46) = 10.10, p < .001$
3	3.95*	4.0	0.82	46	$t(45) = 7.95, p < .001$
4	4.32*	4.0	0.69	47	$t(46) = 13.01, p < .001$
5	3.26*	3.0	0.80	46	$t(45) = 2.21, p < .05$
6	3.78*	4.0	0.77	47	$t(46) = 6.93, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = median; *SD* = Standard Deviation; *n* = sample size.

According to the participants' responses, Leadership impacts many important HF issues in JISR operations and is critical to successful ISR outcomes. Accordingly, the participants indicated that Leadership styles should be studied within the ISR CD&E process.

5.11 DISCUSSION

The purpose of the UV18 pre-trial survey was to discern a broad level of understanding about the role of various HF issues within JISR operations, determine whether HF are studied within the JISR CD&E process, and to determine from the operators if they should be studied in the JISR CD&E process. Overall, the data from the pre-trial survey revealed that the HF issues explored in this survey are important to successful JISR operations. The operators were at times unsure whether some of these HF issues are studied during the JISR CD&E process. The issues that the respondents considered of importance were:

- Situation awareness;
- Workload;
- Organization;
- Visualization;
- Trust;
- Obstacles to information sharing;
- Information management; and
- Leadership.

However, with that said, the operators did agree that these HF issues should be studied during the JISR CD&E process in order to understand how new technologies and processes impact JISR operations.

It is acknowledged that there was a small number of respondents which could limit the interpretation and application of these findings. However, these findings do support previous research findings pertaining to the role of HF in military settings as referenced in Chapter 1. Moreover, more in-depth analyses of the role of HF in JISR operations in the following chapters lend further credence to the importance of these findings to JISR CD&E work. Accordingly, these findings support the intention of NATO HFM RTG-276 that HF should be incorporated into future JISR CD&E research. Indeed, the operators involved in UV18 overwhelmingly support the contention that HF should be included in the ISR CD&E process and the results from this study support this as well.

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Chapter 6 – THE INFLUENCE OF COORDINATION MECHANISMS ON COORDINATION IN FEDERATED PED: AN EXPLORATION OF THE ROLE OF TACIT, ONGOING COMMUNICATION AND MODULARITY COORDINATION MECHANISMS

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In this chapter the influence of three coordination mechanisms on coordination in the JISR process, specifically on federated PED, are examined based on a subset of the empirical data from the UV18 and BQ19 exercises (N = 26). We investigated the following coordination mechanisms: tacit coordination mechanisms, building communication channels (ongoing coordination mechanism) and modularizing processes (modularization). Our results indicate that tacit coordination mechanisms were positively related to coordination, while the other mechanisms were not significantly related to coordination. The findings could indicate that, at the current stage of maturity of the federated PED in NATO, building shared knowledge of other PED-Cells' decision making is more mature and thus support coordination more than efforts at building communication channels for ongoing communication, or the decomposing of the federated PED system into independent subsystems (modularization). It could also indicate that tacit coordination reduces the need for ongoing communication and modularization within the federated PED system. In conclusion we discuss implications for theory and practice as well as limitations and implications for future research.

6.1 INTRODUCTION

In JISR one of the central ways of providing intelligence products is by using so-called Process, Exploit and Disseminate (PED) Cells. PED-Cells process, exploit and disseminate sensor and other data, to make intelligence products. Several PED-Cells can also collaborate from geographically distributed locations to produce this information. Typically, a PED-Cell receives an exploitation task, but the task can be done collaboratively among several PED-Cells that do not work face-to-face; hence the term, federated PED. In the JISR NATO procedure, federated PED is defined in the following way: "Federated PED allows CM collection management elements to plan, task or request component or higher, lower and adjacent level PED nodes and resources. In this sense, collected JISR data can be processed and exploited at different PED locations establishing an architecture of federated PED nodes" [1]. It is this particular JISR process, federated PED that we focus on in this chapter. Specifically, we focus on the coordination, i.e., integration of activities [2], among several PED-Cells and elements that manage these cells. Coordination among PED-Cells and elements that manage these cells is important to ensure that the input for example of one analyst is suited for further work by another analyst in the PED process, and to ensure that the different subtasks of various PED-Cells are integrated into useful intelligence products.

Federated PED can be characterized as a decentralized organization were the authority to do PED is distributed among its participants rather than centrally assigned, as it could be a Collection management element at a PED node that assigns tasks rather than a central node. A PED-Cell can dynamically take on the PED-task without being given the order to do so from a central headquarter. In this respect, a federated PED organization can be seen as a decentralized organization based on Mintzberg's [3] definition of centralization and decentralization. Mintzberg ([3], p. 181) defines centralization and decentralization as "when all power for decision making rests at a single point in the organization – ultimately in the hands of a single individual – we shall call the structure centralized; to the extent that the power is dispersed among many individuals, we shall call the structure decentralized". In the case of federated PED power, to assign tasks, is dispersed among many PED nodes.

Prior research has indicated that decentralization can be problematic with respect to coordination, which can hamper overall performance. Lanaj et al. [4] for example indicate that although in a decentralized organization team performance increases due to more initiatives, coordination could be hampered by less alignments among goals leading to coordination failures. Lanaj et al. [4] indicate that prior training and shared understanding among teams as well as divisionalization, i.e., defining organizational units that are standalone, could decrease coordination failures in decentralized organizations. This again requires mechanisms for information sharing among the units in such standalone arrangements. Other research in a NATO setting similarly indicate that less obstacles to information sharing combined with pre-deployment training fostered coordination in multinational headquarters [1], based on data collected in NATO HFM-163 [5]. Taken together, prior research indicates that there are promises for ensuring decentralized coordination through shared understanding, more modular organizational arrangements as well as through ongoing communication.

Accordingly, in this chapter, we explore the relationship between coordination mechanisms and coordination in federated PED. We define coordination mechanisms as the organizational arrangements that allow individuals to realize a collective performance [6]. Coordination mechanisms could ensure that officers among PED-Cells know what information to share and have the knowledge required to ensure with whom and how they should coordinate. Principally both formal and informal coordination mechanisms, such as plans or mutual adjustment could be used [7], [8]. Moreover, coordination mechanisms could reduce both the need for plans and ongoing communication in order to perform mutual adjustments [9]. According to Srikanth and Puranam [4], [9], tacit coordination mechanisms, explained below, exemplify a mechanism where there is a shared mutual knowledge that may lower the need for explicit communication or plan-based coordination. We draw on Srikanth and Puranam [9] to explore three coordination mechanisms that exemplify such different coordination mechanisms: tacit, ongoing and modularity mechanism. Tacit concerns creating mutual knowledge among teams about their different decision processes and capacities, ongoing communication is about facilitating communication among teams on an ad hoc basis, while modularity is about making smaller subsystems that reduce the need for communication with other subsystems within a work organization.

The purpose of this chapter is to explore the following research question: To what extent do tacit, ongoing and modular coordination mechanisms influence coordination among PED-Cells? By examining this question, we can elucidate what coordination mechanisms may help or hinder coordination among PED-Cells in current NATO exercises. Furthermore, our results can shed light more broadly on what coordination mechanisms could be important for coordination in decentralized organization.

6.2 THEORY: THE INFLUENCE OF TACIT ONGOING AND MODULAR COORDINATION MECHANISMS ON COORDINATION BETWEEN PED-CELLS

Srikanth and Puranam ([9], pp. 850, 851 and 853, respectively) suggest the following definitions of the three coordination mechanisms which we now relate to federated PED. Tacit coordination mechanisms are “mechanisms that enable the formation and leverage of common ground without the need for direct, ongoing communication”. In a federated PED organization, this is exemplified by knowing the capacity of each PED-Cell and/or the specific procedures used by other PED-Cells without having to contact the PED-Cell directly. Coordination mechanisms through ongoing communication are done by “facilitating ongoing (electronic) communication between remotely located actors. Ongoing communication includes feedback and mutual adjustment”. In a federated PED setting this could be done by contacting PED-Cells to query about their capacity during task resolution. Lastly, we investigate the role of modularization: “decompose a system of activities into subsystems (also known as modules or components), such that activities within a module are highly interdependent with one another, but there are few dependencies between activities that are part of different modules”. In the federated PED context, an example is setting up a subsystem of

selected PED-Cells that have complementary expertise and capacities, such as one PED-Cell specializing in human intelligence while another specializes in interpretation of imagery and work together but do not work with other subsystems of PED-Cells.

There are initiatives along all these three types of coordination mechanisms currently going on in NATO. Shared knowledge is manifested in procedures for JISR, as well as in concrete knowledge of capacities of the different PED-Cells and there is support for knowing the status on PED-Cells by using technology. Such knowledge is distributed to all PED-Cells prior to the exercises. There is work on facilitating ongoing communication such as through chat solutions and through decision support systems. The degree to which subsystems of JISR are in place, i.e., modularized, is however to a less degree developed. Federated PED seemed to be (at least in the exercises we were able to collect data from) not modularized to a large degree. However, there is bi-lateral cooperation that may suggest some adjustments among specific PED-Cells to one another. And potentially they form modularized parts of the wider JISR system. On this basis there is no clear hypothesis that can be made as to what coordination mechanisms facilitate coordination, although tacit coordination mechanisms may have come the farthest. We therefore suggest the general hypothesis:

Hypothesis: Tacit, ongoing and modularization coordination mechanisms will all positively relate to coordination of federated PED.

6.3 METHODS

We now present the study context of this particular chapter and items used for measuring each variable and their inter-rater reliability. The demographic characteristics of the sample were provided in the main methods chapter above.

6.3.1 Study Context

Because we were not able to collect data on all three coordination mechanisms in the sample from UV18, we utilized data from the Norwegian exercise Nor Quest 18 that was linked to the UV18 June exercise 2018, as well as the Bold Quest exercise 2019. In UV18 we collected data on two occasions: June 26 and June 28, 2018. The same individuals answered on these two occasions. Bold Quest 19 data (9 respondents) was collected at one day in May 2019. In total, 26 responses were utilized in this analysis. As described below, in UV18 we collected a first round of coordination mechanism and coordination data from all respondents, and then one more round of coordination data. We collected data on all variables in both exercises. In both these exercises, JISR processes were central. In the Nor Quest 18 exercise there was the integration of JISR with other joint processes such as joint targeting, which was a central. Utilizing different PED-Cells in Norway and in Ramstein was an important part of this exercise as well. In Bold Quest 19 different PED-Cells in different geographic locations worked together similarly to UV18.

6.3.2 Measurements

6.3.2.1 Dependent Variable

Coordination was measured using items from the measure of coordination from Ref. [10]. The items were rated on a 1-5 scale ranging from “strongly disagree” = 1 to “strongly agree” = 5: In the Nor Quest 18 data two items were used: “The teams Joint Targeting (JT), JISR, Joint Battlespace Management (JBM) and the Target support cell worked together in a well-coordinated fashion” and “The teams had very few misunderstandings about what to do”. The teams worked together with the purpose of tasking and utilizing the products from federated PED-Cells and so were very much in line with the purpose of enhancing the JISR process. In the Bold Quest 2019 exercise three items for coordination were used “The nodes/ PED-Cells worked together in a well-coordinated fashion”, “The nodes/PED-Cells had very few misunderstandings about what to do” and

"The nodes/PED-Cells accomplished the task(s) smoothly and efficiently." This measure had a reliability of α = .48. Because of a clerical error the items in Nor Quest 18 on June 28 were rated on a 1 – 7 scale and not 1 – 5 as prescribed by Lewis [10]. The responses from the Nor Quest 18 exercise on June 28, four responses, were transformed to confirm to a 1 – 5 scale when used in the correlation and regression analysis reported below.

6.3.2.2 Independent Variables

In order to measure coordination mechanisms we utilized items from Srikanth and Puranam [9], rated on the scale -4 = "little or no effort", -3, and -2 "some effort", -1, and 0 = "moderate effort", 1, and 2 = significant effort", 3, and 4 = "intensive focused effort". The alpha reliability for the items Tacit coordination mechanism was .78; for the ongoing coordination mechanism it was .87; and for the modular coordination mechanisms it was .73. The items as used are shown in Table 6-1. The responses from the coordination mechanisms were repeated for the June 28 data of Joint Quest (4 responses collected). The possible confounding of this repeated measure was controlled for in the analysis.

6.3.2.3 Control Variables

We controlled for whether the respondents were part of the Nor Quest 18 exercise or the BQ19 exercise. We also controlled for each data collection as there were two rounds of data collections in Nor Quest 18, as explained above, and so each participating answered the questions about coordination twice.

Table 6-1: Coordination Mechanism Items.

(Heading in Unified Vision 18/Nor Quest 18): Please tell much effort was spent on the following activities in Nor Quest to facilitate smooth interactions between [the teams]. **(Heading in Bold Quest 2109):** Please tell us how much effort was spent on the following activities in the training period and until now, to facilitate smooth interactions between the different nodes / PED-Cells.
Helping personnel in each location to understand the decision-making procedures used by personnel in the other location (Tacit coordination mechanism).
Using technologies that enable personnel in one location to observe the work-in-progress in other locations (Tacit coordination mechanism).
Encouraging and facilitating personnel in one location to adopt the vocabulary used by personnel in other locations. (Tacit coordination mechanism).
Developing/adapting an IT communication network (Ongoing coordination mechanism).
Training personnel in remote collaboration (Ongoing coordination mechanism.)
Encouraging and facilitating personnel from one location to contact the other location whenever they feel the need (e.g., telephone, chat etc.) (Ongoing coordination mechanism).
(Heading in Nor Quest 2018 for the three items below): Please tell how, much effort was spent on the following activities to enable each team to do tasks by themselves.

Simplifying linkages between processes at one location and linked activities on another location (Modular coordination mechanism).
Adapting the processes on one location to be done remotely so that need for interactions between the processes at this location and activities in other locations are minimized (Modular coordination mechanism).
Partitioning the process at one location into portions with low and high level of interaction (Modular coordination mechanism).

6.4 RESULTS

The correlation matrix, shown in Table 6-2, indicates that tacit coordination mechanism was scored on average highest (mean .74) followed by modularization (mean .71) and ongoing coordination (mean .67). Exercise (i.e., whether UV18 or BQ19) correlated positively with data collection and was marginally significantly correlated with ongoing coordination mechanism and coordination. Data collection correlated positively with coordination. All the coordination mechanisms correlated highly and positively with each other.

Table 6-2: Descriptive Statistics and Correlations.

	Mean	***SD***	**1.**	**2.**	**3.**	**4.**	**5.**
1. Exercise[a]	1.38	.50					
2. Data collection[b]	7.92	.93	.93**				
3. Tacit coordination mechanisms	.74	1.41	-.08	-.12			
4. Ongoing coordination mechanism	.67	1.72	.36†	.31	.56**		
5. Modularization coordination mechanism	.71	1.23	-.03	-.14	.79**	.49*	
6. Coordination	3.17	.78	.38†	.50**	.14	.28	-.02

Notes: N = 26. [a]: 1 = Nor Quest 2018, 2 = Bold Quest 2019. [b]: Data collection: 1 = Nor Quest 2018 26 June 2018, 2 = Nor Quest 2018 28 June 2018, 3 = Bold Quest 2019. *SD* = Standard Deviation

†$p < .10$,* $p < .05$, **$p < .01$,***$p < .001$.

We only included data collection as a control variable, because it was the only control variable that related significantly to the dependent variable. The results of testing the exploratory hypothesis (see Table 6-3) indicated that of the coordination mechanisms only tacit coordination mechanism related positively to coordination (B = .66, $p < .05$). Additionally, data collection related positively to coordination (B = .63, $p < .01$). The model explained 30% of the variance in coordination (adjusted r squared).

Table 6-3: Regression Analysis.

Coordination		
	Model 1	**Model 2**
Data collection[a]	.50**	.63**
Tacit coordination mechanisms		.66*
Ongoing coordination mechanism		-.12
Modularization coordination mechanism		-.38
R^2	.25	.42
Adjusted R^2	.22	.30
ΔR^2	.25	.17
ΔF	8.08**	3.61*

Notes: N = 26. Standardized regression coefficients are shown. a: Data collection: 1 = Nor Quest 2018 26 June, 2 = Nor Quest 2018 28 June, 3 = Bold Quest 2019

†$p < .10$,* $p < .05$, **$p < .01$,***$p < .001$.

6.5 DISCUSSION

This chapter sought to elucidate the following research question: To what extent do tacit, ongoing and modular coordination mechanisms influence coordination among PED-Cells? The empirical findings indicated that tacit coordination mechanisms related positively to coordination among PED-Cells. There was a weak negative tendency in the relation between ongoing coordination mechanisms and coordination and modularization coordination mechanisms and coordination but these results were not statistically significant.

6.6 THEORETICAL IMPLICATIONS

Prior research [4] has suggested that coordination failures are particularly salient in decentralized organizations. Our findings suggest one interesting boundary-condition to this claim. When the different nodes in the organization have a common ground, they actually increase the coordination among them even in a decentralized organization. However, the negative tendency in the relation to ongoing communication may lend support to the claim by Lanaj et al. [4] that in multi-team systems communication may not always lead to better performance because of the sheer size of the system and the cost it takes to communicate when there are a large number of entities involved in communication. Additionally, the non-significant relation from modularity to coordination may lend support to the view that this particular way of supporting coordination would need more development efforts [9], for example through a prior work by the organization on defining interdependencies as well as prospects for creating subsystems within the larger NATO system of PED-Cells.

6.7 LIMITATIONS AND FUTURE RESEARCH

A number of limitations from this current study require further research. The number of data points was low in this study so the statistical robustness of the findings should be improved through future studies. With respect to the variables studied we only used self-report measures. Therefore, objective measures of coordination should be included in future studies. Also related to the measurement issues was the coordination variable which concerned shared understanding and might thus be positively related to the tacit

coordination mechanism which also is concerned with shared understanding. It may be that objective measures of coordination would provide more conservative estimates of the utility of tacit coordination mechanisms. Taken together, increasing the sample and using multiple ways of collecting data could clarify these limitations.

Although we did not find any significant effect of ongoing communication and modularization, in many situations such communication and the creation of standalone subsystems is key and should therefore not be dismissed as unimportant based on our data alone. Perhaps the low maturity of the technology could influence the communication networks' ability to contribute to federated PED at this stage. Future research could examine more specifically what kind of ongoing communications help or hamper federated PED.

Similarly, if there are efforts to assign some PED-Cells as available for certain tasks modularization, that is, decomposing a system into subsystems, this could be an important issue to investigate in the future. How best to design specific task-groups that are independent and standalone with respect to doing PED at the same time as being federated, for example doing various phases of PED, could be interesting to investigate in future research. An example is to investigate how to distribute the core processing, exploitation and dissemination tasks among selected PED-Cells. One PED-Cell could do the processing and another PED-Cell could perform exploitation and dissemination. If NATO choose to make such subdivisions of the overall PED system this could suggest a need to examine the role of divisionalization and modularization as a coordination mechanism [4], [9].

6.8 PRACTICAL IMPLICATIONS

The findings indicate that having shared procedures, which all participants in the federated PED process know in advance, may be particularly important for coordination among PED-Cells in federated PED. This suggests that training and sharing information about procedures and PED-Cells prior to exercises and operations should be a continued priority. However, the role of other coordination mechanisms such as ongoing communication, modularization and divisionalization should not be discounted. Future development of federated PED could focus on all three coordination mechanisms, in particular how to support ongoing communication among PED-Cells and how to best create standalone task-groups of various nations' PED-Cells within NATO.

6.9 REFERENCES

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Chapter 7 – UNIFIED VISION 2018 AND BOLD QUEST 2019 ANALYSES: ORGANIZATIONAL, CULTURAL, AND INDIVIDUAL FACTORS

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7.1 INTRODUCTION

Military organizations, including ISR organizations are facing an increasingly wide spectrum of threats along with a rise in both information volume and requirements. As the wealth of information and complexity of threats increase, the sharing of information and the awareness and understanding of tasks and responsibilities within an organization are increasingly essential for good decision making and organizational effectiveness [1], [2] – in turn also affecting the organization's ability to reach its goals [2], [3], [4]. Efficient organizational processes are understood to be central to C2 and ISR, which in turn are essential in handling traditional military, and cyber and hybrid threats.

This chapter will present the theory, method, and results from the analyses of the organizational, cultural, and individual level factors that theory and previous research suggest are central to successful organizational processes, including in ISR organizations. The analyses are mainly based on data collected before and after the ISR exercise UV18. The results are discussed, pertaining to their implications for the ISR organization.

7.1.1 Usability

The results reported here from an ISR exercise organization are deemed useful for military decision makers and researchers in ISR and human factors related research. The theory may improve the general understanding of individual, organizational, and cultural issues in military ISR. The method is a step on the way towards collecting relevant data to improve our knowledge of human issues related to NATO ISR operations.

7.2 THEORY

Previous research has pointed to organizational factors that are related to organizational effectiveness. The literature also indicates that organizational factors are linked to or are dependent on cultural and individual factors. This chapter presents the literature that underpins the organizational, cultural, and individual factors suggested to have an impact on the effectiveness of the ISR organization.

7.2.1 Organizational Effectiveness

In line with the suggestions of Kozlowski and Ilgen [4], organizational effectiveness is understood as key to organizational processes, operationalized as shared awareness of tasks and responsibilities, information sharing, and decision making, which in previous research have been linked to organizational output [5], [6], [7], [8]. The definitions of the core concepts presented in Chapters 2.1 and 2.2 are in line with the definitions used in Bjørnstad [6], Bjørnstad et al. [9] and Bjørnstad and Ulleberg [1]. The operationalization of organizational effectiveness represents the output/dependent variables in the current research. As indicated above, organizational effectiveness is understood to be central to ISR in military contexts, which in turn is essential in handling traditional military, cyber and hybrid threats.

7.2.2 Organizational Factors: Flat Structure, Decentralized Processes, Flexibility, Alignment, Trust, Competence, and Obstacles to Information Sharing

Being able to avoid erroneous decision making is a central part of good decision making. Research has shown that decentralized leadership and subordinates' propensity to question their superiors' decisions and take responsibility for their own actions to be essential in order to avoid erroneous decision making [10], [11], [12], [13]. In a democratic organization, subordinates are more involved in the decision-making process and there is less distance between the upper and lower levels of the organization, both in terms of fewer levels in the hierarchy as well as in terms of the authority difference between these levels. Democratic organizations should consequently make subordinates more motivated and less afraid to, question and contradict their superiors. Hence, democratic organizations may be seen as an organizational means to minimize erroneous decision making.

Research from military exercises in international contexts at both lower (tactical) and higher (operational) hierarchical organizational levels, linked flatter hierarchies and more decentralized organizational processes (i.e., democratic organization) to more flexibility, better information sharing, higher awareness of tasks and responsibilities and better decision making [6]. However, research conducted by HFM-163 from a different international military exercise had more mixed results [14]; this research failed to find the positive relationship between decentralized processes and effective organizational processes. The positive relationship between flat structure and flexibility was in the latter research also found to be moderated by a cultural difference in power distance (i.e., "the extent to which the less powerful members of institutions and organizations within a country expect and accept power to be distributed unequally"; ([15], p. 28), in terms of the relationship only being significant in low power distance (Pd) cultures. Hence, cultural differences may be an important factor in defining the organizational characteristics that lead to more effective organization and ISR processes in military contexts. This is in line with the theory and research from cross-cultural organizational psychology [16].

The successful handing down of authority to lower levels of command and a decentralization of organizational processes in military and other organizations may also depend on other critical issues such as alignment between structure and processes, trust, competence, and obstacles to information sharing, which in separate lines of research have been found to affect key organizational processes and outcomes [6], [9], [17], [18], [19], [20], [21], [22], [23], [24]. Data from a more recent survey from a Norwegian military organization also suggests that flat structure, decentralized processes, flexibility, and trust positively influence organizational effectiveness [1].

Flat structure is defined as the degree to which the organization may be understood as flat in terms of the number of hierarchical levels in the organization [6], [25]. Decentralized processes mean shorter information-sharing and decision-making loops [26]. Whereas structure is understood as the formal hierarchical structure of the organization, processes is understood to describe how the structure is implemented in terms of collaborative and decision-making processes [6], [27].

Alignment is understood as the congruence between the organization's structure and processes [6]; meaning that a combination of flat structure and decentralized processes would indicate high alignment, whereas a combination of flat structure and centralized processes would indicate low alignment. Flexibility is understood as the ability of the organization to respond successfully and adaptively to the complex, unpredictable and changing demands of the environment [28].

Rousseau, Sitkin, Burt, and Camerer ([29], p. 395) suggested a cross-disciplinary definition of trust, which has been understood in later research to include the most essential elements of trust [20], [21], [30]: "Trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviour of another."

Competence is defined as the knowledge and task-related ability to conduct the job. This definition builds on the work of Brooking [31] and reflects the scope of this research, the exercise aims, and the respondents. Based on the work by Bjørnstad [32], Bjørnstad and Elstad [33], and Lichacz and Bjørnstad [34], obstacles to information sharing is defined as the organizational, technological, and security-based constraints that are perceived by the organization's members to provide hindrances to their sharing of information.

7.2.3 Cultural Factors: Power Distance (Pd) and Uncertainty Avoidance (Ua)

In this study, culture is defined as national culture, which concurs with the current scope and the field of cross-cultural psychology [16], [35], [36], [37].

Cultural differences in Pd influence whether people from different countries are accustomed to and prefer to work in more hierarchical and centralized types of organizations or, conversely, whether they are accustomed to and prefer to work in flatter and more decentralized types of organizations [16]. Cultural differences in Pd have been found to influence the organization and decision-making processes [14], [16], [17]. A high power distance culture makes it less acceptable, and therefore more difficult, for subordinates to question superiors' decisions. In line with this, high power distance has been linked to erroneous decision making in high-risk environments [13]. Hierarchy plays a more central role in organizations in high power distance cultures, and power distance may as such be understood as a cultural vulnerability to erroneous decision making.

Uncertainty avoidance (Ua) is defined as the extent to which the members of institutions and organizations within a society feel threatened by uncertain, unknown, ambiguous, or unstructured situations [16]. In high Ua cultures ambiguity is avoided and rules play a more important role [16].

Pd and Ua are assumed to be the most relevant cross-cultural differences that may affect the organizational processes in a NATO collaborative setting like the UV18. Research has indicated that Pd and Ua are central constructs and valid measures of national differences also in military settings [38], [39]. However, there are some doubt about the validity of Hofstede's [16] measures of the dimensions of individualism and masculinity in military contexts [39], [40].

7.2.4 Individual Factors: Need for Cognition (NFC) and Job Involvement

Need For Cognition (NFC) refers to individual differences in the tendency towards engaging in and enjoying effortful cognitive endeavors [41]. NFC has been found to predict performance on cognitive tasks and is furthermore understood as either a predisposition for, or a central part of critical thinking (e.g., Refs. [42], [43], [44]. Definitions of critical thinking include such mental processes as reflection, questioning, logic, reasoning, meta-cognition, and making judgements (for an overview, see Fischer et al. [42]). Critical thinking has in turn been deemed a pivotal capacity in military leaders and personnel, central to their interpretation of information and decision making [42].

High NFC may be expected to give more effective organizational processes in terms of higher shared awareness, information sharing, and decision making due to more cognitive elaboration and central processing of information (i.e., systematic and in-depth cognitive processes) [45], [46]. Additionally, an organization high in NFC may be more resilient to enemy attempts at negative influence and destabilization by for instance disinformation (i.e., information that may be anything from unfortunate to inaccurate to blatantly untrue), because they will tend to seek out information from more sources and more closely evaluate the truth in the messages sent out relative to those lower on NFC. Indeed, NFC has also been shown to affect the degree to which, and the manners in which, persons are susceptible to persuasion [41], [47]. NFC is therefore deemed important in a defence organizational context. Consequently, it would seem advantageous to foster military organizations where the qualities of NFC are boosted rather than subdued.

Because more responsibility is distributed to the lower levels in the hierarchy in democratic organizational forms, personnel at the lower levels become more involved in the decision-making processes compared to those in more hierarchic and centralized organizational forms. Moreover, there are more factors motivating subordinates to think for themselves in a democratic type of organization. A democratic organization may therefore be understood to promote a culture where there is a high level of NFC, and hence, high probability of elaboration in the organizational members' cognitive processes.

NFC has been regarded as a personal trait, that is, a stable personal tendency not subject to situational influences. However, because a trait is formed by an individual's upbringing, education, and societal experiences, there is reason to believe that the organizational and cultural context, in which individuals work and live, also may exert some effect on a person's level of NFC. For instance, one could imagine that authoritarian and strongly rule-based cultures (i.e., high in Pd and Ua) and hierarchic and centralized organizations would be promoting lower NFC in individuals than democratic and flexible organizations and culture. In organizations, the level of NFC may be affected both through self-selection and in terms of a strengthening or weakening of the personal tendency to engage in effortful thinking. Hence, although considered a personal trait, NFC is expected to be influenced by a number of life experiences. The related concept of critical thinking introduced above, has similarly been viewed as both an ability that can be learned and trained, and as a personal predisposition [42]. There is a need for research that further explores the antecedents of NFC and its malleability in terms of contextual influences. The research reported here is a first small step, where its relationships with some central cultural and organizational factors are explored.

Job involvement as a concept was launched by Lodahl and Kejner [48] in 1965, but has since then been both defined and measured in various ways, focusing on the job's influence on a person's self-esteem [48], identity [49], or cognitive identification with work [50]. Paullay, Alliger, and Stone-Romero [51] defined job involvement as the cognitive preoccupation and engagement with, and concern for one's present job. Related constructs like work centrality and work commitment refer to attitudes and orientations to work in general [51], while organizational commitment refers to the specific commitment or emotional attachment those employees have to their organization [52]. All these concepts have been found to be highly related but distinct constructs in several studies [53], [54], [55], [56]. Brown [53], Butts, Vandenberg, DeJoy, Schaffer, and Wilson [57], and Halberg and Schaufeli [55] furthermore found all these concepts to be positively related to a high degree of autonomy in the workplace, that is, a decentralized organization. Job involvement has been found to influence the effort put into one's job [53], and can as such be understood as a work motivational factor [58]. Because job involvement has been found to promote job effort and motivation, in turn also fostering cognitive elaboration [45], [46], job involvement is expected to promote organizational and ISR effectiveness.

7.2.5 Organizational Model

Building on the research presented above, most notably Bjørnstad [6] and Bjørnstad and Ulleberg [1], an organizational model has been developed in the context of NATO HFM RTG-276 (Figure 7-1). The model attempts to describe the relationships between the factors presented above in this chapter, factors that are anticipated to be central in making a military organization efficient −understood as a basis for good ISR processes − in both traditional and hybrid threats contexts. The literature presented in this chapter suggests that democratic organization, defined as flat structure and decentralized organizational processes, has both direct and indirect positive effects on organizational effectiveness. Organizational effectiveness is operationalized as shared awareness, information sharing, and decision making in the model (for more on this, see Bjørnstad [6] and Bjørnstad and Ulleberg [1]. Job involvement and NFC are the two central individual level factors included in the model, both understood to be mediating factors; partly mediating the effects of structure and processes on the organizational variables. Similarly, obstacles to information sharing and flexibility are understood to be mediating factors. Pd and Ua represent the cultural context factors, which are anticipated to moderate the effects of organizational structure and

processes on the organizational effectiveness variables. This means that the effectiveness of, for instance, flat structure and decentralized processes is expected to be dependent on the cultural context being low Pd and Ua. Pd is also viewed as an independent variable, meaning that a low Pd cultural context is increasing the likelihood of the organization being flat and decentralized. The alignment of structure and processes is also expected to moderate the effects of structure and processes on the effects variables. This means that if structure and processes are not aligned, flat structure may not have a positive effect on the effectiveness variables. Trust and competence represent both independent variables and moderators in the model. This means that for instance trust is expected to have both an independent direct positive effect on organizational effectiveness as well as moderating the effects of structure and processes on flexibility and organizational effectiveness.

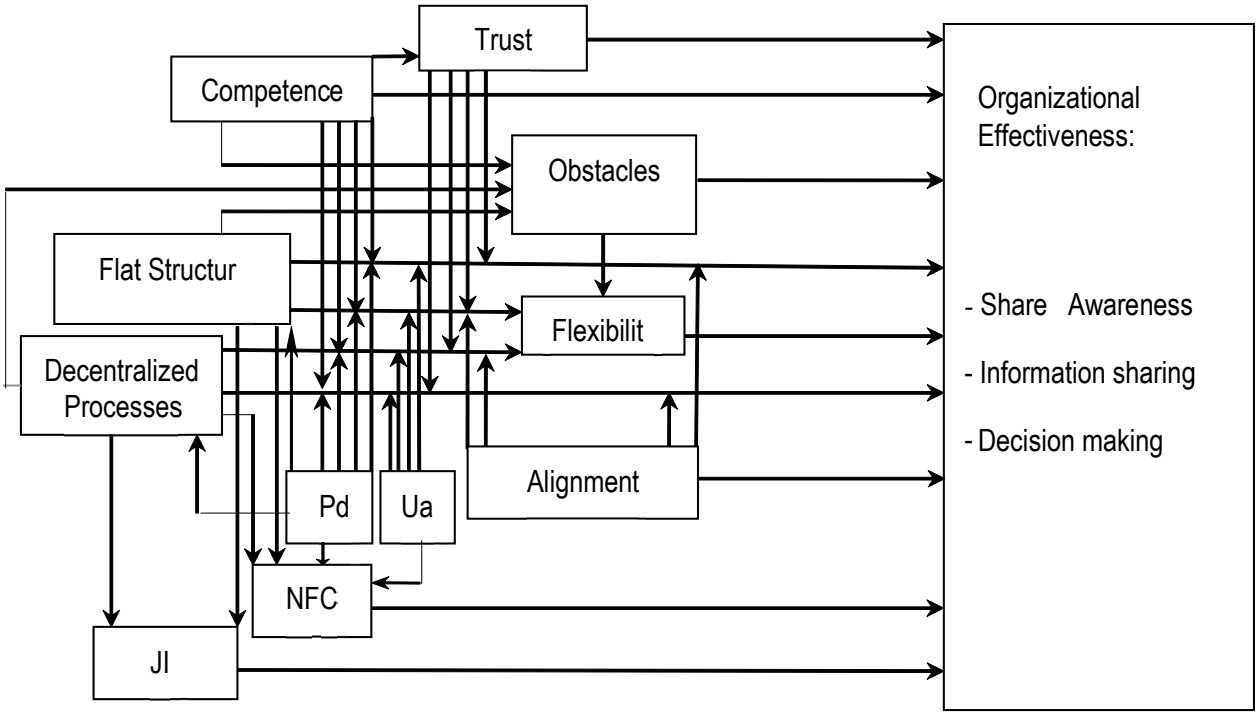

Figure 7-1: Organizational Model of Effectiveness (JI = Job Involvement, NFC = Need for Cognition, Ua = Uncertainty Avoidance, Pd = Power Distance, Obstacles = Obstacles to Information Sharing, and Alignment = Alignment of Structure and Processes). All lines indicate hypothesized relationships, of which all are positive except the relationships of obstacles to information sharing, the relationships of Pd, and the relationships of Ua.

The model is included in this chapter to visualize the expected interconnections between the individual, organizational, and cultural factors and to show how they are anticipated to be linked to organizational effectiveness. It aims to enlighten the reader on the interconnections between the factors and on the importance of each factor for the organizational effectiveness. This contributes to understanding the context of the inclusion of each variable in the survey. However, the data collected in UV-18 are not sufficient in numbers to be able to test the whole model; subsequent data collections will be needed to provide a larger and more complete data set that will allow such advanced analyses. For a more in-depth description of the basis for the model and of the factors less focused on here, please be referred to the cited research [1], [6], [16].

7.3 METHOD

7.3.1 Data Collection Venue, Method, and Procedures

7.3.1.1 Unified Vision 2018 (UV18)

The data analyzed in this chapter were mainly collected at USAFE WPC, in Einsiedlerhof, Germany, in connection with the military exercise UV18 by members of HFM-276, June 11 – 26, 2018. The general aim of the UV18 was to improve NATO joint ISR interoperability and address the improvements needs identified in previous UV trials. This implied a focus on interoperability between NATO and national JISR capabilities to improve the process of TCPED intelligence data. The cells involved in this work are referred to as PED-Cells. The UV series of exercises is a central arena for NATO's practice and evaluation of new technical and operational concepts for conducting JISR in NATO operations. The exercise was geographically distributed with nodes in for instance Italy, France, the Netherlands, the Czech Republic, the USA, and Norway. For more details on the exercise and venue, please see this report's introduction and method chapters (1 and 3).

Self-report questionnaires were distributed electronically to exercise personnel right before the onset of and at the completion of the exercise, henceforth named the pre and post exercise questionnaires respectively. There were also five daily surveys distributed during the exercise from the HFM-276 panel; these are not at the focus of this chapter but are described elsewhere in this report. The surveys presented here were part of a large battery of instruments from different research and analyst groups that were distributed to the participants of UV18.

The original pre- and post-trial questionnaires are included in Annex A and Annex B. The edited version of the post-trial questionnaire is presented in Annex C. There were some changes made on-site based on a demand from the military lead/participants. This meant a shortening of the post exercise questionnaire, so that some measures were cut altogether (job involvement), while others were abbreviated (decentralized processes, flexibility, trust, shared awareness, and decision making) – some down to single-item measures (competence).

7.3.1.2 Bold Quest 2019 (BQ19)

In addition to the UV18, data was also collected from personnel working in the ISR organization during the military exercise Bold Quest, in April – May of 2019. The exercise was hosted by Finland and sponsored and facilitated by the United States Joint Staff. BQ19 was a coalition capability demonstration and assessment exercise, in which nations, services and programs pooled their resources to improve interoperability and information sharing. Multiple command locations, systems and virtual simulators took part in the event from outside Finland via established joint and coalition distributed networks. The goal was to demonstrate and assess the command and control interoperability of joint fires sensors and related systems in a multinational operating environment. The event tested and demonstrated the functional and technical interoperability of ground, sea and air-based ISR and joint fires systems.

As in UV18, self-report questionnaires were distributed electronically to exercise personnel right before the onset of and at the completion of the exercise. The questionnaires corresponded largely to those used in UV18, however, without the changes made on-site during UV18.

7.3.2 Samples

7.3.2.1 Unified Vision 2018 (UV18)

The sample consisted of PED operators participating in UV18. All were participating on a free-will basis. 53 answered the pre-exercise survey, while 32 answered the post exercise survey. The response rate was at

51% and 31%, respectively. Measures that had incomplete answers, meaning that there were missing values on one or more items, were not included in the analyses. The sample consisted of participants from 13 different countries. (the first and second number in parenthesis represents the number of respondents from each country having completed the pre- and post-trial surveys respectively): Belgium (2/0), Croatia (7/5), Czech Republic (5/4), France (2/1), Germany (4/3), Great Britain (0/1), Italy (3/2), Poland (2/1), Romania (1/0), Slovenia (1/1), Spain (11/8), Turkey (1/0), and USA (13/6). Demographics of the participants are further detailed in Chapter 4 in this report.

7.3.2.2 Bold Quest 2019 (BQ19)

The BQ19 sample was very limited in size; there were only 10 respondents, but due to missing values, the number of responses (N) was down to 6 on two measures.

7.3.3 Metrics

7.3.3.1 Unified Vision 2018 (UV18)

The measures used to collect data on the variables described in the Theory (Section 7.2), were based on existing measures, some slightly altered to fit the UV18 context (Method, Section 7.3).

The organizational variables, flat structure, decentralized processes, flexibility, alignment, obstacles to information sharing, trust, and the organizational effectiveness variables, shared awareness of tasks and responsibilities, information sharing, and decision making were all measured using scales developed for use in military contexts and whose psychometric properties were tested in Bjørnstad and Elstad [33]. These measures were based on earlier work by Bjørnstad et al. [9], Lichacz and Bjørnstad [34], Bjørnstad [6], [32], and Yanakiev and Horton [14]. Alignment is calculated and represents the absolute difference in scores between the flat structure and decentralized processes measures. Obstacles to information sharing was measured using an adaption of Bjørnstad's metric [32], [33], [34], [59] and trust was measured using the metric from Bjørnstad et al., [9]. The measure of competence was based on Bjørnstad and Ulleberg [1]. All these measures are used and described in Bjørnstad and Ulleberg [1]. Trust, competence, and shared awareness were measured in relation to both the respondents' own PED-Cell/operational component and in relation to the other PED-Cell/operational components. Trust was additionally measured both pre and post exercise.

We measured NFC using the NFC scale developed by Cacioppo et al. [41]. The cultural differences, Pd and Ua were measured using Hofstede's Values Survey Module, VSM 2013 [60]. There is research supporting the notion that the Pd and Ua measures are valid also in military settings [38], [40].

Response categories were on five-point scales. Some items were recorded in order to make high scores indicate the same across items and measures. The cultural measures were calculated using Hofstede's formulae [60] (www.geerthofstede.com): Pd = 35(m07 – m02) + 25(m20 – m23) + C(pd) and Ua = 40(m18 - m15) + 25(m21 – m24) + C(ua), where "m" is the mean score on the numbered item and "C" is a constant that may be added to render scores between 0 and 100.

As indicated above, HFM-276 members on-site were charged with shortening the post-trial questionnaire. This meant that the job involvement measure was cut altogether, and the competence measure was cut down to a single-item measure. Furthermore, the decentralization, flexibility, trust, shared awareness, and decision-making measures were each abbreviated with one item. There were also made changes in the wording of some of the measures, notably to the flat structure, decentralization, flexibility, and decision-making measures. The flat structure, decentralization, and flexibility measures had "organization" exchanged with "organizational structure". This change was unfortunate, as it may have served to confuse the respondents in separating between the organizational structure (flat structure) and process measures (decentralization and flexibility).

In addition to cutting the decision-making down to a two-item measure, the response categories of the first item were changed so that in effect two of the response categories on the five-point scale were cut. This was unfortunate. Consequently, the scale had to be recoded to a scale with the values 1, 3, and 5, to make it fit the other five-point scale in the measure. As indicated above, the final version of the post-trial questionnaire is included in Annex C following the original measures.

7.3.3.2 Bold Quest 2019 (BQ19)

Data from BQ19 were collected using the same metrics as in UV18, however, as indicated above, without the changes that were made on-site during UV18. However, we did not collect data on trust pre-exercise nor on any of the cultural factors. There were also some changes made to the flat structure measure, including a change of direction of the two last items (i.e., in terms of the meaning having been turned so that the answers to these two items had to be recoded).

Based on the low N, we could only conduct descriptive and reliability analyses. Accordingly, these analyses should be interpreted with care.

7.4 RESULTS

7.4.1 Unified Vision 2018 (UV18)

7.4.1.1 Descriptive Analyses

The mean (*M*), Standard Deviation (*SD*), reliability (Alpha), and number of responses (*N*) of the measures are presented in Table 7-1.

Table 7-1: Mean (*M*), Standard Deviation (*SD*), Reliability (Cronbach's Alpha Based on Standardized Items), and Number of Responses (*N*).

	M	*SD*	Alpha (*α*)	*N*
Flat structure (5 items)	3.41	0.25	.60	28
Decentralized processes (4 items)	3.10	0.66	.80	31
Flexibility (4 items)	3.33	0.54	.64	31
NFC (19 items)	3.68	0.44	.84	40
Power distance (Pd) (4 items)	35.80	22.72	–	50
Uncertainty avoidance (Ua) (4 items)	-102.17	60.12	–	52
Internal competence (i.e., in own PED-Cell (1 item)	3.59	1.19	–	32
External competence (i.e., in other PED-Cells (1 item)	3.19	1.05	–	31
PreEx internal trust (i.e., in own PED-Cell (3 items)	3.99	0.87	.93	45
PreEx internal trust (i.e., in own PED-Cell) (2 items)	3.98	0.85	.86	45
PreEx external trust (i.e., in other PED-Cells) (3 items)	3.68	0.75	.93	44
PreEx externaltrust (i.e., in other PED-Cells) (2 items)	3.69	0.76	.93	45
PostEx internal trust (i.e., in own PED-Cell) (2 items)	3.14	0.72	.85	28
PostEx external trust (i.e., in other PED-Cells) (2 items)	3.03	0.71	.67	31

	M	*SD*	Alpha (*α*)	*N*
Obstacles to information sharing (14 items)	2.47	0.51	.80	30
Shared internal awareness (i.e., in own PED-Cell) (4 items)	3.53	0.77	.76	30
Shared internal awareness (i.e., in own PED-Cell) (3 items)	3.57	0.80	.65	31
Shared external awareness (i.e., in other PED-Cells) (3 items)	3.13	0.81	.70	30
Information sharing (3 items)	3.32	1.06	.88	32
Decision making (2 items)	3.73	0.86	.84	27

Note. All measures were rated on 5-point scales. The alpha could not be calculated for Pd, Ua, and competence; there were too few respondents from each country in regard to Pd and Ua, and competence had been cut down to a single-item measure in UV18. NFC = need for cognition.

With the exception of flat structure, flexibility, and one of the truncated trust and shared awareness measures, the measures demonstrated between acceptable (α > .70) and very good (α > .90) reliability. This means that most measures may be deemed reliable and hence the results from these may be deemed trustworthy. The competence measure was cut down from a four-item to a single-item measure, and the validity and reliability may thus have been compromised. The exceptions are discussed in more depth in the subsequent chapters.

The highest mean scores were achieved for pre-trial trust and decision making; just below four on the five-point scales used in the survey indicating good trust and decision making. The lowest scores were obtained for the obstacles to information sharing and flat structure Item 5 (Table 7-1). The scores were below average right between the two and three, indicating a somewhat hierarchical structure and that the different obstacles were between rarely and sometimes a hindrance for information sharing.

7.4.1.2 Flat Structure, Decentralized Processes, and Alignment

As presented in Table 7-1, the flat structure full five-item measure demonstrated an unsatisfactory reliability estimate. Therefore, an if-item-deleted reliability analysis and a comparison of item means were conducted, as presented in Table 7-2. Comparing the means of the items within the measure revealed that the participants had rated the fifth item quite differently from the first four. The "α if-item-deleted" column in the table further reveals that removing this fifth item would help the reliability estimate well above the accepted .70 limit.

Examining the wording of the items reveal that, especially after the on-site item moderations, items one to four may be interpreted more in the direction of describing whether there was perceived to be a small or large *part* of the hierarchy included in the exercise, rather than saying something about whether the structure was interpreted to be hierarchic or flat in itself. Item five was closer to the original and more clearly about whether the part of the structure included was interpreted to be a hierarchic or flat (i.e., irrespective of whether this could be considered a small or a large part). This difference in meaning between items one to four and item five in the flat structure measure may also explain the different relationships to the other variables shown in the correlation matrix (Table 7-6), if split up into a single-item measure (Item 5) and a four-item measure (Items 1 – 4). Based on these findings we conclude that item five best reflects the intended meaning of the flat structure measure, in line with previous research [1], [6], [33]. This item has previously been validated and used as a single-item measure [6]. However, in the subsequent analyses (Correlations, Section 7.4.1.8) we have also included the mean of items one to four as a secondary measure of the hierarchy, but interpreted to mean whether a small or big part of the home organizations' hierarchy was perceived to be included or not in the exercise. The variable is henceforth labelled "few levels included in exercise."

Table 7-2: Flat Structure: Item Mean (*M*), Item Standard Deviation (*SD*), Corrected Item-Total Correlation, and Alpha (α) if-Item-Deleted.

Items	*M*	*SD*	Corrected Item-Total Correlation	α if-item-deleted
1. Work in this trial's organizational structure is concentrated within few hierarchical levels.	3.50	0.75	.44	.41
2. There are few decision-making levels within this trial's organizational structure.	3.75	0.52	.77	.30
3. Information needs to travel through few hierarchical levels in this trial's organizational structure.	3.64	0.78	.37	.46
4. Responsibility is distributed across a few hierarchical levels in this trial's organizational structure.	3.64	0.73	.70	.23
5. In general, how would you describe the organizational structure in this trial?	2.54	0.74	-.31	.81

Note: $N = 28$.

The decentralized processes and flexibility measures were, as indicated in the Method (Section 7.3) cut with one item (the general item) and the meaning altered by exchanging "organization" with "organization structure" in all of the items of both measures. As indicated, this makes the results less interpretable, as the meaning has been blurred. Decentralization demonstrated good reliability, while flexibility was just below the .70 limit for acceptable reliability.[1] The lowered reliability score could be due to the changes in the measures, as described in the method chapter, compared to the original measure validated in previous research from military contexts [33].

As indicated in the Theory and Method sections of this chapter, alignment scores represent the difference between the flat structure and the decentralized processes scores in absolute values. The flat structure single-item (Item 5) score was used to calculate the difference between flat structure and the decentralized processes. Descriptive analyses yielded an alignment mean score of .80 (SD = 0.62); high scores indicating low alignment.

7.4.1.3 Power Distance (Pd) and Uncertainty Avoidance (Ua)

As indicated in the method chapter, Pd and Ua were calculated using Hofstede's formulae [60]: Pd = 35(m07 – m02) + 25(m20 – m23) + C(pd) and Ua = 40(m18 - m15) + 25(m21 – m24) + C(Ua), where "m" is the mean score on the numbered item and "C " is a constant that may be added to render Ua scores between 0 and 100. The constant "200" was thus added to make the scores positive and mainly also below 100. Because these measures are at the country level, we should have had a minimum sample of n = 20, preferably 50, per country in order to calculate the measures correctly [60]; we had between 1 and 12. The

[1] As the coefficient alpha is heavily dependent upon the number of items within the scale, low alpha values can be expected when few items are used to measure the construct of interest. Although the alpha values ideally should have been higher, standards for acceptable reliability, such as .70 ([61], p. 245) are conventions, and not clear cut-off criteria (for a discussion, see Pedhazur and Schmelkin, ([62], pp. 109-110).

mean values calculated for each country are therefore deemed unreliable, and the current research means presented in Table 7-3 should be interpreted with great care. In order to calculate any relationships between Pd and Ua, and the organizational and individual measures, it will therefore be necessary to revert to using values from previous research, such as Hofstede [15] and Soeters [38]. Values from these studies were therefore included in Table 7-3. Hofstede [15] had the most complete sample of countries compared to the current sample, whereas Soeters [38] had the most similar social cohort in his sample (i.e., from military academies). Mean values differ due to some changes in the scale used in the three studies.

Table 7-3: Country Power Distance (Pd) and Uncertainty Avoidance (Ua): Mean (*M*), Rank Order (RO), and Sample Size (*n*) from the Current and Previous Data Sets (IBM: [15]; Military Academies: [39]).

	Pd							Ua						
	Current			Hofstede		Soeters		Current			Hofstede		Soeters	
NAT.	*M*	RO	*n*	*M*	RO	*M*	RO	*M*	RO	*n*	*M*	RO	*M*	RO
USA	59.00	2	13	40	3	84	6	74.25	8	13	46	12	72	5
ESP	9.35	10	11	57	8	92	5	113.70	3	11	86	5	89	1
CRO	41.80	5	7	73	2			90.65	5	7	80*	8		
CZE	20.00	9	5	57**	8			130.00	2	5	74**	10		
GER	46.25	4	4	35	11	63	7	85.00	6	4	65	11	75	3
ITA	7.50	11	3	50	10	114	3	10.00	12	3	75	9	86	2
BEL	50.00	3	2	65	7	95	4	50.00	11	2	94	1	74	4
POL	25.00	7	2	68**	4			95.00	4	2	93**	2		
ROU	25.00	7	1	90**	1			55.00	10	2	90**	3		
SLO	110.00	1	1	71*	3			65.00	9	1	88*	4		
TUR	35.00	6	1	66	6			80.00	7	1	85	7		
FR	--	--	--	68	4	116	2	360.00	1	2	86	5	71	6
GB	--	--	--	35	11	131	1	--	--	--	35	13	49	7

Notes: * = reanalysis of data (Hofstede) [16], ** = estimated (Hofstede) [16].

7.4.1.4 Obstacles to Information Sharing – Details

As indicated in Table 7-1, obstacles to information sharing demonstrated good reliability. However, the measure is also intended for use at the item level [33]. The item descriptive statistics are presented in Table 7-4. We see that technical and procedural difficulties represented the most important obstacles to information sharing. A mean score of 3.4 indicated that these obstacles were between sometimes and often perceived to be a hindrance for information sharing. Approachability of the commander and political constraints represented the least important constraints to information sharing. A mean score of 1.77 indicated that these obstacles rarely were perceived to be a hindrance for information sharing. None of the items had a very high mean score, just a bit above average at the most, which may be interpreted to mean that none of the measured obstacles represented a critical hindrance for information sharing.

Table 7-4: Obstacles to Information Sharing: Item Mean (*M*) and Standard Deviation (*SD*).

Items	*M*	*SD*
1. How often did technical difficulties represent an obstacle to information sharing during this trial?	3.40	1.10
2. How often did procedural inefficiencies represent an obstacle to information sharing during this trial?	3.40	0.89
3. How often did low English proficiency of participants represent an obstacle to information sharing during this trial?	2.17	0.99
4. How often did differences between PED-Cells/operational components represent an obstacle to information sharing during this trial?	2.90	1.00
5. How often did differences in national culture represent an obstacle to information sharing during this trial?	2.13	1.22
6. How often did time constraints represent an obstacle to information sharing during this trial?	2.33	0.96
7. How often did the approachability of the commander represent an obstacle to information sharing during this trial?	1.77	0.82
8. How often did lacking knowledge about who needs the information represent an obstacle to information sharing during this trial?	2.83	0.99
9. How often did differing priorities represent an obstacle to information sharing during this trial?	2.77	0.94
10. How often did political constraints/control represent an obstacle to information sharing during this trial?	1.73	0.83
11. How often did security issues represent an obstacle to information sharing during this trial?	2.13	0.86
12. How often did document classification represent an obstacle to information sharing during this trial?	1.93	0.74
13. How often did system classification represent an obstacle to information sharing during this trial?	2.00	0.87
14. How often did mismatches between real world processes and the simulated processes represent an obstacle to information sharing during this trial?	3.07	1.02

Note: $N = 30$.

7.4.1.5 Shared Awareness

Shared awareness of tasks and responsibilities both within and across PED-Cells/operational components demonstrated mean scores above average (Table 7-1).

As indicated in the method chapter, because the post-trial survey exceeded acceptable length for the participants, we ended up with three instead of four items in the shared external awareness metric. Table 7-1 shows an acceptable reliability estimate for the original four-item measure of shared internal awareness, while reducing the measure to three items made reliability a bit below the commonly accepted >.7 limit . Subsequent research should therefore strive to use the whole measure to ensure acceptable reliability.

Comparing the scores for shared internal awareness and shared external awareness based on three items (Table 7-1), revealed a difference in scores, indicating that there was a higher awareness of tasks and responsibilities within than across PED-Cells/operational components (0.46 difference). Testing the significance of the difference using a Paired samples t-test revealed that the difference was significant (t = 2.86, df = 30, p = .008), and calculating Cohen's d-value indicated that the difference was medium sized (d = 0.52).

7.4.1.6 Competence

As indicated above, competence was measured by a single item. Most probably, cutting three of the four items may have hampered the reliability of the measure. It is recommended that future research use the whole measure.

Table 7-1 suggests that there might be a difference between the internal and external competence, that is, competence within PED-Cells/operational components seemed to be rated higher than competence across PED-Cells/operational components.

Testing the significance of the difference using a Paired samples t-test revealed that the difference in means (0.39) was marginally significant (t = 2.04, df = 30, p = .050). Calculating the d-value indicated that the difference could be classified as between small and medium in size (d = 0.37). Hence, competence was perceived to be somewhat higher within than across PED-Cells/operational components.

7.4.1.7 Trust

Trust was measured both pre- and post- exercise, in relation to both the respondent's own PED-Cell/ operational component ("internal") and in relation to the other PED-Cell/operational components ("external").

As indicated above, the post-trial survey was cut in length. For the trust measures, this meant that it was cut down from three to two items in the post-trial metric. Table 7-1 indicates that the original three-item metric used to measure trust demonstrated very good reliability, while reducing it to two items decreased the reliability. Post-trial external trust reliability was slightly below acceptable reliability. Subsequent research should therefore strive to use the whole measure to ensure acceptable reliability. However, the mean values for pre-trial internal trust based on two or three items were very close (a 0.01 difference for both internal and external trust). In order to compare the scores on the pre and post exercise measures, all the subsequent analyses are based on the same two-item measures.

The mean values in Table 7-1 indicate that the biggest differences in trust were between the pre- and post-trial measures; post-trial trust was lower than pre-trial trust, especially the internal trust. The use of Paired samples t-tests (Table 7-5) indicated that there was a significant difference between trust in own PED-Cell/operational component compared to trust in other PED-Cell/operational components pre-exercise, and between trust pre- and post-trial in both trust in own PED-Cell/operational component and trust in other PED-Cell/operational components. Cohen's d was calculated for all the differences (Table 7-5) and indicated a large difference between trust in own PED-Cell/operational component pre and post exercise. The size of the differences between trust in other PED-Cells/operational components pre- and post-trial could be regarded as medium as was the difference between trust in own PED-Cell/operational component compared to trust in other PED-Cell/operational components pre-exercise. Moreover, personnel in the UV18 exercise reported considerably more trust in their own PED-Cell/operational component colleagues' pre-trial compared to post-trial. They also reported quite a bit more trust in their colleagues from other PED-Cells/operational components pre-trial compared to post-trial. Similarly, they reported quite a bit more trust in their own PED-Cell/operational component colleagues than in their colleagues from other PED-Cell/operational components post exercise.

Table 7-5: Paired Samples t-Test and Cohen's d: A Comparison of Trust Measured Pre- and Post-Trial ("preEx" and "postEx"), Within ("Internal") and Across ("External") PED-Cells / Operational Components (Based on 2-Item Measures, i.e., Comparable Scores).

Trust Compared Between:	*M* diff	*SD* diff	*t*	*Df*	*p*-value	*d*-value
PreEx: Internal and external trust	0.32	0.58	3.63	43	.001	0.55
PostEx: Internal and external trust	0.17	0.52	1.67	26	.107	0.32
Internal trust: PreEx and postEx	0.90	0.83	4.99	20	.000	1.09
External trust: PreEx and postEx	0.60	0.97	3.10	24	.005	0.62

The graph in Figure 7-2 portrays the differences in trust measured within and across PED-Cells/operational components at two different times (pre- and post-trial).

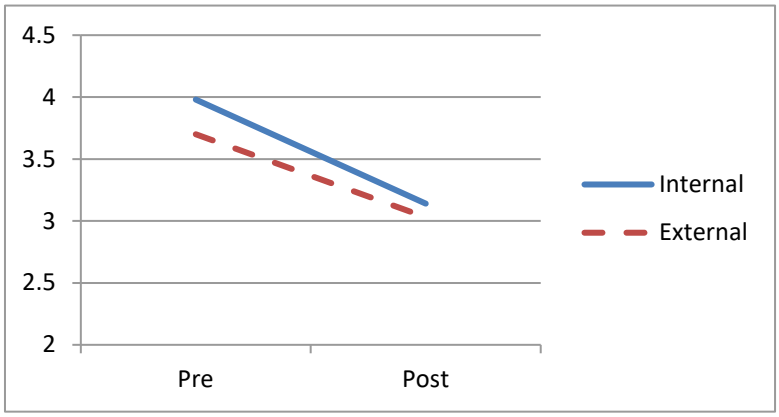

Figure 7-2: Internal and External Trust Measured Pre and Post Exercise.

7.4.1.8 Correlations

In order to do a first cut on the analyses of the relationship between the variables, a zero-order correlation analysis was performed. The results of this analysis are presented in Table 7-6.

The correlation matrix revealed some surprises compared to previous research. For instance, although not significant, there seemed to be a negative tendency in the correlations between the competence (internal and external) and the trust (internal and external, pre and post exercise) measures. Moreover, there was a tendency for competence to be negatively correlated with almost all of the other measures, especially the input measures. This is contrary to expectations based on theory and previous research.

Surprisingly, the data also showed a negative tendency in the relationships between flat structure and the output variables, and decentralization and the output variables. The relationships between flat structure and decision making, and decentralization and decision making were significant. There were no significant correlations between alignment and the output measures, and there appeared to be no systematic tendency in the correlations.

As expected, the NFC-measure had a positive, unfortunately non-significant relation, to the flat structure, information sharing, and the shared awareness measures, whereas a weak negative tendency was found in relation to decentralization and decision making. Especially the latter negative tendencies were not as

anticipated. NFC also demonstrated a negative tendency in its relationships to competence – significant between NFC and rated competence in other PED-Cells/operational components. NFC showed a positive tendency in the relationships with the trust measures, of which its relationship to pre-trial trust in own PED-Cell / operational component was significant.

Although not significant, the obstacles to information sharing seemed to relate about as expected to the output measures (shared awareness, information sharing, and decision making) and trust – that is, negative relationships.

Table 7-7 shows how Power distance (Pd) and Uncertainty avoidance (Ua) relates to the other variables. As indicated above, current data on Pd and Ua was unreliable due to the low n from each country. Hofstede's [16] country mean values (as listed in Table 7-3) were therefore used to calculate the correlations between the cultural measures and the organizational and individual measures. The table reveals significant correlations between NFC and Pd, and NFC and Ua.

7.4.1.9 Moderator Analyses

The presented theory suggested moderator effects of alignment, trust, competence, Pd, and Ua on the effects of the independent variables, flat structure and decentralization on the mediator, flexibility and on the dependent variables, shared awareness, information sharing, and decision making (i.e., the organizational effectiveness measures). Because the competence variable had been abbreviated from a four-item measure to a single-item measure that did not relate to the other measures as anticipated, indicating hampered validity and reliability, competence was not included in the moderator analyses.

The variable scores were first mean centered, then the interaction terms were calculated, before the terms were included in the regression analyses (see Aiken [6] West [63]). The moderator effects all proved non-significant and are therefore not described any further. The lack of significant moderator effects was not surprising considering the small sample size [64].

7.4.2 Bold Quest 2019 (BQ19)

7.4.2.1 Descriptive Analyses

As indicated in the method chapter, as a consequence of the low N in BQ19, we only conducted descriptive and reliability analyses. The results from these basic analyses should also be interpreted with great care due to the limited number of responses. The mean, standard deviation, reliability, and number of responses of the measures are presented in Table 7-8.

With the exception of the flat structure, decentralized processes, internal competence, external competence, post-trial external trust, and decision making measures, the measures demonstrated between acceptable ($\alpha > .70$) and very good ($\alpha > .90$) reliability. Considering the low number of respondents, it was not surprising that six of the thirteen measures did not demonstrate acceptable reliability.

However, the negative alpha associated with the flat structure measure indicated there that may be a problem with negative correlations between some items in the measure. As indicated in the method chapter, this measure had been modified based on the UV18 analyses. The results from BQ19 indicate this measure should be studied further in future research.

Table 7-6: Zero-Order Correlation Coefficients.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Flat structure (single item)																	
2. Few levels in exercise	*r*	-,312															
	p	.106															
3. Decentralized processes	*r*	.285	-.264														
	p	.127	.166														
4. Alignment	*r*	-.306	.013	.591**													
	p	.100	.949	.001													
5. Flexibility	*r*	.145	-.258	.135	.057												
	p	.445	.177	.469	.764												
6. NFC	*r*	.308	-.125	-.114	-.221	-.077											
	p	.174	.589	.612	.335	.734											
7. Internal competence	*r*	-.157	.151	-.051	-.208	-.492**	-.305										
	p	.407	.434	.786	.271	.005	.168										
8. External competence	*r*	-.186	.404*	.032	-.003	-.263	-.444*	.569**									
	p	.324	.030	.866	.989	.153	.038	.001									
9. PreEx internal trust (2 items)	*r*	.196	.049	.311	.249	.404*	.502**	-.385	-.266								
	p	.348	.824	.130	.230	.045	.001	.057	.198								

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
10. PreEx external trust (2 items)	*r*	.358*	.133	.075	-.056	.312	.175	-.322	-.106	.746**							
	p	.079	.544	.723	.791	.129	.294	.116	.613	.000							
11. PostEx internal trust (2 items)	*r*	.105	.056	-.132	.041	.242	.207	-.116	-.257	.395	.281						
	p	.609	.790	.510	.841	.224	.411	.555	.196	.077	.218						
12. PostEx external trust (2 items)	*r*	-.068	-.120	-.085	.236	.224	-.100	.075	-.099	.264	.209	.743**					
	p	.721	.535	.648	.208	.225	.658	.688	.596	.203	.317	.000					
13. Obstacles to information Sharing	*r*	.081	-.201	.084	.101	.120	.003	-.154	.080	-.363	-.266	-.176	-.082				
	p	.675	.304	.660	.602	.528	.989	.415	.676	.081	.209	.391	.666				
14. Shared int. awareness (3 items)	*r*	.132	-.091	.086	.046	.026	.407	-.124	-.165	.319	.072	.445*	.236	-.187			
	p	.496	.644	.650	.813	.892	.060	.508	.383	.129	.737	.020	.209	.332			
15. Shared ext. awareness (3 items)	*r*	-.222	.176	-.321	-.143	.303	.033	-.100	.048	.203	.157	-.012	.012	-.067	.425*		
	p	.248	.371	.084	.459	.104	.886	.598	.801	.342	.465	.953	.950	.728	.022		
16. Information sharing	*r*	-.649**	.227	-.441*	-.018	-.032	.198	.168	-.011	.136	-.047	.258	.319	-.338	.311	.537**	
	p	.000	.237	.013	.924	.862	.378	.358	.955	.517	.825	.185	.080	.068	.088	.002	
17. Decision making	*r*	-.280	.164	-.081	.179	.414*	-.177	.238	.275	.090	-.139	.336	.476*	.024	.061	.333	.532**
	p	.166	.433	.688	.381	.032	.469	.233	.165	.698	.548	.100	.012	.909	.766	.096	.004

Note: This correlation analysis is based on Hofstede's [16] scores on Power distance (Pd) and Uncertainty avoidance (Ua). n = 29-53. NFC = Need For Cognition, DM = Decision-Making

Table 7-7: Zero-Order Correlation Coefficients: Power Distance (Pd) and Uncertainty Avoidance (Ua).

		1 Flat struct	2 Few levels	3 Dec. pros.	4 Align-ment	5 Flex.	6 NFC	7 Int. comp.	8 Ext. comp.	9 PreEx int. trust	10 PreEx ext. trust	11 PostEx int. trust	12 postEx ext. trust	13 Obstac. info. shar.	14 Shar int. awar.	15 Shar ext. awar.	16 Info. shar.	17 DM	18 Pd
17. Pd	*r*	.162	.136	.120	-.055	.203	-.340*	-.056	.165	-.153	.075	-.025	.015	-.273	-.050	-.062	-.120	.134	
	p	.394	.481	.521	.773	.274	.032	.761	.376	.315	.622	.900	.935	.144	.790	.743	.512	.505	
18. Ua	*r*	.232	.050	.290	,072	.232	-.325*	-.064	.149	.021	.175	-.209	-.050	-.109	.175	.143	-.245	-.076	.593**
	p	.218	.798	.113	,703	.209	.041	.728	.425	.892	.250	.285	.788	.565	.347	.450	.177	.705	.000

Note: This correlation analysis is based on Hofstede's [16] scores on Power distance (Pd) and Uncertainty avoidance (Ua). $n = 29 – 53$. NFC = Need For Cognition, DM = Decision-Making

Table 7-8: Mean (*M*), Standard Deviation (*SD*), Reliability (*α*) (Cronbach's Alpha Based on Standardized Items), and Number of Responses (*N*)

	M	*SD*	Alpha (*α*)	*N*
Flat structure (5 items)	3.30	0.21	-1.31	8
Decentralized processes (4 items)	3.30	0.35	.41	6
Flexibility (4 items)	3.50	0.72	.90	8
NFC (19 items)	3.56	0.44	.80	10
Internal competence (4 items)	3.56	0.48	.09	8
External competence (4 items)	3.59	0.40	.45	8
PostEx internal trust (3 items)	3.94	0.65	.87	6
PostEx external trust (3 items)	3.92	0.45	.40	8
Obstacles to information sharing (14 items)	2.10	0.50	.86	9
Shared internal awareness (4 items)	3.73	0.70	.74	10
Shared external awareness (4 items)	3.69	0.79	.94	10
Information sharing (3 items)	4.00	0.99	.95	10
Decision making (3 items)	3.62	0.68	.66	8

Note: All measures were rated on 5-point scales. NFC = need for cognition. "Internal" refers to own PED-Cell / operational component, whereas "external" refers to other PED-Cells/operational components. "PreEx" refers to pre-trial and "postEx" refers to post-trial.

Furthermore, a closer inspection of the item statistics in the competence measure, suggested this measure may be two-dimensional. Because we only had a single item of this measure included in the UV18 data collection, this may also be an issue to explore in future research.

The highest mean scores were achieved for trust and information sharing; at four and just below four on the five-point scales used in the survey suggesting good trust and information sharing. The lowest scores were obtained for obstacles to information sharing. The scores were below average (just above two), suggesting that the different obstacles were between rarely and sometimes a hindrance for information sharing.

As indicated in the Theory and Method sections of this chapter, alignment scores represent the difference between the flat structure and the decentralized processes scores in absolute values. Descriptive analyses yielded an alignment mean score of .25 (SD = 0.10); indicating good alignment between the organizational structure and processes.

When comparing the UV18 with the BQ19 results, there appears to be only small to trivial differences in mean values. However, the differences found between trust, competence, and shared awareness within as opposed to across PED-Cells/operational components in the UV18 data, did not seem to materialize in the BQ19 data. Overall, it seemed that the trust, competence, and shared awareness were higher across PED-Cells/operational components in BQ19 than in UV18, but the reliability of this "eyeballing" of the results was difficult to test due to the small N in BQ19.

This concludes the presentation of the BQ19 results; because of the limited number of respondents in BQ19 and the subsequent uncertainty of the results, the results are not commented on any further in the subsequent Discussion (or elsewhere).

7.5 DISCUSSION (UV18)

7.5.1 Descriptive and Comparative Analyses

The descriptive analyses demonstrated that trust and decision making obtained the highest scores (a bit above average), and flat structure (single item) and obstacles to information sharing the lowest scores (a bit below average).

This means that decision making was perceived quite positively by the personnel in the UV18 exercise, in terms of the pace and the success of the decisions made. The structure of the organization was viewed as more hierarchic than flat. The item details of the obstacles to information sharing measure indicated that the approachability of the commander, political constraints, and document classification did not represent much hindrance to information sharing in the exercise. However, technical difficulties and procedural inefficiencies obtained over average scores, indicating more important hindrances to information sharing. Hence, for future UV trials the results suggest there is room for improvement within the technological solutions and procedures used.

The above average scores on trust indicated generally good trust in other exercise personnel. Results further indicated that personnel in the UV18 exercise trusted their colleagues both within their own PED-Cell and in other PED-Cells more pre-trial than post-trial. There was also a difference in trust between the scores from within and across PED-Cells in favor of own PED-Cell. The difference was, however, only significant in the results from the pre-trial data. Moreover, the results suggest that the personnel's expectations towards both members of own PED-Cell and other PED-Cells were more positive than their subsequent experiences. The personnel's higher expectations towards members of own cell relative to other cells prior to the exercise, demonstrates in-group favoritism [65], [66], [67]. On the positive side, in-group favoritism was lowered by actual experiences. On the negative side, trust overall was lowered by actual experiences. Because trust has been found to be positively affected by team training [68], including in global virtual teams [69], the fact that trust was lower post exercise than pre-exercise suggest that personnel experienced incidents that lead to lowered trust. It is proposed that future research look more closely into the details of such experiences, and address what can be done to amend the issues that lead to lowered trust both within and across PED-Cells.

Similar to the case of trust, results indicated that personnel perceived that colleagues within their own PED-Cell were somewhat more competent than their colleagues in other PED-Cells. The level of shared awareness was also rated higher within than across cells (classified as a medium sized difference). These results from the comparative analyses (i.e., on trust, competence, and shared awareness), within versus across PED-Cells, all suggest the same – that there is a more positive perception of the personnel and processes from within the PED-Cell compared with the perception of other PED-Cells. This is, as indicated above, a classic finding of in-group favoritism [65], [66], [67].

7.5.2 Reliability Analyses

The reliability analyses indicated between acceptable and very good reliability for all the measures except flat structure, flexibility, trust measured by two items, and shared awareness measured by three items.

A follow-up in-depth reliability analysis indicated that the five-item measure of flat structure needed to be divided into a single-item measure that was understood to measure flat structure (comparable to the single-item metric used in Bjørnstad, [6]), and a four-item measure that was understood to measure the

perceived number of levels included in the exercise. The correlation analysis even suggested that these two parts were negatively related. Whereas flat structure and decentralization demonstrated a negative tendency in their relationships to the output variables, few levels included in the exercise demonstrated a positive tendency.

Decentralization showed good reliability, while flexibility was just below the .70 limit for acceptable reliability. As indicated in the method chapter, on-site changes blurring the meaning of these measures made the results less interpretable. The lowered reliability scores could thus be due to the changes in the measures, compared to the original measure validated in previous research from military contexts [33].

The results from the reliability analysis suggested that the full measure of trust (three items) is preferable in future research. However, comparing the results in the correlation analysis revealed only trivial differences between the three- and two-item measures. Hence, the measure seemed to have largely maintained predictive validity.

The reliability analysis indicated below acceptable reliability for the shortened shared awareness measure (i.e., the four-item measure of shared external awareness was shortened to a three-item measure in UV18) suggesting future research should use the full shared awareness measure (the full measure was used for measuring shared internal awareness, which demonstrated acceptable reliability). However, comparing the results in the correlation analysis revealed only trivial differences between a four- and a three-item measure, suggesting that the predictive validity may have been maintained despite the low reliability score.

It was pointed out above that personnel perceived that colleagues within their own PED-Cell were somewhat more competent than their colleagues in other PED-Cells. However, as the measure was cut from a four-item measure to a single-item measure in UV18, these results are somewhat unsure and should be interpreted with care. The correlation analyses did not clarify the matter – many relations were not as expected. There was a negative tendency in almost all the relationships to competence, even for the trust measures, which was quite surprising. Based on previous theory and empirical research, the relationship between competence and trust was expected to be positive [1]. This suggests that the truncation may have compromised the measure's predictive and content validity. Hence, it is strongly advised that future research in military ISR contexts use the original measure.

There were too few respondents to reliably calculate the country level Pd and Ua. Values from previous research [16] were therefore used in order to calculate any relationships between the cultural constructs and the organizational and individual constructs.

7.5.3 Correlation Analyses

The correlation analyses produced results that were both surprising and results that were unsurprising according to the theory and previous research visualized in the conceptual model (Figure 2-1).

The organizational effectiveness measures seemed to relate to each other as expected; decision making and information sharing were positively related, and shared external awareness and information sharing were positively related. Although not quite significant ($p < .10$), there was also a positive tendency in the relationship between shared external awareness and decision making. Shared internal awareness also demonstrated a positive tendency in the relationship to information sharing, but there was no relationship with decision making.

In line with previous research, the correlation analyses also suggested a positive relationship between trust and organizational effectiveness. This indicates that trust may be important to foster in the organization both within and across PED-Cells in order to give the best organizational output.

The tendency in the relationships between obstacles to information sharing and the output measures (shared awareness, information sharing, and decision making), and between obstacles to information sharing and the trust measures seemed to be about as expected; although not significant, the tendency was negative. There seemed to be no relationships between obstacles and the input measures. Follow-up research may also look more into the details of the components of the obstacles measure, to see whether there are differences in how the various obstacles are related to the input measures as well as in how they influence the output measures.

The NFC-measure related about as expected to flat structure, information sharing, and the shared awareness measures (not significant, but a positive tendency), whereas a weak negative tendency was found in relation to decentralization and decision making. Especially the latter negative tendencies were not as anticipated. Cultural aspects may also here play a part. This needs also to be further analyzed in future research in military ISR contexts. The NFC-measure furthermore demonstrated a negative relationship with the rating of competence in other PED-Cells and a positive relationship to the pre-trial trust in own PED-Cell. There were no specific expectations or hypotheses linked to these latter findings.

The negative correlations between the input measures flat structure and decentralized processes on one side, and the output measure information sharing on the other, was also quite surprising compared to previous research [6]. Because cultures that are high in Pd and Ua have been linked to people being used to and preferring more hierarchic and centralized types of organization [16], cultural differences in Ua and Pd in the samples may explain the surprising findings. Moderator analyses were conducted, but did not produce any significant results. Due to the small sample size, this was not considered a surprise. Changes in the flat structure, decentralized processes, flexibility, and decision-making metrics may also be part of the picture. The qualitative observations in Chapter 9 offers some additional insight to this finding. However, follow-up analyses and future research in military C2 and ISR contexts should look into these matters.

The significant correlations between NFC and Pd, and NFC and Ua indicate that cultural differences may have an impact on the tendency for the individuals in a society to like to think in depth about issues. Authoritarian and rule-based parenting more common in high Pd and Ua cultures may cause less motivation to think in depth about issues, because there is less room for individual thinking and initiative. This finding supports the theoretical propositions in Bjørnstad [70].

In sum, some of the surprises in the correlation matrix may certainly be attributed to the changes made to the metrics as used in the UV18 exercise, while others may be due to differences in the organizational settings and the samples included in the different research. Many moderating and mediating factors such as cultural differences may also have had an impact on the relationships. Due to the small sample size, these results were considered inconclusive.

7.5.4 Implications for ISR Decision Makers

Decision making is an output measure that taps into the perception of the C2 processes. The results from this study indicated that personnel in the UV18 exercise perceived the pace and success of decisions quite positively. This implies that the decision makers generally had the means and capacity to make timely and good decisions. Although the scores were above average (e.g., almost reaching the “quite successful” score), there is room for improvement. In line with previous research from military settings, information sharing was found to be positively linked to decision making, and shared awareness was positively linked to information sharing. These relationships may suggest a mediation effect, where a shared understanding of roles and responsibilities is important to the efficient sharing of information, both within and across PED-Cells. This underscores the importance of facilitating information sharing and a shared awareness and understanding of the roles and responsibilities both within and across PED-Cells to ensure the effectiveness of the organization’s ISR decision-making processes.

There was a medium sized difference between shared awareness within compared to across PED-Cells. This implies that although the shared awareness was rated a bit above average across PED-Cells, there was more room for improvement in clarifying roles and responsibilities across than within the PED-Cells. This may be important to have in mind both when preparing for future ISR exercises and when aiming to improve the daily ISR processes.

In line with previous research from military settings, trust was found to be positively related to decision making and shared awareness. More specifically, trust within the PED-Cells (measured post exercise) was significantly related to shared awareness within the PED-Cells, and trust across PED-Cells (measured post exercise) was significantly related to decision making. These results imply that trust both within and across PED-Cells is vital for ISR and C2 processes. Hence, in order to improve ISR processes, building trust within and across PED-Cells seems to be a take-home message from the current results. Also, because there was a medium sized difference in trust within compared to across PED-Cells pre-exercise, it may be advisable to pay extra attention to the building of trust across PED-Cells. The large difference in trust pre- as opposed to post-trial implied that the actual experiences that the personnel made when cooperating during the exercise, lead to lowered trust both within and across PED-Cells. The data did not reveal the reason for this decline, but it is suggested that this finding be examined in future research. It may also be a good idea for decision makers in the ISR organization to look into such matters – in order to rectify or minimize the experiences that led to the lowering of trust between colleagues during the UV18 exercise.

Similarly to trust, shared awareness, and competence were also rated lower across than within PED-Cells. It is deemed vital that decision makers in ISR are aware of this basic human tendency to focus on and be more positive towards their own group [65], [66]. Being aware of this tendency towards in-group favoritism may allow measures to be taken to counteract it. For instance, building relations, positive experiences, and identities across groups, may be examples of such measures (see Bjørnstad [70] for an overview). Chapter 9 offers some qualitative support and explanations to the lower shared awareness across PED-Cells.

In terms of the organizational structure and processes, the results were inconclusive. Due to the changes made to these measures, and the indications of hampered reliability and validity, there are no clear implications on organizational structure and processes for ISR. However, compared to previous research, the relationships to information sharing appeared to be in the opposite direction, indicating that hierarchical structure and centralized processes may have been beneficial to the sharing of information in this ISR organization. On the other hand, perceiving the number of hierarchic levels (i.e., command and decision-making levels) included in the exercise to be few rather than many showed a positive tendency in the relationship to information sharing (not significant). These results may indicate that the systems for sharing information in this ISR exercise, whether technological, procedural, or organizational, may simply have been set up for a hierarchic and centralized information sharing. This interpretation was supported by the finding that technical difficulties and procedural inefficiencies were rated the most important hindrances to information sharing (rated between “sometimes” and “often” on average). Additionally, mismatches between real world processes and the simulated processes were rated the third most important hindrance to information sharing (rated just above “sometimes” on average). Hence, for future UV trials the results suggest there is room for improvement within the technological solutions and procedures used. However, as indicated above, differences in culture (Pd and Ua) and in the metrics in the current compared to previous research may also have produced the differences in results. Therefore, it is simply recommended that future ISR research study these matters further.

The approachability of the commander, political constraints, and document classification did not seem to represent much hindrance to information sharing in the exercise. Hence, decision makers in ISR may consider these issues a success in the UV18 exercise.

Finally, the negative relationships found between NFC and Pd, and NFC and Ua indicate that cultural differences may have an impact on the tendency for the individuals in a society to think in depth about

issues. The implication for the organization of ISR is that more rule-based and centralized organizational and decision making processes may foster and select individuals that are less motivated to think in depth about issues, because there is less room for individual thinking and initiative in such organizations. This suggests that a democratization of the ISR organization (i.e., decentralizing decision-making and empowering the lower levels), allowing for more individual thinking and initiative, may be advantageous for the propensity of the personnel to think in depth about issues in their everyday job. This propensity may in turn be advantageous for the organization's problem-solving and decision-making ability. However, these interpretations need to be investigated further in future research.

7.5.5 Limitations and Future Research

As indicated above, we had a limited sample, which put some restrictions on the analyses possible. With only a few respondents from each of the participating countries the cultural measures Pd and Ua could not be reliably calculated. Moderator analyses were conducted, but the lack of significant results was not a surprise considering the sample size. It is suggested that follow-up research with larger samples further test for moderator effects and also calculate differences in Pd and Ua. With more ample data material in future research, one may also test the entire organizational model in a military ISR context. In this initial study, the conceptual model was included to visualize the theoretical and empirical background of the current research.

The findings presented in this chapter reflect the participants' perception of organizational and related factors; they do not reflect object reality. Perceptions are nevertheless relevant, as perceptions spur on human evaluation and behavior. Indeed, perceptions are at the basis of an extensive part of human factors research.

There were changes made to the questionnaires on-site. This meant a shortening of the post-trial questionnaire, so that some measures were cut altogether while others were abbreviated and some altered. It was deemed that many of these changes may have hampered the validity and reliability of the measures, and it is therefore advised that future research in military ISR contexts use the original measures.

7.5.6 Closing Remarks

In order to better understand the organizational, cultural, and individual issues in an ISR context, HFM-276 developed a survey instrument and data were collected before and after the ISR exercise UV18. This chapter (Chapter 7) has presented the statistical analysis of the individual, organizational and cultural data, including descriptive statistics, reliability analyses, correlation analyses, and moderator analyses. The implications for the ISR organization were discussed.

Data was also collected after the BQ19 exercise, but the very limited sample size did not allow any conclusions to be drawn. However, there seemed to be only small to trivial differences in variable mean values in the BQ19 and the UV18 data.

The results from UV18 highlighted the importance of facilitating information sharing and the understanding of roles and responsibilities both within and across the PED-Cells, to assure the effectiveness of the organization's ISR decision-making processes. The results furthermore suggested that commanders need to pay special attention to building trust and understanding across organizational components to improve the C2 effectiveness in ISR operations. Finally, the results implied that there is room for improvement in future UV trials pertaining to the technological solutions and procedures used.

The research reported here is deemed useful for military decision makers and researchers in ISR and human factors related research; the theory and results may improve the general understanding of individual, organizational, and cultural issues in military ISR. The method part expands the available metrics for collecting relevant data to improve our knowledge of human issues related to ISR operations both in national and international contexts.

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Chapter 8 – UNIFIED VISION 2018 ANALYSES: SYSTEM FACTORS

Rune Stensrud, Sigmund Valaker, Anne Lise Bjørnstad,
Stéphane Buffat, Fred Lichacz, Daniel Zelik

The NATO HFM RTG-276 Panel's research on the role of System factors: Technology, Source (of quality data), Data sharing (across boundaries), System usability, and Visualization in JISR operations and the need to have methods evaluating these factors in the ISR CD&E process is regarded as important. This chapter's main result is a method measuring Source of quality data on military enterprise networks. The method is a combination of prominent approaches applied on a data set collected from a NATO Joint ISR process trial named Unified Vision 18 to determine an overall estimate of Data sharing (across boundaries) and end-to-end Data Quality (DQ). In order to "measure" dimensions and identify aspects of end-to-end Quality of Data and Quality of user Experience (QoE) in Joint ISR and linked Operational processes, we have proposed a few new attributes to be integrated in the generic HFM-276 model to enhance the already established set of measurements.

8.1 THEORY

8.1.1 System Factors: Technology, Source of Data Quality, Data Sharing Across Boundaries, System Usability, and Visualization

8.1.1.1 Technology

Technologies in the areas of sensors and platforms as well as network technology and storage capacity have evolved to the level where mass data can be easily shared and disseminated. To make use of these new capacities, there is a need for systems and services that can interact with each other in a well-defined way. In the generic model for HFM-276 we have to handle this in a way that makes sense for the military operators and is relevant to NATO processes for JISR. Fielded systems and planned implementation supporting Joint ISR is under way in NATO with solutions focusing on the data and information flow throughout different processes and across domains [1].

We propose a decomposition of technology consisting of 1) Network Technology and Communication measured by Quality of Service (QoS) metrics; 2) Information Technology measured by Data Quality metrics; and 3) Sensor Technology capabilities and availability [2].

8.1.1.2 Source of Data Quality

Based on a theory for evaluating Data Quality on Military Enterprise Networks we propose an approach to system factors. The variable Source is proposed to be decomposed into the attributes of (1) Quality of Data at Source (QDS), and (2) Data Relevance (DR) separating data at source and in the different phases of exploitation. These distinctions and decompositions are necessary to reflect the separation in development, procurement and management of sensor and network systems as well as to support new concepts for verification and validation of DQ.

8.1.1.3 Data Sharing (Across Boundaries)

Evaluation of data sharing across boundaries requires a holistic view according to Battle and Harrington [2] and Carlile [3]. Insights into how we approach obstacles to data and information sharing in military operational processes need to be discussed. Circumstances, solutions and challenges when different types of

processes – transferring, translating, and transforming processes – associated with JISR meets obstacles is presented below. Examples of obstacles to information sharing and approaches to decompose boundaries and ways of addressing the consequences is of common interest in the context of HFM-276. The sharing of data and information objects need to be examined from different points of view. The proposal for HFM-276 is inspired by the fact that data and information entities in JISR and other Operational Processes is transferred, translated and transformed across progressively complex boundaries presented in Figure 8-1(a) [3]. An analysis tool is proposed and exemplified by samples from UV18. The theory describes practical mismatches that occur when data exchange is desired and how this relates to types of different boundaries (boundary objects and artifacts) and processes [4].

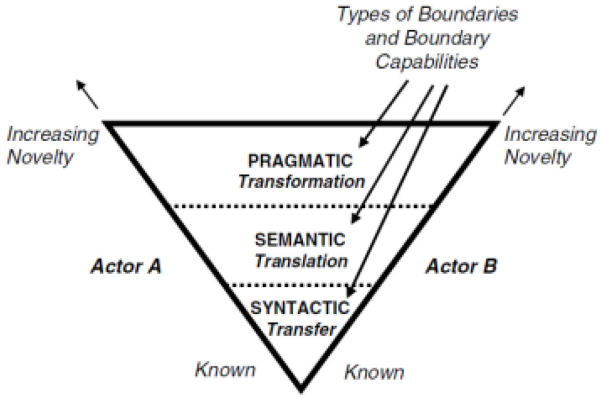

Figure 8-1(a): A Data Sharing Model for Managing Knowledge Across Boundaries [3].

8.1.1.4 System Factors Model

Building on and extending the research presented above, a system factors model has been developed in the context of HFM-276 (Figure 8-1(b)). The model attempts to describe some of the relationships between variables presented.

Evaluation of data sharing across boundaries requires a holistic view according to Battle and Harrington [2]. Three contexts are described on the left side of Figure 8-1(b): a net-centric context, traditional network context and cyber-security context. The method for applying measures for these contexts to evaluate data quality across JISR and other Operational Processes are presented on the right side of Figure 8-1(b).

JISR and Other Operational processes must be able to handle the context described in Figure 8-1(b), e.g., meeting the requirements of:

1) Support Military Operations (SMO) within Joint ISR
2) Enter and Manage data on the Network (EMN) (within a network system) in a satisfactory way
3) Effectively Exchange Data (ED) (exchanged with external network systems)
4) Transfer, translate, and transform data products "fit for use"[1], e.g., produced in a network of physically distributed sites by systems and services from different nations and vendors in an interoperable way
5) Provide data products that shall be visible, accessible, understandable – and trusted through the usage of standardized services, interfaces and formats.

[1] Data "fitness of use" definition takes the perspective of assuring quality based on user needs within organizations and between organizations.

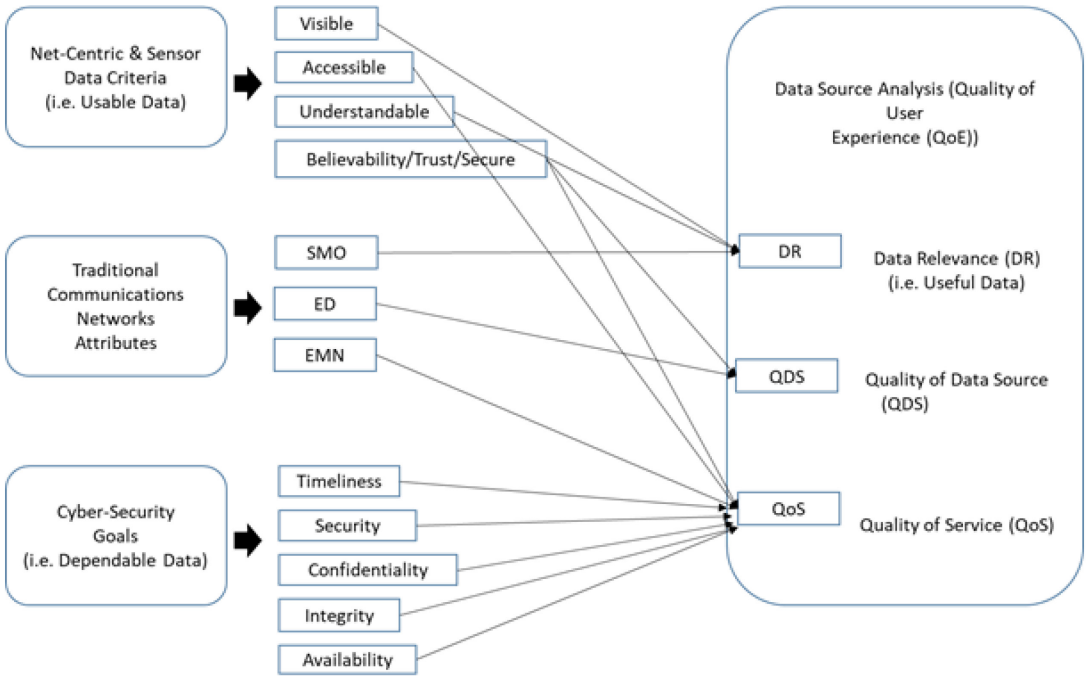

Figure 8-1(b): System Factors Model, Net-Centric and Sensor Data Criteria (Visible, Accessible, Understandable, Believability / Trust / Secure), Traditional Communications Networks Attributes (Able to Support Military Operations (SMO), Able to Effectively Exchange Data (ED), Able to Enter and Manage Data on the Network (EMN)) and Cyber-Security Goals (Timeliness, Security, Confidentiality, Integrity, Availability). All lines indicate relationships, of which all are positive relationships.

Although the line between each type of goal, objective, and criteria is clearly connected in Figure 8-1(b), the transition where one ends and another begins is not easily explained. The System Factors model in Figure 8-1(b) requires further research in military contexts to better understand the relationships within the model [2]. Therefore, we present a re-drawing of Figure 8-1(b) shown in Figure 8-1(c) to be able to better trace indicators and understand the relationships of elements within context [2]. In Figure 8-1(d) we are reformatting Figure 8-1(c) by mapping the DQ dimensions into a generic product and service performance model for information quality [5] (adapted RTG-276 model) without any context.

Data Quality dimensions adapted to the RTG-276 model is presented in Figure 8-1(d). This is a 2 X 2 model consisting of two rows and two columns making up four quadrants. The two rows of the model correspond to the fact that the data (information) could be treated either as a product or a service. The two columns correspond to the fact that DQ could be measured either by predefined specifications or whether it meets or exceeds user expectations. Each of the four quadrants has its own specific DQ dimensions [5].

According to the dimensions of DQ, the adapted RTG-276 model data shall be sound, useful, usable and dependable. Sound data is data that conforms to specification. Sound data shall be free-of-error, concise, representable, complete, and consistent. Sound data should meet the criteria of QDS (an output factor for Joint ISR and others). Useful data is data that meets or exceeds user expectation should meet the criteria of Data Relevance and shall be in appropriate amount, relevant, understandable, interpretable and objective. Dependable data is considered to be data that meets the criteria of timeliness, security, confidentiality, integrity and availability depending on Network QoS. Usable data must be usable and visible to the consumer. Usable data should meet user expectation and provide support to the consumer's military operations. For instance, usable data must be believable, accessible, easy operable, understandable and have good reputation (in communication networks).

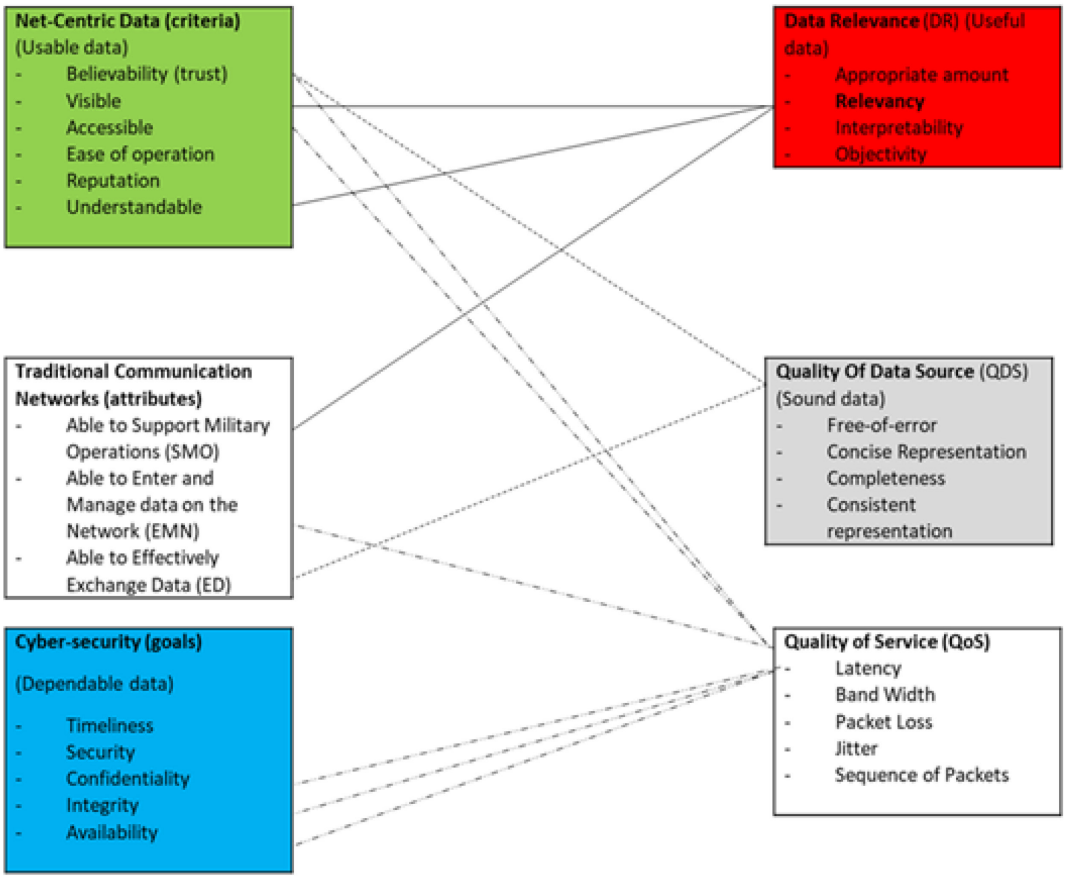

Figure 8-1(c): System Factors Model with Context.

End-to-End Quality of User Experience	Conforms to Specification	Meets or Exceeds User Expectation
Product Quality: Quality Of Data Source (QDS) Data Relevance (DR)	Sound data (syntax) • Free-of-error • Concise Representation • Completeness • Consistent representation	Useful data (semantics) • Appropriate amount • **Relevancy** • Understandability • Interpretability • Objectivity
Service Quality: Quality of Service (QoS)	Dependable data • Timeliness • Security	Usable data (pragmatics) • Believability (trust) • Accessibility • Ease of operation (manipulation) • Reputation • Value-Added

Figure 8-1(d): Mapping the Data Quality Dimensions into Product and Service Performance Model for Information Quality Without Any Context [5] (Adapted RTG-276 Model).

8.1.1.5 System Usability

The term "usability" refers to a set of multiple concepts, such as execution time, performance, user satisfaction and ease of learning. Standards related to usability can be classified in the following categories:

1) Product effect (output, effectiveness, and satisfaction at the time of use of the product);
2) Product attributes (interface and interaction);
3) Process used to develop the product; and
4) Organization's capability (life cycle and capability of use in context) [6].

The term "system" is a collection of elements or components that are organized for a common purpose. Evaluation of System usability, is the output of a multi-dimensional evaluation process representing the results from a system and its:

1) Product effect;
2) Product attributes;
3) Process used to develop the product; and
4) Organization's capability (life cycle and capability of use in context) [6].

One of the many purposes of the NATO HFM RTG-276 model and methods introduced, is identifying aspects of a system's usability for JISR applications. User trials like UV18 offers a flexible mean of evaluating Joint ISR applications and systems design. UV18 involved system end-users performing a series of ISR tasks with devices and "IRM and CM software products" in order to evaluate various features associated with the usability of the systems in question. A trial like UV18 is typically utilized to generate a set of design recommendations or remedial measures for the systems and software in use or processes under analysis.

The Post Study System Usability Questionnaire (PSSUQ) was used to evaluate System Usability at UV18. It is a valid and reliable measure. The PSSUQ's exclusively positively phrased questions could bias results [7]. The PSSUQ requires that the usability of a system (software) is considered along three dimensions (e.g., System usability (8 questions), Information quality (7 questions) and Interface quality (4 questions) – 19 questions) [8].

Another method to consider is the Software Usability Measurement Inventory (SUMI) and Software in Use methods. The SUMI was not used because of its cost: the SUMI may require substantial development to be used in the analysis of C4I systems. The SUMI is comprised of 50 attitude questions [9].

Usability of Software (SW) (i.e., Computer software, or simply software, defined as a collection of data or computer instructions that tell the computer how to work,(according to ISO9241-11) [10] was not used because it needs input to usability metrics (on-line business monitoring tools was not available during UV18). The use of the SW [10] requires that the usability of software is measured by objective measurements. It is considered along three dimensions; effectiveness, efficiency, and attitude.

8.2 METHOD

8.2.1 Data Source Analysis Method

The Data Source Analysis (DSA) method subjectively assesses the user satisfaction referred to as QoE based on an opinion score. The measurement of data quality consists of three attributes: QDS, DR, and network QoS. We propose to integrate the method as a part of HFM-276.

Data Quality is defined as measuring to what degree data meet the implicit or explicit expectations and requirements of users or systems utilizing the data. Further, information and data quality are defined and measured according to syntactic, semantic and pragmatic quality. Syntactic and semantic quality is measured through a verification process, whereas pragmatic quality is measured through a validation process [11].

The DSA method uses a product-based perspective, commonly called DQ, focusing on the design and internal (information) system view. From this view, quality is defined in terms of the degree to which the data meets requirements or the degree to which the data represents relevant observations (phenomena). The dimensions or criteria are presented below supporting the evaluation of subjective measures of quality data. The challenge is that even if data corresponds to specifications or real-world observations, there can still be quality deviations with respect to actual use-related data requirements. In fact, it is the data users that are the final judge of quality [12].

Since data quality continues to be dictated by the "fitness for use principle" [13], the DQ user requirements and user expectation to DQ are highly dependent on the organizational context [14]. Data Quality and Data Quality Management should be viewed as necessary pre-requisites when integrating data sharing concepts into operations. A JISR coalition is a complex enterprise, therefore, a structured approach to data quality management is needed, which must be explicitly tailored to the specifics of the coalition supported by data quality requirements and Joining Instructions. In a JISR coalition, different types of systems interact with each other. On the one hand, there are systems consuming the products published and shared. Sensor systems produce sensor data, exploitation systems produce annotated imagery and exploitation reports, and IRM&CM systems produce information requirements and collections tasks. A data sharing concept supporting use cases of these system-of-systems in a JISR coalition are thus the retrieval of published ISR products, by users in need of respective information. Further on, the main use cases include the use of the retrieved products, and the publishing of ISR products. Data quality management for a JISR coalition has to support these use cases, technically, procedurally and organizationally to:

1) Ideally, enable a user to find and retrieve usable (valid), sound (consistent) and dependable (current) ISR products according to his or her (informational) needs;
2) Or, more generally, enable a user to handle his or her required ISR products based on the assessed and known quality of these products; and
3) Support a user when producing and sharing useful and relevant products [1].

The DSA method (adapted RTG-276 model) we are suggesting, is a set of techniques that are designed for measurement assessment, and improving DQ in a given application or organization. We are making a proposal of an appropriate list of data quality dimensions, investigated by a questionnaire-based method designed in order to do State reconstruction, Assessment and Improvement of DQ:

1) State reconstruction: collects contextual information on organizational data, processes and services,
2) Assessment / Measurement: measures the quality of data along relevant dimensions". The term "measurement" refers to measuring the values of data itself, and the term "assessment" refers to comparison against reference values. Main focus is to measure" dimensions and identify "weak" dimensions in the organization (application or system) and needs for improvement of data quality,
3) Improvement: proposes techniques and strategies for reaching higher levels of data quality, levels specified by the data quality requirement of the organization's management to improve data quality [15].

The first component of the methodology is the Product and Service Performance and Information Quality (PSP/IQ) model. This is the 2 X 2 model consisting of two rows and two columns making up four quadrants presented in Figure 8-1(d). The second component of the methodology is a questionnaire. The questionnaire is used to measure data quality along the dimensions of the 2 X 2 model. The third component of the methodology consists of a gap analysis technique. (An example of applying the technique is presented in Figure 8-5).

8.2.2 Post Study System Usability Questionnaire (PSSUQ) Method

The PSSUQ is a valid and reliable method. However, the PSSUQ's exclusively positively phrased questions could bias results [7]. The PSSUQ requires that the usability of software is considered along three dimensions[2] [8] (Figure 8-2).

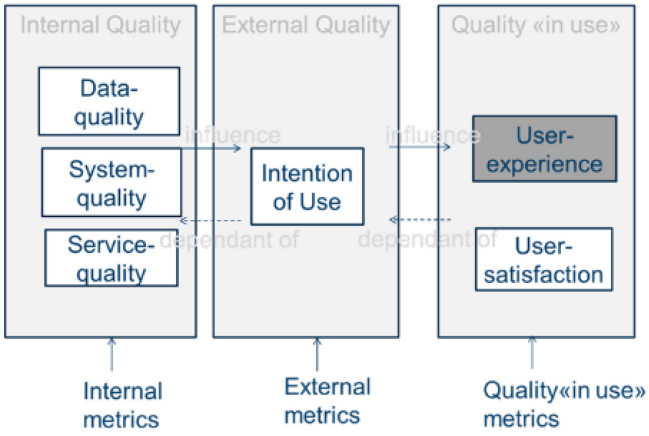

Figure 8-2: The PSSUQ-Method Introduced Subjectively Assesses the System Quality by Measuring the User Satisfaction Referred to as User-Experience Based on Internal, and External Metrics [11].

8.2.3 Data Collection Venue, Method, Procedures, and Sample

The data was collected during UV18 by members of HFM-276, in June 2018. UV18 was conducted over a two week period at the USAFE Warrior Preparation Centre (WPC), Einsiedlerhof, Germany. Participants worked in designated areas performing tasks specific to their TCPED-Cell. In addition to the JTF headquarters at WPC, the trial included live activities at a number of locations. Each day's activity was based on a number of vignettes, which involved a mix of simulated and live-fly collect. Some of these vignettes were of short duration (one day) but some extended over a five-day period. The main focus for the operators in UV18 was to exercise the force's capability to take in and process/exploit data from a variety of aerial, ground and maritime surveillance and reconnaissance platforms. Specifically, the NATO exercise aimed to test and improve the interoperability of JISR assets and involved fast jets, unmanned aircraft vehicles, frigates, under-water gliders, and maritime vehicles. Unified Vision has become NATO's main trial to practice and evaluate new technical and operational concepts for conducting JISR in NATO operations.

After the one week of exercise period on the ISR systems simulating JISR missions the participants were asked to fill out a post-trial questionnaire to rate the importance of a variety of HF issues to JISR operations. A sub-set of questions rated System factors issues were answered during the post-trial questionnaire at UV18 on June 22nd (i.e., post-trial survey questions 65 – 79). The participants used a 5-point Likert rating scale to rate the questions based on their knowledge of various HF issues in ISR operations. The ratings for the scale used were:

1) Strongly Disagree
2) Disagree
3) Neutral
4) Agree
5) Strongly Agree

[2] Only a sub-set of these questions were answered during the post-trial survey at UV18 the 22nd of June 2018; post-trial survey questions 65 – 79.

8.2.4 Metrics

We define the QoE as a measure of usability for the end-user. Primarily because usability is essential for performance given the intended use of a system. An application or system featuring good usability, will allow the user to perform the expected task faster and more efficiently. We define a generic dependency of quality metrics (internal, external and in use) due to the fact that QoE introduced is about measuring data and data sharing based on QDS (intrinsic quality), sharing performance (service quality), and DR (product quality meeting consumer expectation and usability of data). Internal metrics can provide a measure of non-executable software – concept and development steps (request, requirements and design specification and source code development) to predict the quality of a finished product. External metrics can for example measure system behaviour during test and in operational use. There is still no best set of DQ dimensions and metrics for operations within JISR.

To be able to verify and validate products we have to discuss data quality influenced by big data (the flow of data from internet) and open source data that can influence the perceived (intrinsic) quality of data in a JISR coalition. Big data is a new concept, and academia has not made a uniform definition of its data quality and quality criteria. The literature differs on a definition of data quality, but one thing is certain, data quality depends not only on its own features but also on the business environment using the data, including business processes and business users. Only the data that conform to the relevant uses and requirements can be considered qualified (or good quality) data. Usually, DQ standards are developed from the perspective of data producers. In the past, data consumers were either direct or indirect data producers, which ensured the DQ. However, in the age of big data, with the diversity of data sources, data users are not necessarily data producers. Thus, it is very difficult to measure DQ. Therefore, we propose a hierarchical data quality evaluation method based on the works of Lee et al. [5] and Cai and Zhu [16] in Figure 8-3 and Figure 8-4.

The proposed hierarchical model is combining pseudo-metrics presented in Battle and Harrington [2] and the PSP/IQ based on the work of Lee et al. [5] in Figure 8-4.

The DQ elements chosen are syntactic, semantic, pragmatic, and time and security critical quality elements. The DQ indicators chosen are QDS, DR, QoS and QoE. An example of a DQ framework based on the ideas of Cai and Zhu [16], the PSP/IQ based on the work of Lee et al. [5], and the quality indicators (pseudo metrics) of Battle and Harrington [2] are shown in Figure 8-5.

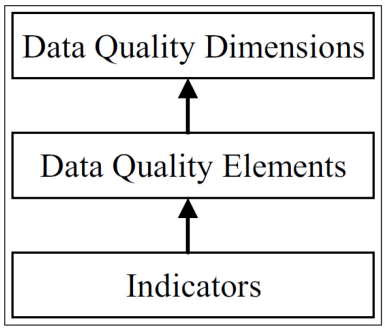

Figure 8-3: A Hierarchical and Generic Data Quality Evaluation Model is Proposed as the Architecture for the Evaluation of Quality Data in HFM-276 [16].

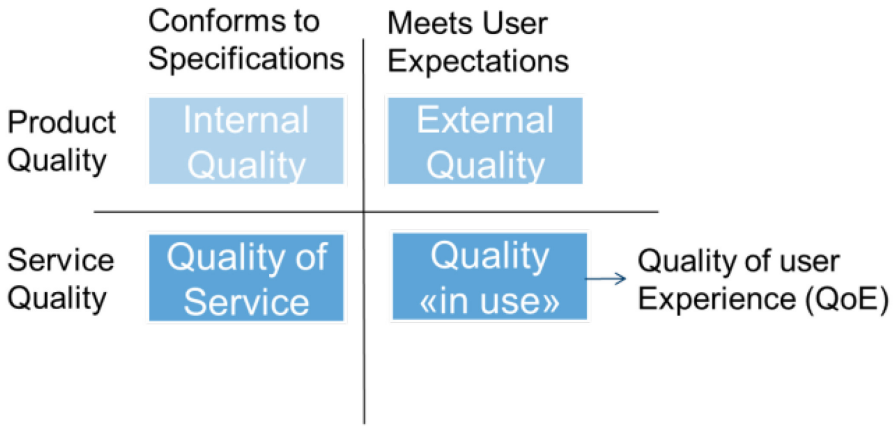

Figure 8-4: The Product and Service Performance Model for Information Quality (PSP/IQ) Based on Lee et al. [5].

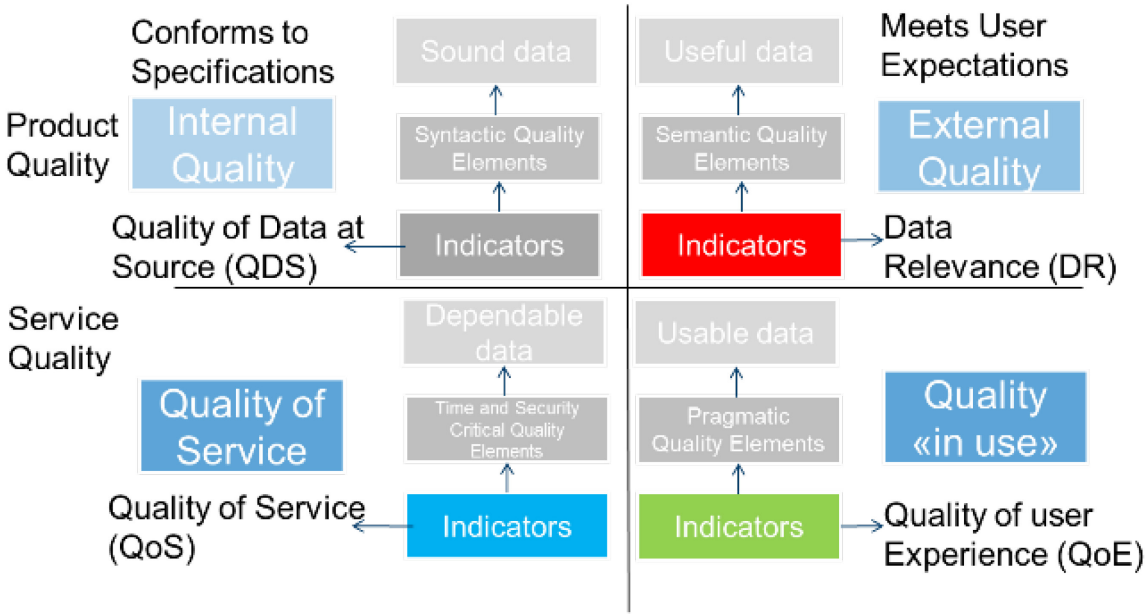

Figure 8-5: Example of a Populated Hierarchical Data Quality Evaluation Framework Combining the Product and Service Performance Model for Information Quality (PSP/IQ) Based on Lee et al. [5], a Generic Evaluation Method Frame Work by Cai and Zhu [16], and Quality Indicators (Pseudo Metrics) from Battle and Harrington [2] Proposed for Evaluation of Quality Data in HFM-276.

The development and implementation of a DQ evaluation method in the ISR CD&E process would allow researchers to directly observe how DQ impacts user performance. The DQ issues part of the survey were generally concerning data and metadata quality measuring along the data quality dimensions proposed in Figure 8-6: Sound data, Useful data, Dependable data and Usable data:

1) Sound data is data that conforms to specification, meeting the criteria of QDS.
2) Dependable data such as cyber-security criteria is data considered to be dependable upon data that meets the criteria of timeliness, security, confidentiality, integrity and availability depending on Network QoS.

3) Useful data expresses the utility provided by the data towards the consumers' objectives and should meet the criteria of DR and shall be in the appropriate amount, relevant, understandable, interpretable and objective.

4) Usable data should meet user expectation and provide support to the consumers' military operations: usable data must be believable, accessible, easy operable, understandable, and have good reputation (in communication networks) [5].

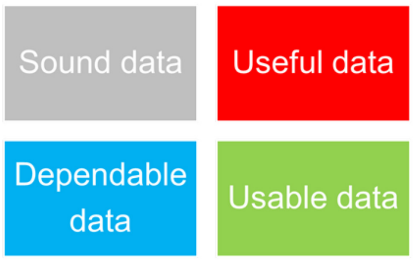

Figure 8-6: A Proposed Set of Data Quality Dimensions i.e., Sound, Useful, Dependable and Usable Data Based on Lee et al. [5] Proposed as Data Quality Dimensions in HFM-276.

8.3 RESULTS AND ANALYSIS

8.3.1 Results of Data Source Analysis Method

To determine if the average scores differed significantly from Neutral, a one-sample t-test was conducted comparing the observed mean against the midpoint of the scale (neutral value of 3) for each item at each assessment time.

Sound Data (Quality of Data at Source)

The participants indicated that the data they received in their Operational component were in correct format (e.g., appropriate language, symbols, and units) and definitions were clear. (M = 3.09, SD = 0.947, $t(32) = 0.551$, $p = 0.585$).

Dependable Data

The results revealed that data meets the criteria of timeliness depending on Network QoS (M = 3.45, SD = 0.905, $t(32) = 2.887$, $p = 0.007$). Still, the operators indicated that information sharing is negatively impacted by technical difficulties ($M = 4.45$, $SD = 0.89$, $t(45) = 11.25$, $p < 0.001$).

Useful Data

The analysis showed that the volume of data received is appropriate for the operator task-at-hand ($M = 3.28$, $SD = 1.054$, $t(31) = 1.509$, $p = 0.141$). (The result is not significant.)

The data received is easy to understand ($M = 3.79$, $SD = 0.650$, $t(32) = 6.964$, $p<0.001$).

Usable Data

The findings revealed that the data needed is available when needed it or is quickly retrievable (M = 3.21, $SD = 0.927$, $t(32) = 1.314$, $p = 0.198$)). (The result is not significant.)

The data received is true and credible (M = 3.56, SD = 0.948, $t(31)$ = 3.356, p = 0.002). The need for an improvement cycle of data quality management according to Moghaddasi, Sajjadi, and Kamkarhaghighi [17] is presented below as a future option of HFM-276 model. We nuance this perspective building on the cybernetic theory of Wiener [18] as a framework to explain individual Data Quality Manager's (DQM) evaluation of data quality (inner loop; Liang and Xue [19]) in a production process of intelligence products (outer loop; Zhu and Wang [20]) in Figure 8-7. Figure 8-7 may be described by an analogy to control theory; the user (customer or/and DQM) compares the received intelligence product with his or her intelligence requirements and makes an evaluation (verification and validation) according to DQ requirements and requirements of data content.

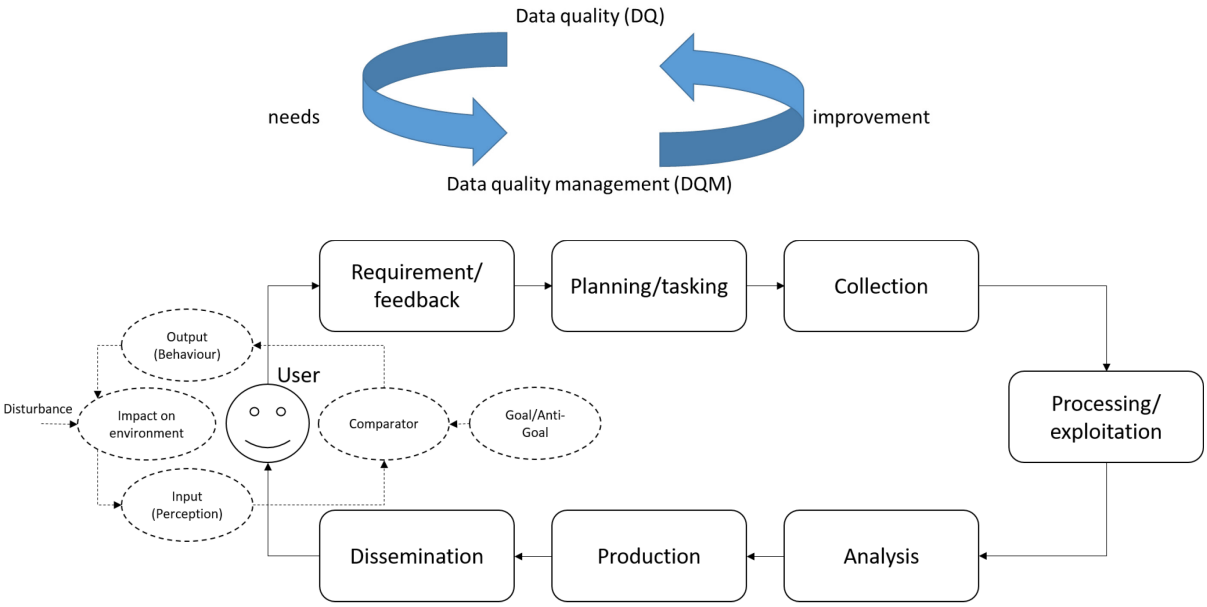

Figure 8-7: The Need for an Improvement Cycle of Data Quality Management According to Ref. [17] Illustrated by Intelligence Production Process of Products with Cybernetic Theory as a Framework [19], [20].

The Processing, Exploitation and Dissemination (PED) of data is the production process that transforms raw data to intelligence information (when we include the production process of creating the finished intelligence products useful for the customer). PED is a substantial part of an Intelligence Production Process of Products. Intelligence production is a dynamic and iterative process, as illustrated by the outer loop in Figure 8-7. Below we describe the major steps involved and we use cybernetic theory as a framework. Intelligence customers' needs are explained and converted to Intelligence Requirements (IR). The expected quality of intelligence products varies, and a method for describing Data Quality (DQ) is needed. Planning and collection; either intelligence at hand is sufficient, or extra intelligence is needed to be collected. This requires the ability of knowing what information is available. In the case this is not true, intelligence collection is necessary. The quality and reliability of collected sound data need to be assessed routinely by a data quality manager (DQM) to ensure quality of the finished intelligence products produced using these sources (i.e., processed and exploited to relevant data (analytic usable data)).

Reverting to the subject of analysis, we return to determining the value of QoE user satisfaction. The work of Battle and Harrington [2] proposes an analytical tool to identify areas of improvement and allocation of resources more effectively across the network. They propose to model end-to-end data quality mathematically in the form of the Abraham Wald's as cited in Battle and Harrington's [2] minimax model.

An example of a Chart of Data Quality $\min\{QDS_{max}, QoS_{max}, DR_{max}\}$ is presented in Figure 8-8.

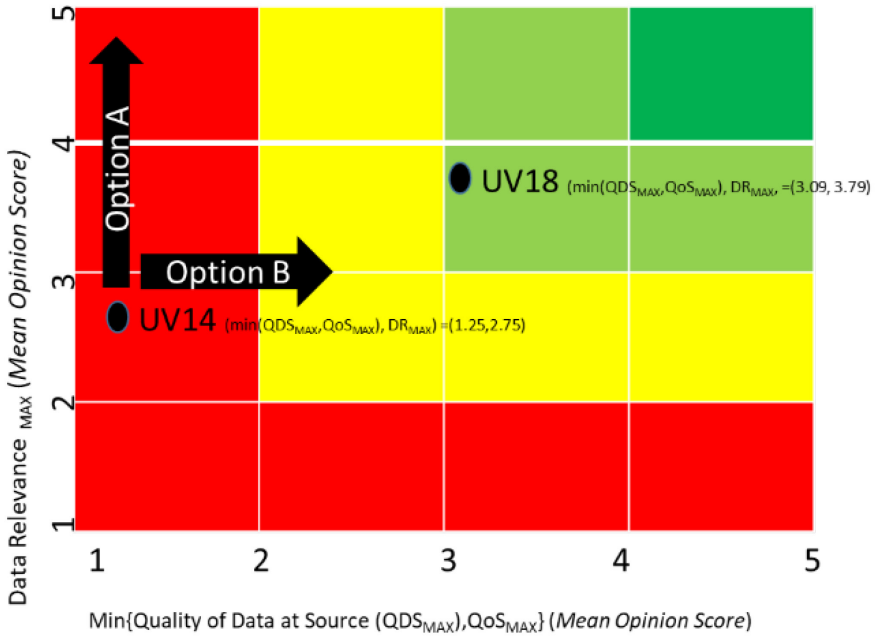

Figure 8-8: Chart of End-to-End Data Quality Measurements – Identifying Areas of Improvement and Allocation of Resources Based on the Methods of Battle and Harrington [2].

Our intention is to integrate this technique (measuring end-to-end data quality in HFM-276) to quantify a few indicators for the overall assessment of the data (Data Source analysis) in JISR processes, seen from the user's perspective.

QoE Assessment is the process of measuring or estimating the QoE for a set of users of an application or a service with a dedicated procedure, and considering the influencing factors (possibly controlled, measured, or simply collected and reported). The output of the process may be a scalar value, multi-dimensional representation of the results, and/or verbal descriptors. All assessments of QoE should be accompanied by the description of the influencing factors that are included. The assessment of QoE can be described as comprehensive when it includes many of the specific factors, for example a majority of the known factors. Therefore, a limited QoE assessment would include only one or a small number of factors.

We have used a sampling of users' scores as a preferred and direct method for measuring QoE. In the chart in Figure 8-8 the subjective measure of overall user satisfaction referred to as QoE is rated with surveys (Mean Opinion Score (MOS)).

An illustration has been made to indicate an overall estimation of QoE for UV18 based on post-trial survey mean opinion score on DR, QDS and QoS. The example is partly constructed because of missing data (i.e., missing valid Quality of Service data). In Figure 8-8 a particular value of user experienced data quality (QoE) is given at the start labeled UV14. From the start one could continue to improve DR (Option A) with no increase in the overall value of the QoE, whereas modifying the system delivering QoS and QDS (Option B) does increase the overall QoE [2].

The UV14 results are based on data logs (business monitoring of all tasks) and surveys, interviews and feedback from the Norwegian PED Cell [21]. The UV18 results are based on a survey designed to assess the perceptions of the data quality of the data of use in the various workplaces (nodes or PED-Cells) for accomplishing tasks during UV18, and to assess the information culture and information behaviors within these cells. The perceived subjective end-to-end QoE, based on the MOS value from UV18 post-trial survey on the 22nd of June chart, indicates *fair* to *good* on DR and *fair* on QDS.

The UV18 results indicate an evolution of JISR process following the Option B alternative defined in Figure 8-8 compared to the UV14 results. The UV18 results analysis based on the digital dump (simple persistence service log) from the UV18 log of June 18th to 22nd 2018 indicates that approximately 50% of the tasked assets where digitally connected to the infrastructure and operated according to procedure (NATO Standardization Office, 2016). We must assume that the collection tasks are visible and that the national IRM / CM tools have captured these tasks. Based on the results of UV18 we can deduce that there were a total of 240 tasks digitally tracked and monitored. A fraction of these tasks followed procedure and terminated with the status: *Accomplished* (1 of 4). This is a good result given the timeframe and the different maturity level of the participating entities. The workflow status of (exploitation) tasks analysis indicates that 3 of 4 either failed, timed out or ended undefined (see also Valaker et al. [22]).

During UV14 of June 21st to 23rd 2014 only 10% of the tasks followed the pre-planned process and terminated with the status Accomplished (75 of approx. 750 tasks). This represents the *bad* to *poor* portion of the scale of Figure 8-8 [21].

The results of the UV18 post-trial survey on data quality presented are based on the questions concerning data and metadata quality. The survey questions were designed to "measure" the perceptions of the data quality seen from the user workplace (Component node or PED-Cell).

The UV18 post-trial survey were designed to assess perceptions of the data quality in node/PED-Cell for accomplishing tasks during UV18. The lowest score observed was associated with the Sound data. For example, when the product quality of the data does not conform to specifications.

8.3.2 Results of Post Study System Usability Questionnaire (PSSUQ) Method

The results of the PSSUQ method is presented below. Figure 8-9 presents the set of data collected at the UV18 post-trial survey on the 22nd of June 2018. The Post-Trial results for System Usability (A-D) are the results of post-trial question number 72 –75. The Post-trial results of Visualization (J-M) are linked to question number 76 – 79. Unfortunately, the results of the Visualization part of the PSSUQ-method (J-M) where not significant and could not reveal how Visualization impacts operations.

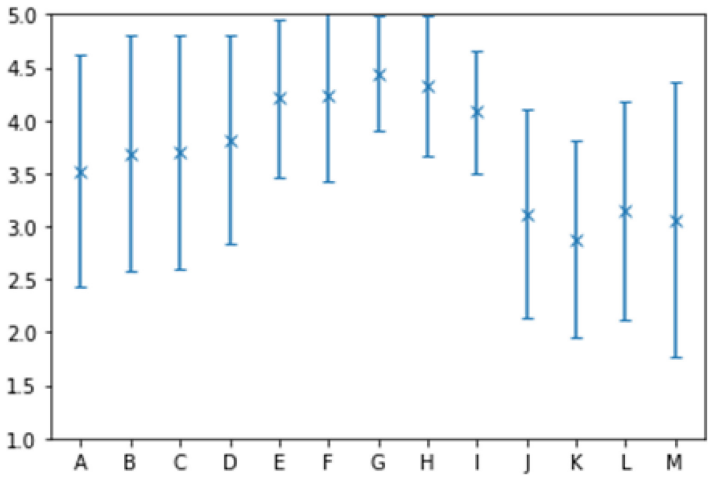

Figure 8-9: The Set of Data Collected is Composed of Results from the UV18 Pre- and Post-Trial Survey of June 2018. The first set of data is from the Post-Trial Survey results for System Usability (A-D) which are the results from post-trial survey question number 72 – 75. The second set of data is from the Pre-Trial Survey results of Visualization (E-I) are pre-trail survey question labeled Visualization. The third set of data are from the Post-Trial Survey results of Visualization (J-M) are the results of post-trial survey question number 76 – 79.

System Usability

The results of the PSSUQ-method indicated that it was simple to use the application for the tasks dedicated for their role in their Operational component (A) ($M = 3.52$, $SD = 1.093$, $t(32) = 2.707$, $p = 0.011$).

The results revealed that the user was able to complete their tasks and daily vignettes quickly using their application for the tasks dedicated for their role in their Operational component (B) ($M = 3.69$, $SD = 1.120$, $t(31) = 3.473$, $p = 0.002$).

The analysis showed that the operator felt comfortable most of the time using their application for the tasks dedicated for their role in their Operational component (C) ($M = 3.70$, $SD = 1.104$, $t(32) = 3.628$, $p = 0.001$).

The findings revealed that it was easy to learn to use their application for the tasks dedicated for their role in their Operational component (D) ($M = 3.82$, $SD = 0.983$, $t(32) = 4.782$, $p < 0.001$)).

Visualization

The result of the PSSUQ-method indicated that the manner in which data is presented is important to successful JISR operations (E) ($M = 4.21$, $SD = 0.74$, $t(47) = 11.27$, $p < .001$). Visualization impacts information sharing (F) ($M = 4.24$, $SD = 0.82$, $t(45) = 10.23$, $p < .001$), decision-making (G) (M=4.44, $SD = 0.54$, $t(47) = 18.37$, $p < .001$), and SA (H) ($M = 4.33$, $SD = 0.66$, $t(47) = 13.93$, $p < .001$). The result of the pre-trial survey indicated that the ISR CD&E process should experiment with different types of data visualization in order to improve JISR operations in the best way possible (I) ($M = 4.08$, $SD = 0.58$, $t(46) = 12.75$, $p < .001$).

Unfortunately, the results of the Visualization part of the PSSUQ-method (J-M) where not significant and could not reveal how Visualization impacts operations.

The result did not indicate how end-users rated how the application(s) gave feedback and error messages to fix problems when operating the application(s). (J) ($M = 3.12$, $SD = 0.992$, $t(32) = 0.702$, $p = 0.488$).

The findings did not show that the operators' views about whether the organization of information (such as online help, on-screen messages and other documentation) on the application screens was clear and instructive in helping to complete their tasks and daily vignettes. (K) ($M = 2.88$, $SD = 0.927$, $t(32) = -0.75$, $p = 0.458$).

The result did not indicate whether the operators liked using the interface of their application(s) (L) ($M = 3.15$, $SD = 1.034$, $t(32) = 17.501$, $p < 0.001$) or, that their applications had all the functions and capabilities they expected it to have to support their tasks during daily vignettes (M) ($M = 3.06$, $SD = 1.298$, $t(32) = 0.841$, $p = 0.406$).

The PSSUQ was supplemented by non-structured interviews and ergonomic observation, and internal technical studies, and system-logs**.**

The UV18 end-user's typical physical working environment supported the exercise activities, and did not affect the performance of the end-user in a negative way (see Buffat, this report – Chapter 9).

8.3.3 Results on Obstacles to Data Sharing

To illustrate the obstacles to Data sharing we have added samples from UV18 (and compared with results from UV16).

Syntactic Boundary

A syntactic boundary may be referred to as a transfer of static or dynamic data in the context of JISR operations.

Some example of the obstacles to information sharing is missing organizationally metadata and security markings on products and workflow data. An inspection of the releasable markers showed that different security markings are present in the workflow data from UV18. Some of the labels were only used a few times, and the elements were test elements. Wrong security metadata will also reduce information flow.

Security classification markings of ISR products are mandatory. That is, they were to be labeled according to the policy stated.

We are looking into the security classification markings of workflow entities (e.g., ORBAT, collection requests, tasking) and comparing UV16 and UV18 data regarding naming conventions and organizational markings in Table 8-1.

Table 8-1: Examination of Correct Naming Conventions and Organizational Metadata Elements on Datasets from UV16 and UV18.

Naming Conventions and Organizational Metadata Elements by:	Unified Vision 16 – Correct Metadata (in %)	Unified Vision 18 – Correct Metadata (in %)
Publisher of product / workflow data	56.9%	
Source of product / workflow data	54.5%	
Creator of product / workflow data	47.4%	48% (measured strictly according to syntactic quality measures)
Overall security attributes	70.1%	91% (measured according to pragmatic quality and fitness for use)

Incorrect overall security metadata will reduce information flow such as of syntactic boundaries according to Carlile [3].

Semantic Boundary

A semantic (i.e., interpretative boundary) may be referred to as a translation of requirements (ISR, RFI, Task) to collect data in the context of JISR.

Some data elements are created during the planning and direction phase of a military operational process and are carried on until the dissemination phase. An example of this is an Area of Interest (AOI) that is linked to an information request and tasking a sensor system within the collection phase. The sensor system produces a sensor product (imagery, picture, video clip, radar track) that covers the AOI. Subsequently, a single-source exploitation product during process and exploit phase of the JISR process is created with the AOI linked to it or integrated into it. The annotated product or report is disseminated back into the operational process (normally the intel cycle process) linked to Joint ISR as part of a Joint ISR result. According to the work of Essendorfer, Kuwetz, and Sander [1] the solution to Distributed Information Management is through the concept of Coalition Shared Data (CSD).

The AOI Use Case of Essendorfer et al. [1] is an example of where the operators, prior to the digital age, were using artifacts such as maps to interpret and negotiate knowledge across domains and users. Digitizing military operations changed the so-called negotiation process due to the transfer of AOI among the clients of JISR infrastructure. Despite the fact that “new” boundaries make collaboration across them difficult, some objects (e.g., tools) actually help operators in JISR operations. When the users are “fully integrated” the objects described as boundary objects help create a shared context between specialized communities because

they help actors share their knowledge and assess the knowledge being used in other specialized communities [4]. Extended use of Chat-tools at UV18 is an example of "new" boundaries that make collaboration across them difficult. A fully integrated IRM&CM-tool is an example of objects (e.g., tools) at UV18 that help JISR operators in Data sharing.

Pragmatic Boundary

A pragmatic boundary may be referred to as a *transformation* of data to knowledge in the context of JISR operations (e.g., process and exploit – disseminated back into operational process as part of a Joint ISR result).

The UV18 CSD infrastructure provided the interfaces necessary in order to facilitate the ISR process and to transform data into intelligence (single source products).

Generally, infrastructure support to the operators is both an enabler and a boundary to cooperation and translation of tasks and information requirements (e.g., federated PED) in JISR operations. According to the UV18 evaluation-team (see Albert [23]), all the product streams were able to be searched and replayed using a web client for disadvantaged users, other than those provided with specific STANAG 4559 compliance tools. This is an example of mitigation where disadvantaged users could get support to problem-solving activities to reach end-state.

UV18 – CSD infrastructures:

1) Are used for exchanging workflow elements as part of the Joint ISR process.
2) Keep the status on workflow elements usually short lived and subject to rapid changes.
3) Handle fragmented workflow elements and often referenced product, streams and/or other referenced workflow elements.
4) Keep track of ORBAT and partial-Intel Architecture connected by workflow elements.
5) Exchange tasks, task statuses, ISR-requests, RFIs, NAIs, TAIs, ISR Requirements which are all elements in the workflow.
6) Support workflow elements associated with (different) metadata.
7) Consisting of workflow data in the form of XML-documents formatted according to schemas defined by the CSD Standard.

Generally, in order to take advantage of the infrastructure, interoperable user systems are required. Participating clients who can only access part of the CSD infrastructure, for example, a client might retrieve a product from the IPL, but not the ISR question it answers. This may represent a pragmatic boundary in missions or trials where many users who do not have sufficiently integrated tools. Partially integrated systems may break the end-to-end workflow, leaving parts of the process "invisible" to the CSD infrastructure or requiring a huge amount of manual data input from the operators to keep track of the tasks. Poorly or partially integrated systems are also likely to reduce data quality.

An inspection of the number of ISR-requests forwarded between different units showed that the IRM/CM-cycle was not always correctly closed during UV18. Also some of the accomplished IRM&CM entities were set at this final status without reporting any product associated to them. The workflow data consists only of the information objects exchanged on the CSD Infrastructure. Workflow using chat or any other means of communication will not necessarily be included in the workflow.

Additionally, the operators need to:

1) Be aware of different locations limitations and possibilities in order to choose the "right" communication tool
2) Know the required tools and process
3) Understand the infrastructure's ability to support operator requirements
4) Be aware of the business process diagrams in relevant doctrines for the different roles at the different locations
5) Connect the infrastructure according to business rules based on the relevant doctrines (e.g., AJP-2, AJP2-7 and AINTP-14) and system capabilities
6) Cope with limitations of the connectivity between the different locations

8.3.4 Modeling of Output Factors

Based on our findings, we suggest a minor change on the modeled Output factors as part of the HFM-276 model (for JISR and other operational processes).

The minor revision of the dependent Output factors for Joint ISR and other operational processes to-be consists of the following "instruments":

1) Shared situation awareness (as is).
2) Data analysis (QoE) (new):
   a) Measure DR;
   b) Measure QDS; and
   c) Measure Network QoS.
3) Information sharing (new):
   a) Measure syntactic capacity e.g., verification methods, On-Line Tactical Processing (OLAP) analysis;
   b) Measure semantic capacity e.g., validation methods, semantic mapping methods, cross-functional interactions/teams, boundary spanners/translators; and
   c) Measure pragmatic capacity e.g., validation methods, prototyping different kinds of boundary objects that can be jointly transformed.
4) Decision making (as is).

8.4 DISCUSSION

How good is a system's DQ? Answering this question requires DQ metrics. In the article we have proposed data dimensions, DQ measures necessary for developing metrics that can help develop data quality metrics in JISR. We have introduced DQ as a multi-dimensional concept. The question is how to assess the effect of DQ on a federated PED process – e.g., CSD concept validated by the user. The concept of Distributed Data Management through the CSD concept and the integration into operations needs DQ assessment and management. Subjective DQ assessment reflects the needs and experiences of the end-users of JISR. According to Essendorfer [24], this implies that it must be ensured that the data itself remains intact and interpretable throughout the whole life cycle. Data (exchange) must be reliable and accurate. In general, the whole process must be coordinated and flexible (responding to emerging events and to loss of own assets). To enable higher-level product management techniques, the data and information models as well as the data formats that are present throughout the life cycle need to be interoperable. Security rules (on multiple levels)

as well as time constraints must be obeyed. In the article we have presented a method applied on a data set collected from a NATO JISR trial named UV18. The presented method use subjective measures to present a Chart of Data Quality for the stakeholders. If stakeholders assess the quality of data as poor, their behavior will be influenced by this assessment. In the note we have used a questionnaire, developed to assess data quality dimensions listed. A follow-up investigation into the root causes of differing assessments should be provided to get more insight on areas needing improvement. Given that a high user satisfaction for the end-to-end DQ can only occur when all the selected attributes ranged with a medium to high score. We may be able to present a "chart of end-to-end data quality" e.g., a cost benefit aggregate (of a decomposition of objective measurements) supporting the selection of relevant measures.

Not considering data quality in a coalition network system can lead to serious problems. In NATO operations intelligence is produced through the management of ISR assets and actors available within coordinated sub-processes. According to NATO (NATO Standardization Office, 2014) the Intelligence Cycle is the sequence of activities whereby information is obtained, assembled, converted into intelligence and made available for users. Creating intelligence following the phases of the Intelligence Cycle and the JISR process points out a number of requirements relevant in terms of the management of data. During the different phases, multiple data elements are created with some of them only being relevant during a short timeframe or within one specific phase and others being relevant throughout the whole Intelligence Cycle. In the article, the QoE is a subjective Quality in Use metrics influenced and dependent on internal metrics that involves human dimensions. It ties together user perception, expectations, and experience of JISR applications and network performance on military enterprise networks. The main question is how do we best implement analysis methods and how do we guide the analysts with the purpose of identifying and designing recommended practices for end-to-end analysis.

A possible way forward to guide the users of the methodology is to divide it into main "phases and steps".

The context used for the evaluation should match environments in which the system(s) will be used in the future. A question is how we best implement and adapt the techniques to the context and environments for the assessment and improvement of data quality in a specific application or organization. In this article, the primary tool used for evaluation is based on a survey. System attributes introduced referred to as quality attributes is connected to the discussion of quality of data in a communications network. Usually, these attributes are limited to evaluating traditional quality of service, for instance, performance metrics like latency, bandwidth. QoS expects prioritization has occurred prior to the data entering the network. Not all data is the same, some is more relevant to the user's needs when compared across all the data. Supporting results from observations, technical analysis tools are used to obtain a background picture of systems in use. Generally, at one extreme one should make measurements in the "field" using a real work situation as the basis for the evaluation of the quality in use of the JISR software system. However, the advantage of using the laboratory based approach is that it offers the opportunity to exercise greater control over the variables which are expected to have critical effects on the level of quality in use achieved, and more precise measurements can be made. The disadvantage is that the artificial nature of a laboratory environment can produce unrealistic results. The UV18 assessment team along with HFM-RTG-276 was supported by data captured during the execution phase (18 – 25 June 2018) from a real work situation as the basis for the evaluation of ISR capabilities and process with its advantages and disadvantages regarding the context of use. In this way UV18 comprised a compromise between the field and the laboratory and was in many ways a "naturalistic" setting for studying data quality. UV18 allowed intrusive measurements valuable for the data collection and analysis of Joint ISR capabilities and process.

Assessment and selection of measurements of the relevant dimensions of data quality is often based on one's own judgment. A guideline for a future questionnaire-based DQ methodology should determine and verify, and help the user to implement, the quality metric system most appropriate. Objective assessments can be task-independent or task-dependent. Task-independent metrics reflect states of the data without the contextual knowledge of the application, and can be applied to any data set, regardless of the tasks at hand.

Task-dependent metrics are reflecting states of the data with contextual knowledge of the organization's business rules, doctrines, procedures and government regulations, and constraints provided by the stakeholders. For purposes of benchmarking and quality management, every Joint ISR product should be measured according to the quality metrics that correspond to the subject and use of the product (i.e., assessment in context). A guideline should include categorization mechanism, quality dimensions and selection of design instruments for measurement and validation tools for instruments and verification mechanisms for the overall quality metrics system proposed.

Also some more discussions of strength and weaknesses of a very user focused quality theory could be included in further studies of data quality in the context of JISR. For example with respect to artificial intelligence and better computer processing will human user focus be as important? Will the human user role be important in other ways than before, for example where the supervisor role will be more important in order to utilize the AI and increased computing capacity?

Jayawardene [14] argues that a major proportion of the data quality management portfolio should be human-centric and only a lesser proportion can be handled using automated data quality problem detection and prevention mechanisms. Jayawardene [14] argues that this insight may be helpful in designing data quality management strategies.

8.5 CONCLUSION

We introduced descriptions of a DSA method along with metrics to support the development and assessment of QDS. The method also identified the need for separating the measures of QDS and Relevance of Data. Our findings suggest that researchers may successfully apply these measures of DQ when evaluating NATO Intelligence and JISR processes. These findings are consistent with the framework developed by Battle and Harrington's [2] understanding that high-quality data should be intrinsically good, contextually appropriate for the task, clearly represented, and accessible to the data consumer operating in communication networks. The framework may be useful describing obstacles to data and information sharing in the HFM-276 [3].

The metrics to support the development and assessment of DQ at the Source as part of user experience is considered the inherent quality of the originating data prior to its entry into the network. According to Wang and Strong [25], intrinsic DQ denotes that data have quality in their own right.

Post-trial survey results from the combined NATO JISR process trial UV18 were used as data input to the method. The results from the measurements of perceived data quality consist of three attributes: QDS, DR, and Network QoS. A method describing the perceived DQ using minimax decisions based on users' survey ratings for a given network configuration is applied. The presented method offers decision support tools to enable agencies in their allocation of limited resources towards improving the performance of their net-centric service offerings to the enterprise network. Results on perceived QoE from the UV18 post-trial survey indicates that the weak dimensions measured was the dimension: Sound Data. The highest mean opinion score observed was on Usable Data, when data meets or exceeds User Expectation. The Sound Data measurements seem not to be influenced by applications or systems directly according to the mean opinion scores on System Usability (which was given a high score). The low score on intrinsic data quality indicates the importance of Sound Data in JISR systems.

The metrics to support the development and assessment of DQ measuring the DR part of user experience is considered the measure expressing the utility provided by the data towards the consumer's objective(s). According to Wang and Strong [25] the dimensions proposed for assessment of DQ have contextual features, representational features and accessible to the data consumer as well as intrinsic features. Contextual data quality highlights the requirement that data quality must be considered within the context of the task-at-hand. Representational data quality and accessibility of data emphasize the importance of the role of systems.

To follow up the intention of the proposal, the evaluation method provides support for a balanced use of resources due to the Chart of Data Quality aggregating Quality and Relevance of Data. We claim that once an accepted set of data quality characteristics and associated metrics for JISR is available there is a good case for explicitly incorporating it into current and future JISR systems. The design philosophy for the overall assessment of the end-to-end DQ should be determined by the attribute with the lowest user satisfaction. A discussion of strength and weaknesses of a very user focused quality theory should be included in future studies. Further on, we propose human involvement supervising rule-based DQM. Will the human user role be important in other ways than before, for example where the supervisor role will be more important in order to utilize the AI and increased computing capacity?

The various goals, objectives, and measures of data focus areas of JISR (e.g., Chart of Data Quality for the stakeholders) are proposed to be integrated and mapped into the HFM-RTG-276 framework.

Along with the DQ metrics, we also introduced descriptions of the PSSUQ method along with metrics to support the development and assessment of System Usability.

Post-trial survey results based on PSSUQ measuring System Usability from the combined NATO JISR process trial UV18 were presented. Highest mean opinion score presented was on System Usability, when System Quality meets or exceeds User Expectation. The results revealed that users were able to complete their tasks and daily vignettes quickly using their application for the tasks dedicated for their role in their Operational component. The findings revealed that it was easy to learn to use their application for the tasks dedicated for their role. Subjective judgment indicates the importance of System Usability in JISR systems without proper integration of sensors we are not reaching the objective of sound data (i.e., features of intrinsic data quality before system and applications enters the network.

Generally, the interface design was old, and not user centered. The result of the pre-trial survey indicated that the manner in which data is presented is important to successful JISR operations. Unfortunately, the results of the Visualization part of post-trial survey-query where not significant and could not reveal how Visualization impacts operations. The results could not explain how end-users rated the application(s) nor gave feedback and error messages to fix problems when operating the application(s). Highest mean opinion score presented was on System Usability, when System Quality meets or exceeds User Expectation.

However, system performance and technical capabilities were good at UV18 compared to UV14. User-satisfaction provides a perceived and subjective assessment measure of Quality in use metrics. However, the measurements indicate that there are a number of challenges to usability meanings and interpretation discussed in the referenced literature [6]. It is expected that metrics of Quality “in use” can be available and accurately built as a function of objective measures from network, applications, environment, and terminals. To understand cause and affect it is ideal to have the full reference, that is, process and task data at the source as well as objective measurements of process log data on the network that can be used to correlate with the end user’s experience and satisfaction. Examples of analysis of procedural task data are beyond the scope of this article. However, objective measurements of accomplished tasks and the rate of successfully terminated collection tasks and analysis products generated by the JISR processes should be included in the Quality in use-analysis.

The theory and results contribute to increasing the general understanding of DQ issues relevant for improving the information quality management of ISR. We contribute to fill this gap by introducing a framework of data quality, which we use to estimate DQ on military enterprise networks when evaluating NATO Intelligence and JISR processes. The essence of this framework is to characterize in a parsimonious way data requirements from sensor to shooter. Since data quality continues to be dictated by the “fitness for use principle”, the DQ user requirements and user expectation to DQ are highly dependent on the organizational context. DQ and Data Quality Management should be viewed as necessary pre-requisites when integrating data sharing concepts into operations. A JISR coalition is a complex

enterprise, therefore, a structured approach to data quality management is needed. We suggest DQM be explicitly tailored to the specifics of the coalition supported by DQ requirements and Joining Instructions. In a JISR coalition, different types of systems interact with each other. On the one hand, there are systems consuming the products published and shared. Sensor systems produce sensor data, exploitation systems produce annotated imagery and exploitation reports, and IRM&CM systems produce information requirements and collections tasks. A data sharing concept supporting use cases of these system-of-systems in a JISR coalition are thus the retrieval of published ISR products, by users in need of respective information. Further on, the main use cases include the use of the retrieved products, and the publishing of ISR products. Data quality management for a JISR coalition has to support these use cases, technically, procedurally and organizationally to:

1) Ideally, enable a user to find and retrieve usable (valid), sound (consistent) and dependable (current) ISR products according to his or her (informational) needs;
2) Enable a user to handle his or her required ISR products based on the assessed and known quality of these products; and
3) Support a user when producing and sharing useful and relevant products.

Subjective judgement indicates the importance of Sound Data in JISR systems i.e., depending on features of intrinsic quality before data enters the network (dependent on sensor integration). The suggested Data Source Analysis method (adapted RTG-276 model) are a set of techniques that are designed for measurement assessment, and improving data quality in a given application or organization. We are making a proposal of an appropriate list of data quality dimensions, investigated by a questionnaire-based method designed in order to do State reconstruction, Assessment and Improvement of DQ. In the future, we propose to build system support that allows for a systematic tracing of challenges and improvements in DQ.

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Chapter 9 – APPLICATION OF THE THEORETICAL MODEL TO A PED-CELL NODE

Stéphane Buffat, Rune Stensrud, Daniel Zelik, Sigmund Valaker, Anne Lise Bjørnstad, and Fred Lichacz

9.1 INTRODUCTION

The PED-Cell in Bruz, France, was one of the geographically distributed PED-Cells that fed information into the JISR HQ at the WPC in Germany. The PED-Cell leader in Bruz permitted a NATO HFM RTG-276 panel member the opportunity to study PED-Cell operations within the theoretical framework used to guide the panel's research in UV18. All following considerations were organized to match the theoretical model of organizational behaviour developed by members of the NATO HFM RTG 276 panel (see Figure 9-1). This work occurred over a two-day period.

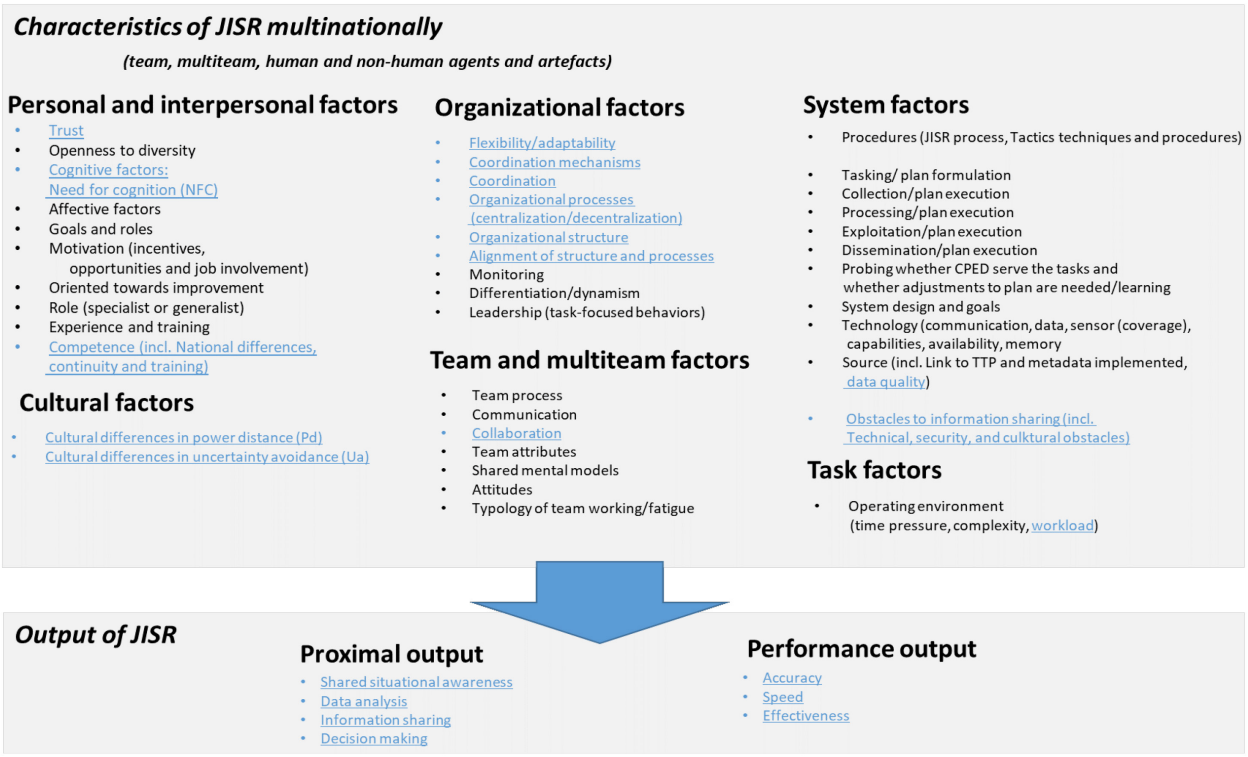

Figure 9-1: Human Factors Influencing JISR and Its Output Factors – General Model.

Over the two-day period, there was an examination the PED-Cell's operations in relation to the different aspects of the theoretical framework as they occurred within the PED-Cell. Second, data was collected and analyzed regarding daily flexible adaptive behaviour. Adaptive behaviour involves operators switching attention rapidly and accurately between different stimuli or information provided by various sensors and human intelligence collection input. Often, changing rapidly between different inputs results in the degradation in target report accuracy and time response.

9.2 DAY 1, JUNE 18

The examination of PED-Cell operations event was broken down by the operators' position in the PED node and by major components of the theoretical framework.

On the first day of the exercise, the PED-Cell node Bruz France leader gave a general briefing about the UV18 objectives (NATO and National) from the Bruz PED-Cell capabilities perspective.

The daily schedule was as follows: The Morning Briefing was done before the official start of the day. From 10h00 to 15h00, the PED-Cell node worked on the daily "battle rhythm", an out debrief was performed via video-conference at 17h00, followed by an internal debrief at 18h00.

9.3 PED-CELL NODE LEADER AND TECHNOLOGY EVALUATOR

9.3.1 Personal and Interpersonal Factors

The PED-Cell leader in Bruz has extensive experience working in multi-nation settings. In addition, he has extensive NATO experience, including participation in Unified Vision 2016 (UV16). His view on experience and leadership is that it is very important for leaders to exhibit higher-level perspectives on operations in order to guide operators and other staff members. He views his role as a facilitator for personnel under his command.

From a cultural standpoint, he has stated that the capacities of some other nations within NATO are unknown. This lack of awareness of other allies' capacities can lead to a level of potential mistrust between NATO partners. This level of mistrust can be amplified by examples of reports misunderstanding between two nations that often occur. Language barriers and a lack of critical data (e.g., proper coordinates) are also important contributors to issues of trust. For example, "NATO English" can be a barrier to communications and intent due to linguistic subtleties specific to language. Fortunately, during UV18, the leader of the Bruz PED-Cell indicated that these potential linguistic barriers were not an issue.

9.3.2 Countermeasures for Operational Problems

The Cell node leader has said that it his duty to ensure all operations run smoothly via all external communications. As well, the PED-Cell leader set up additional training for his staff to ensure proficiency with all of the operational procedures and use of Chat and phone systems including information acknowledgement and presentation quality for all deliverables.

9.4 ORGANIZATIONAL FACTORS

Horizontal dialogue outside of hierarchical structure such as the sensor attribution level or even a direct tasking by N+2/N+3 was not found to be appropriate.

Structural and form defects seemed to have been impacted at higher echelons of the exercise.

There is a working tendency to have information clearly stated, detailed, and structured to improve efficiency. Information from higher echelon lacked this detail level somewhat. There appeared to be no micromanagement during UV18 at the Bruz PED-Cell.

9.5 TASK FACTORS

UV18 was viewed as very complex and appeared to have a greater workload for team leaders and commanders than those at the operator level. However, operational conditions for the exercise were very good in Bruz because the battle rhythm was rehearsed the week previous to the start of the exercise.

The PED-Cell in Bruz was fortunate enough to be at full operational capacity during training in order to respond appropriately to all tasks. Additionally, this PED-Cell had an excellent technical support.

9.6 SYSTEM FACTORS

There were no technical issues during the exercise due to pre-trial preparations and a reactive technical support team.

9.7 INTERFACE

The PED-Cell node was brightly lit mainly with neon lights and a few indirect lights. The exercise did not last during the night, so it is difficult to extrapolate the eventual shortcomings of the installation for night shifts.

9.8 HARDWARE

The PED-Cell layout included desk computers (mainly laptops) and flat screens with 3-button mice. The maximum graphic configuration was a double 4K computer screen. As well, notebooks, pen and paper boards were used for briefings and debriefings. The operators did not have tablets or touchscreen technologies. Although no true ergonomic chair was available, there was ample space for the operators to do their jobs. The open space configuration was deemed good for crosschecks and instant communication. There was limited noise level from local computers/servers, no audio alerts, and phones used a very muted ring tone.

9.9 SOFTWARE

With regard to working with the database, the majority of the work was mainly about determining relationships between information and groups. This work was conducted without any specific network visualization. Inside each database system, there was little automation (e.g., interface) to help in the generations reports.

9.10 COMMUNICATIONS

During UV18 exercise, the PED-Cell was linked with more than ten chat channels at any given time. There was no hierarchy for the channels. The operators had to check them all the time, and to switch from one chat channel to another to get the correct information.

9.11 NETWORK

Some systems were not interconnected. It was determined that the NATO Standardized Agreements (STANAGs) in place during the exercise were not enough to ensure good interoperability between nations.

9.12 TEAM FACTORS

All personnel had plenty of professional experience and were well trained. There were enough people to perform crosscheck work. According to the PED-Cell node leader, this is not how operations would work in normal theatre conditions. The PED-Cell node was understaffed at times during actual operations and the need of having more people for UV18 was noted. An understanding of the shortcomings of the exercise at the team level helped to create a relaxed and professional atmosphere. In addition, task sharing at each station lowered the overall workload for the operators.

9.13 OUTPUT FACTORS

For the most part, deliverables were produced when asked for within reasonable delay. In addition, the PED-Cell node played an integral part in helping to update some of the vignettes.

9.14 PERFORMANCE OUTPUT

For component of the theoretical framework, it is important to keep in mind that UV18 was designed primarily as a technical evaluation and not an operational assessment. Nonetheless, the operational performance of the overall exercise as seen from the Bruz PED-Cell node could be improved if operational assessment was the focus. For example, there was a perceived lack of C2 at Direx. This should be seen as a Lessons Learned for future Unified Vision exercises.

9.15 TASK SWITCHING

Day-to-day flexible adaptive behaviour requires the ability to switch attention fast and accurately between different stimuli or information provided by our data collecting technologies. However, it has been shown that rapid attention switching often occurs with a cost in terms of decreased target report accuracy and time response. This cost depends on many factors, including resolution and the degree of interference from previous events, tasks, and processes related to task setting and task preparation [1]. The impact of flexible adaptive behaviour on operators' performance during JISR operations was studied in the Bruz PED-Cell during UV18.

9.16 MATERIALS AND METHOD

9.16.1 Observers

Ten observers (Age 24 +/-3) volunteered for the experiment. They had normal visual acuity and color vision. They were not informed about the true purpose of the experiment until after the data was collected.

9.16.2 Stimuli

Color pictures of animals, vehicles, and landscapes were taken from a large commercial database. Their size was 512 × 512 pixels. Images of animals and vehicles could be presented upside-down in some experimental conditions.

9.16.3 Apparatus

The stimuli were presented on a CRT monitor (1,024 × 768 pixels) at a refresh rate of 120 Hz, coupled with a high spatial and temporal frequency stimulus presentation device (Visual Stimulus GeneratorTM, ViSaGe, Cambridge Research Systems, Rochester, UK). Participants were seated in a dimly lit room, 57 cm from the screen. Responses were recorded with a dedicated button box.

9.16.4 Procedure

In the response criterion-shift paradigm, each stimulus was presented for 120 ms. Each RSVP sequence was comprised of 26 visual stimuli, which were presented in the same central location on the screen.

In control trials, participants were instructed to monitor their computer screens for the same criterion for the entire duration of the trial. There could be no target, one, or two targets. In the experimental criteria shifts trials, the participants were cued to immediately switch the target criterion from one specified target category, T1, to another, T2.

A color criterion cue [2] was used to indicate the when to switch task:

1) A green frame cue signaled the Semantic condition (S); all pictures of animals were eligible targets,
2) A red frame cue signaled a Physical condition (P); all pictures of objects (animal and vehicles) presented upside-down were eligible targets,
3) A blue frame cue signaled a Physical condition (P); pictures of objects, in which the object covered less than a quarter of the picture, were eligible targets.

Task-sets were either Semantic (S) or Physical (P) (see target types above). The position of the targets T1, task-switch and target T2 followed the RSVP method first presented by Allport and Hsieh [3]. Switch-Target Intervals (STI) were 1, 3 or 7 frames (120, 360 or 840 ms).

The participants' objective was to report an eligible target at the end of the trial. Two response screens were presented in succession, one for each target, for the operator to make their response.

9.17 RESULTS

9.17.1 Shift Trials

On shift trials, there was a decrease in target report accuracy accompanied by a progressive recovery of pre-switch performance (Figure 9-2). The task-switch cost was greater for S→P than for P→P for the first STI, but also for the last STI investigated. However, there is no main effect for the type of condition (non-switch, P→P and S→P) $F(2,90) = 2.67$, $p = 0.0746$). Only the difference between non switch and S→P is significant for STI=1 (Fisher Test, mean diff. = 19.3%, crit. Diff. = 17,3%, p value = 0.0336).

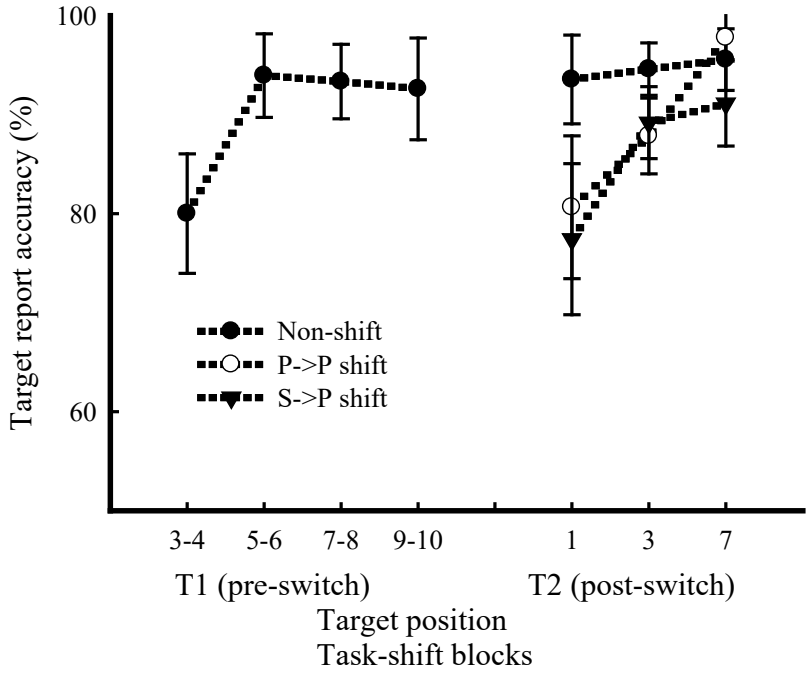

Figure 9-2: Data from the Criterion-Shifts Blocks: On No-Shift Trial, and for Physical → Physical (P->P) and Semantic → Physical (S->P) Trials Criterion Shift.

9.17.2 PED-Cell Node Co-Leader

The PED-Cell Nod co-leader also had previous NATO experience (participation in UV16). He thought that the French PED Node at Bruz was well staffed for UV18, compared with UV16. There was a good organization, a very efficient technical backup, and an efficient warm-up plan in time the week before.

9.17.3 Database Operator

At the operators, level, there was a lot of 'menuing,' and a lot of Icons to manage. The format for objects/files naming was compatible with UV18, but there was a need for an object "description" column. Of special interest, there was a report of high workload when two reapers were tasked at the same target. Regarding the interface/system: the multiple layers of functions and icons multiplication can be related to previous software versions.

9.17.4 17h00 Outbrief Webex

The audio quality of the Webex meeting was subpar. Surprisingly, there was no video sharing. The cell node had to downloaded pdf files from the UV18 website.

9.17.5 17h45 Local Debrief

The local debrief was a textbook debrief of events on the day followed by goals and expectations for the day after. The debriefing includes every member and all visitors with clearance (if any) as well.

9.18 DAY 2, JUNE 20

9.18.1 PED-Cell Node Leader and Technology Evaluator

9.18.1.1 Performance Output

According to the PED-Cell node leader, "What defines a quality deliverable is the completeness of the required fields, the quality of the information filling the fields, and the relationship between demand and product, both in content and schedule."

9.18.1.2 PED-Cell Image Specialist

The Image specialist was not aware of the existence of neither the NATO HFM RTG-276 panel nor any HF specialist investigating the role of HF in ISR process/interface issues.

9.18.1.3 Personal and Interpersonal Factors

The language barrier was seen as the major factor impacting multi-national work. Briefings were usually kept short and very focused which was attributed to the lack of English fluency in the PED-Cell. Some effort was dedicated to ensure that the event was thought of as a real life operation and not to be confounded with synthetic environment.

9.18.1.4 System Factors

According to the PED-Cell Image Specialist, there were too many windows for the interface image analysis. The Windows layout must be configured manually each time the operator uses the software. There is no apparent layout setup memory. Unfortunately, the interface is far from intuitive.

9.17.1.5 8h30 UV18 In-Brief

The morning briefing was conducted via Webex. Again, sound quality was poor. The level of English fluency varied greatly across the participating nations which led to some comprehension issues.

9.18.1.6 9h00 Local Briefing

The local briefing focused on improving the details and accuracy of products. There was also a reminder about reporting and operating within the proper chain of command.

The exercise started at 10AM sharp.

9.19 HQ Evaluator

9.19.1 Personal and Interpersonal Factors

There was concern about the degree of interaction between a particular PED-Cell from one nation and the rest of the PED-Cells in the event. There was also concern about the degree to which one nation in UV18 had "boots on the ground" to support UV18 operations.

There are important exchanges occurring at the operator levels via the workstations. The participants viewed these exchanges as an important factor for group cohesion and technical efficiency.

Everybody agreed that the Webex quality (input) and the product quality (ppt as output) could be much improved. There was also a concern regarding this type of output and the C2 tools insofar as it could be improved by:

1) Their use of new software programs for automated translation with AI.
2) The use of algorithms to slow the rate of speech flow to aid understanding without changing the voice timbre.

9.20 Organizational Factors/Task Factors

It was noted that there are differences in doctrines across nations for sensor attribution. For example, the PED-Cell Node in Bruz realized that there was a different doctrine for sensor attribution between France and Norway which differed mainly in terms of the Organic vs. functional. This difference in doctrines provided for unclear situations at UV18. That is, these differences created a certain degree of misunderstanding across nations when it came to issues such as sensor attribution which supports and expands the quantitative findings in Chapter 7 that pertain to lower shared awareness across PED-Cells.

9.20.1 System Factors

During UV18, it was noted by the PED-Cell Node at the Bruz site that they were an ad hoc set up that is quite different from a classic operation center. As a result, software programs were designed according to the doctrinal needs of the experiment and were thus different than what operators were used to using during actual NATO operations.

9h30: Preparations for the day's activities are warming up and reaching critical point in terms of background voice noise.

9.20.2 Operator 1: Sensor Side Low Workload

During UV18, file naming is critical. There have been some issues with the file naming protocols. In addition, some test materials from the technical week were not purged in time for the experimental trials at some operators' stations and this residual data was acting like noise in the actual data and causing increased workload.

One concern is whether the System Supervisor should manage the database.

9.20.2.1 System Factors

All objects are accessed through the database.

There are a lot of exchanges via chat. Chat boxes are limited in size. Overall, the amount of information flowing across chat forces the design of the system to opt for high resolution and small font size.

Chat at UV16 was better organized (there were chat moderators, information was more focused on mission factors, and there was a more formal protocol).

The interface design is old, and not UV centered. However, system performance and technical capabilities are very good.

The training process is long and intensive, but the updates cause additional training needs.

During UV18, there are two operators, so tasks are shared, whereas usually a single operator works alone.

Note that posture is an issue due to seat positions, screens positions and task sharing. These factors could be improved to alleviate posture discomfort.

9.20.3 Operator 2: Analysis Side Medium Workload

The role of this operator is to prepare the detailed data for production. There is no automation (e.g., automatic vehicle recognition) at this stage which increases the workload of the operator.

9.20.4 Coordinator's High Workload

9.20.4.1 Task Factors

As one operator reported, "Products are produced and must be up to date." The depth of analysis is completed after the initial report is prepared. Given the almost continuous updates, the workload for members of the production team is reported to be high. They are always rushing to prepare the final product edition and coordination at this level is key and intense.

9.20.4.2 System Factors

The output format is mainly ppt. and there is no predefined object designed for the product, only standard ppt. objects. However, there are UV18 templates that help, along with some copy-paste functions that are working well to help put together products.

9.20.4.3 Experience

The need to proofread written English before sending information up the chain slowed down the delivery of some of the intelligence reports. This contrasts the findings from Chapter 10 which showed English language

proficiency is not an obstacle for information sharing. Thus, it could be that there are isolated pockets within the JISR enterprise where language proficiency is a problem but is lost in the larger aggregated analyses. This issue that will require closer attention in future research.

9.21 17H00 OUTBRIEF WEBEX

There were no issues during this outbrief.

9.22 17H45 LOCAL DEBRIEF

The local debrief was conducted very professionally.

9.23 GENERIC COMMENTS

Fatigue, outside the normal levels of fatigue during these types of operations, was not an issue during the UV18 exercise. This is primarily due to the lack of a night shift, which is very different from regular combat operations. Working long hours inside the building with only artificial light is known to impact health [4] and could be studied during future UV events. During the interviews, many questions were raised about Artificial Intelligence (AI) and JISR that they believed should be examined by an ergonomist.

Embedding in the exercise was excellent, and every member of the PED-Cell willingly participated, with the clear intention to improve JISR operations.

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Chapter 10 – POST-TRIAL SURVEY RESULTS

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10.1 INTRODUCTION

The post-trial survey questionnaire (see Annex B and Annex C) was developed to gain an understanding of how the UV18 JISR Trials impacted specific HF issues associated with operator performance. The survey consisted of eight sections with multiple statements about each respective HF issue. In general, the findings revealed that the trials did not negatively impact upon the JISR operators' ability to do their jobs. This could be due to the 'artificial' setting or context within which the trials took place. However, certain lessons learned can be gleaned from these findings for future CD&E trials and applications to real world operational settings. These findings can be used for future UV trials and ISR CD&E research in general.

All participants were requested to complete the post-trial survey questionnaire immediately following the conclusion of the UV18 trials. There were 32 personnel responded to the survey. As with the pre-trial survey questionnaire, the participants were asked Likert-type questions using a 5-point rating scale about how the UV18 trial impacted a variety of HF issues:

1) Strongly Disagree
2) Disagree
3) Neutral
4) Agree
5) Strongly Agree

The means, medians, and standard deviations from the data are reported in the corresponding Tables. To determine if the average scores differed significantly from Neutral, a one-sample t-test was conducted comparing the observed mean against the midpoint of the scale (neutral value of 3) for each item at each assessment time [1].

Unfortunately, due to time constraints, some questions on the post-trial questionnaire had to be removed or re-written. Some questions were removed if they were deemed repetitive by the NATO data collection team (see Annex C).

10.2 ORGANIZATIONAL STRUCTURE

The results presented in Table 10-1 revealed that the operators view the organizational structure of the exercise as hierarchical in nature. This is an interesting finding given that previous research on military HQs has provided support for a more horizontal command structure. Interestingly, some of these findings contrast some of the findings in Chapter 7. This could be the result of incomplete answers and recoding issues. (See Chapter 7 for in-depth discussion of this finding).

Table 10-1: Means, Medians, and Standard Deviations of Views on Organizational Structure ISR Operations.

Organizational Structure					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	3.50*	4.0	0.72	32	$t(31) = 3.94, p < .001$
2	3.77*	4.0	0.49	31	$t(30) = 8.66, p < .001$
3	3.67*	4.0	0.75	31	$t(30) = 5.04, p < .001$
4	3.68*	4.0	0.69	32	$t(31) = 5.61, p < .001$
5	2.55*	2.0	0.72	31	$t(30) = -3.47, p < .01$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.3 ORGANIZATIONAL PROCESS

The results from Table 10-2 indicate that the organizational processes of the experiment were neither centralized nor decentralized. This finding might shed light on whether the findings from Table 10-1 can be looked at as either positive or negative from a command structure point of view.

Table 10-2: Means, Medians, and Standard Deviations of Views on Organizational Process in ISR Operations.

Organizational Process					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	2.84	3.0	0.76	32	$t(31) = -1.53, p < .258$
2	2.81	3.0	0.89	32	$t(31) = -1.18, p < .245$
3	3.31*	3.0	0.85	32	$t(31) = 2.05, p < .05$
4	3.31*	3.0	0.85	32	$t(31) = 2.05, p < .05$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.4 ORGANIZATIONAL FLEXIBILITY

The operators indicated that the organizational processes were quite flexible or neutral. They were not rigid. These findings seem to contrast the hierarchical characterization of the organization structure by the operators and the neutral view of the organizational processes (Table 10-3).

Table 10-3: Means, Medians and Standard Deviations of Views on Organizational Flexibility in ISR Operations.

Organizational Flexibility					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	3.46*	4.0	0.76	32	$t(31) = 3.48, p < .01$
2	2.91	3.0	0.77	32	$t(31) = -.68, p < .500$
3	3.48*	4.0	0.75	33	$t(32) = 3.68, p < .001$
4	3.42*	3.0	0.75	33	$t(32) = 3.24, p < .01$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.5 OBSTACLES TO INFORMATION SHARING

The data from Table 10-4 provides an examination of the extent to which various issues posed a problem for information sharing in this experiment. In general, the findings showed that there were not any real problems for information sharing. Not surprisingly, the data suggest that these variables "sometimes" caused problems for information sharing but the majority of the issues such as low English proficiency, differences in national culture, time constraints, approachability of the commander, political constraints, security, document and system classifications, were found to rarely have a negative effect on information sharing.

Table 10-4: Means, Medians, and Standard Deviations of Views on Obstacles to Information Sharing in ISR Operations.

Obstacles to Information Sharing					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	3.36	3.0	1.08	33	$t(32) = 1.93, p < .063$
2	3.30	3.0	0.95	33	$t(32) = 1.83, p < .077$
3	2.09*	2.0	0.97	33	$t(32) = -5.34, p < .001$
4	2.91	3.0	0.92	32	$t(31) = -.57, p < .572$
5	2.06*	2.0	1.19	33	$t(32) = -4.51, p < .001$
6	2.30*	2.0	0.95	33	$t(32) = -4.21, p < .001$
7	1.73*	2.0	0.80	33	$t(31) = -9.13, p < .001$
8	2.82	3.0	0.98	33	$t(32) = -1.06, p < .296$
9	2.73	3.0	0.91	33	$t(32) = -1.72, p < .095$
10	1.66*	1.0	0.82	33	$t(32) = -9.38, p < .001$
11	2.09*	2.0	0.85	32	$t(31) = -5.98, p < .001$
12	1.87*	2.0	0.74	33	$t(32) = -8.71, p < .001$
13	1.91*	2.0	0.87	33	$t(32) = -7.13, p < .001$
14	2.94	3.0	1.05	33	$t(32) = -.33, p < .744$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.6 INFORMATION SHARING

Despite the findings presented in Table 10-4, Table 10-5 reveals that the operators were for the most part neutral about the amount and content of the information they received primarily only somewhat content overall with information that they received.

Table 10-5: Means, Medians, and Standard Deviations of Views on Information Sharing in ISR Operations.

Information Sharing					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	2.84	3.0	1.25	33	$t(32) = -.69, p < .492$
2	2.75	2.0	1.19	33	$t(32) = -1.16, p < .254$
3	2.33	2.0	1.05*	33	$t(32) = -3.65, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.7 SHARED AWARENESS AND RESPONSIBILITIES

In general, the data from Table 10-6 on shared awareness and responsibilities revealed that with regard to working with others in their own nation/PED-Cell, the operators were aware of each other's' roles and how to execute shared tasks but were neutral when it came to being aware of each other's area of responsibility. Interestingly, the operators tended toward being more neutral about the same question about colleagues from other nations/PED-cells. Similarly, to the findings presented Table 10-1, there are some discrepancies with the data and analyses presented in Chapter 7. This discrepancy might be due to issues pertaining to internal and external shared awareness. See Chapter 7 for a more in-depth analysis and discussion of this topic.

Table 10-6: Means, Medians, and Standard Deviations of Views on Shared Awareness and Responsibilities in ISR Operations.

Shared Awareness and Responsibilities					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	2.81*	2.0	.92	32	$t(31) = -4.40, p < .001$
2	3.52*	3.0	1.06	33	$t(32) = 2.78, p < .01$
3	2.44*	2.5	0.95	32	$t(31) = -3.35, p < .01$
4	2.33*	2.0	1.05	32	$t(31) = -3.65, p < .001$
5	2.66	3.0	1.02	33	$t(32) = -1.87, p < .07$
6	3.16	3.0	1.13	31	$t(30) = .79, p < .432$
7	2.96	3.0	0.93	32	$t(31) = -.19, p < .851$
8	3.30*	3.0	0.88	33	$t(32) = 1.97, p < .05$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.8 DECISION MAKING

The operators indicated that decisions were made somewhat quickly. But although the operators indicated that they were neutral about the quality of the decisions made, they did reveal that the decisions made were quite successful (Table 10-7).

Table 10-7: Means, Medians, and Standard Deviations of Views on Decision Making in ISR Operations.

Decision Making					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	3.72*	4.0	1.48	29	$t(28) = 2.63, p < .01$
2	2.52*	3.0	0.88	31	$t(30) = -3.03, p < .01$
3	2.35*	2.0	0.75	31	$t(30) = -4.75, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.9 TRUST

Here, high scores represent low trust (Table 10-8). Accordingly, the data revealed that the operators did trust the operators from their own nations and PED cells as well as the operators from other nations and PED cells to share information, provide assistance when needed, and do their jobs. However, when the data are re-coded and analyzed using a different and more stringent methodology (see Chapter 7), slightly different results are obtained in terms of the pre- and post-exercise data (see Chapter 7 for in-depth discussion of these findings).

Table 10-8: Means, Medians, and Standard Deviations of Views on Trust in ISR Operations.

Trust					
Item	*M*	*Md*	*SD*	*n*	*t-statistic*
1	1.97*	3.0	0.73	29	$t(28) = -7.62, p < .001$
2	1.68*	1.0	0.79	31	$t(31) = -9.31, p < .001$
3	1.96*	2.0	1.96	32	$t(31) = -6.77, p < .001$
4	1.94*	2.0	1.94	32	$t(31) = -7.92, p < .001$

Note: Asterisked items are statistically significant; *M* = mean; *Md* = Median; *SD* = Standard Deviation; *n* = sample size.

10.10 DISCUSSION

The post-trial survey was developed to gain a broad understanding of how the UV18 JISR operations event impacted specific HF issues associated with operator performance. Even though it was acknowledged by the researchers and the UV18 operators that this event was artificial and the impact of the various aspects of the event on HF would likely be different during real life operational conditions that involve differing tempos and urgencies, in general, the operators provided positive feedback about the various aspects of the event on the HF issues.

The operators responded that the organizational structure was slightly hierarchical yet the organizational processes of the experiment were neither centralized nor decentralized. Moreover, the results revealed that the organization is quite flexible or neutral; it was not a rigid organization. The trail organizers should be happy with this finding as military research has shown that military headquarters tend to perform more effectively and efficiently when the command structure is characterized as more flexible than rigid [2].

In general, the data revealed that there were not any real problems for information sharing. Specifically, the operators indicated that the variables listed in the survey "sometimes" caused problems for information sharing. However, for the majority of potential obstacles to information sharing, issues such as low English proficiency, differences in national culture, time constraints, approachability of the commander, political constraints, security, document and system classifications, were found to rarely have a negative effect on information sharing. Yet, despite the 'lack' of obstacles to information sharing, the operators were only somewhat content with information that they received. However, despite the data showing that low English proficiency was not deemed and obstacle to information sharing in the overall analysis, the data from Chapter 9 collected at the French PED-Cell highlighted English language proficiency as an important problem. So, there could be mitigating circumstance that the data analysis was not sensitive enough to pick up and should be considered in future research of this sort. Within their own nation/PED-Cell, the operators indicated that they were aware of each other's' roles and how to execute shared tasks but were neutral when it came to being aware of each other's area of responsibility. Interestingly, the operators tended toward being more neutral about their awareness of the roles and responsibilities of their colleagues from other nations/PED-cells. The operators indicated that the pace of decision making was somewhat fast and while the operators indicated that they were neutral about the quality of the decisions made, the data indicated that the operators believed that the decisions made were quite successful.

With regard to issues about trust, the operators were confident that members from their own nation and other nations would share information and fulfill their responsibilities to ensure the operation would be a success. This is an important finding especially from within the context of multinational operations. Often the prevailing feeling is that cultural tensions and negative issues can surface within international efforts which can lead to negative outcomes. This study and others [3] show that there should not be too much concern among NATO members that multinational colleagues cannot work together. However, differences in results between Chapters 5 and 10, and Chapter 7 suggest that this is a more complex issue than previously thought. The discrepancy in findings between Chapters 5 and 10, and Chapter 7, might reflect the need for more careful coding of the data and more rigorous analytical techniques than used in Chapters 5 and 10.

In general, the findings revealed that the operational context of UV18 was considered a successful event. The setup of the HQ and the SOPs seemed to have been met with approval by the JISR operators. These findings bode well for NATO JISR operations in the current and future operations. NATO leaders should be confident in the way the manner in which they plan and execute JISR operations will lead to successful outcomes.

10.11 REFERENCES

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Chapter 11 – SUMMARY AND CONCLUSIONS

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11.1 GENERAL CONTRIBUTION

The NATO HFM RTG-276 Panel developed a study to get an understanding of the role and importance of HF issues during JISR operations. The nature of this work was exploratory. The task group used a model of organizational effectiveness developed by members of the NATO HFM-276 task group to guide the development of a data gather strategy. The HF assessment task used in UV18 and BQ19 was defined in line with the four goals of HFM RTG-276:

1) To gauge current knowledge about HF research in the ISR CD&E process;
2) To identify critical HF issues for effective JISR operations within a simulated NATO JISR operation;
3) To further explore a model of organizational effectiveness for understanding, explaining, and measuring different aspects of HF issues in JISR operations;
4) To make recommendations regarding improvement of education and training of NATO and partner countries' militaries for ISR CD&E coalition operations.

To achieve the goals of NATO HFM RTG-276, we developed and applied our model (presented in Chapter 2) in two of the major NATO field-exercises related to JISR federation among the NATO nations. This chapter conclude the findings related to goal 1) and 2) which is crystalized in our empirical findings (Section 11.2 Summary of Main Findings), 3) further explore a model which is discussed by way of limitations to our current study (Section 11.2 Limitations), and lastly we make recommendations as to 4) specifically how measuring HF issues could aid in the improvement of JISR (Section 11.3 HF Methodology for JISR CD&E).

Our results shed light on salient and general topics related to organizational effectiveness as well as particular issues pertaining to HF issues in ISR. This was accomplished by collecting data from JISR operators participating in the exercises UV18 at the WPC Germany and at BQ19 in Finland in addition to other sites used in both exercises. A combination of surveys, observations, interviews, and experimentation were used to collect information about the role of HF in JISR operations and how the structures and processes of UV18 and BQ19 impacted important HF issues during JISR operations.

Our findings revealed the importance of HF issues for the effective and efficient conduct of JISR operations. In particular the JISR operators responded that an understanding of HF is important to improving JISR operations. Moreover, by including a HF research and evaluation methodology in the JISR CD&E process, researchers have a quality control tool to observe how changes in technologies and processes can impact important HF variables. Using such tools consistently over time can aid in revealing critical gaps that can be addressed by the coalition.

11.2 SUMMARY OF MAIN FINDINGS

The pre-trial survey questionnaire was designed to get an understanding of the operators' general understanding of the role of a number of key HF issues important to military contexts. The survey consisted of eight sections with multiple statements about each HF issue. The HF issues were based on previous HF research in military settings and the theoretical framework of HF in JISR operations (see Chapter 2).

The eight sections were made up of questions pertaining to: basic human factors knowledge, situational awareness, workload, organization, trust, information sharing, information management, leadership, culture, and cognition. The participants were asked to rate the degree to which they agreed with statements about these HF issues as they pertain to JISR operations. This survey was meant to provide an uncomplicated look at the role of HF in JISR operations based on the experience of JSR operators. In a way, these findings can be viewed as providing a foundation or first step for future research in this field of study.

Broadly, the findings from the pre-trial survey (Chapter 5) revealed that the HF issues examined in this JISR CD&E trial were considered important components for successful JISR operations. Although the operators were at times unsure whether some of these HF issues are studied during the JISR CD&E process, there was general agreement the HF in the survey are important aspects of successful JISR operations. Through their ratings, the operators also made it clear that during the JISR CD&E process, the impact of new technologies, procedures, and organizational changes on these HF issues, and likely other HF issues, should be studied. It is important to know how new technologies, procedures, organizational changes, etc. impact HF both positively and negatively so that adjustments can be made to JISR operations to ensure that JISR operators perform to their highest capabilities.

The Post-Trial Survey along with the other surveys, experimentation and data analyses from the other chapters were developed to gain a broad understanding of how the UV18 JISR and BQ19 trials impacted a variety of HF issues. In essence, these HF studies compliment the pre-trial survey insofar as they can be viewed as a type of quality control mechanism from which to assess the impact of the UV18 and BQ19 trials on HF issues.

Like the pre-trial survey, the post-trial survey (documented in Chapter 10), represented an uncomplicated way to get an understanding of how the UV18 trial would impact HF issues deemed important to JISR operations. In general, the operators provided positive feedback about the various aspects of the event on the HF issues. The responses that the operators provided in the post-trial survey indicated that the UV18 JISR CD&E event did not impact various HF issues in a negative manner. While the post-trial survey provides a cursory look at the JISR operators' views on how the UV18 trial impacted important HF attributes, it does provide a general overview of the trial's impact on HF which can be used as the basis for more in-depth analyses. As such, post-trial surveys such as this one can be used to quickly assess the general impact of JISR CD&E processes on HF and operator performance to help guide more in-depth research where needed.

The research findings from Chapters 6, 7, 8, and 9 represent more in-depth analyses of certain aspects of the impact of the UV18 and BQ19 trials on important HF issues in JISR operations than is offered by the pre-and post-trial surveys. Chapter 6 examines coordination mechanisms for the coordination between PED-Cells. Chapter 7 analyses the impact of individual, organizational, and cultural issues for the effectiveness of the ISR organization. Chapter 8 examines data and information quality. Chapter 6, 7 and 8 thus focus on complementary parts of the theoretical model presented in Chapter 2: Chapter 6 concerns the coordination among nations, Chapter 7 concerns central organizational drivers of such coordination and collaboration including how trust is related to information sharing, shared awareness, and decision making, and Chapter 8 focuses on the actual quality of information. Chapter 9 focuses on how one particular PED-Cells worked internally and with other PED-Cells. Chapter 9 also took a holistic look at the whole research model and examined all factors through the lens of one PED-Cell.

In Chapter 6, daily surveys were used to assess the impact of three coordination mechanisms on the coordination of information sharing across the different PED nodes in UV18 and in BQ19. Specifically, the influence of 1) Tacit coordination mechanisms; 2) Building communication channels; and 3) Modularizing processes, on the coordination between PED-Cells was examined. The results indicated that tacit coordination mechanisms were positively and significantly related to the coordination during the trials. The other two mechanisms that were examined were not significantly related to the coordination. This finding suggests a couple of outcomes. First, the current stage of maturity of the federated PED used in NATO,

building shared knowledge of other PED-Cells' decision making, is at a level that supports coordination more than efforts at building communication channels for on-going communication or the decomposing of the federated PED system into independent subsystems. Second, the results also indicate that tacit coordination may reduce the need for on-going communication and elaborate planning within the federated PED system. The results could indicate that further improvement is needed on the way federated PED processes are organized (such as through grouping selected PED-Cells into smaller divisions or modules) or supported by on-going communication (such as through chat and decision support systems). Federation and coordination could be improved by improving the way information is shared and through reduction of coordination needs (for instance through modularization) during execution of operations.

The theory and results from Chapter 7 contribute to further increase the understanding of individual, organizational, and cultural issues relevant for improving the effectiveness of ISR. It was found that trust had an impact on the organizational output. Moreover, the results suggested that commanders need to pay special attention to building both trust and understanding of roles and responsibilities across PED-Cells to improve the C2 effectiveness in ISR operations. Facilitating information sharing and the understanding of roles and responsibilities both within and across the PED-Cells was also found to be important for the effectiveness of the ISR organization's decision making processes. The results furthermore suggested that the systems for sharing information in UV18 may have been set up for hierarchic and centralized information sharing, and that there is room for improvement in future UV exercises pertaining to the technological solutions and procedures used. Finally, the results indicated that cultural differences in power distance and uncertainty avoidance may have an impact on the tendency for individual thinking and initiative in the organization.

The theory and results from Chapter 8 contribute to increasing the general understanding of data quality issues relevant for improving the information quality management of ISR. There is no general accepted set of data quality characteristics and associated metrics for Joint ISR, hampering a common way of exchanging ISR data. We contributed to fill this gap by introducing a framework of data quality, which we use to estimate data quality on military enterprise networks when evaluating NATO Intelligence and Joint ISR processes. This framework distinguishes between different aspects of data quality: quality of data at the source (Sound Data), data relevance (Usable data), and network Quality of Service (Dependable Data). The essence of this framework is to characterize, in a parsimonious way, data requirements from sensor to shooter. Sound Data was the weakest dimension measured in UV18. Highest mean opinion score presented was on Usable Data, when data meets or exceeds User Expectation. The Sound Data seems not influenced by applications or systems directly according to the mean opinion scores on System Usability. Subjective judgement indicates the importance of Sound Data in Joint ISR systems i.e., depending on features of intrinsic quality before data enters the network (dependent on sensor integration). In the future, we propose to choose dimensions of data quality in JISR based on scientific methods, and thorough analysis, and understanding of data quality requirements to improve management of DQ in JISR. This allows for a systematic tracing of challenges and improvements in data quality.

Finally, the work undertaken in Chapter 9 produced two outcomes. The observational data and interviews provided a validation of the theoretical framework used by the RTG-276 panel to guide this research effort. This study endorses the theoretical assumption of the theoretical framework used to guide this study that the JISR process, as carried out in an alliance context, cannot be easily captured by any one specific organizational model. But rather, the JISR process as configured in UV18, better conceptualized as a mix of pre-planned and designed sequential processes, and emergent processes whereby the JISR process contains two interacting forces: the planned actions and the emergent actions that leads to an understanding of how human factors influence JISR operations.

Taken together the findings from these chapters could suggest that for JISR to work across NATO nations it involves a host of individual, group, and organizational HF issues. More specifically it requires both knowledge about each nations' decision procedures and that technical networks per se are not ensuring

coordination alone (Chapters 6 and 9), building of trust and understanding of roles and responsibilities within and across nations (Chapter 7) as well as further development of data quality (Chapter 8). While the nations were able to "run" the JISR operations the results could indicate that more work needs to be done to ensure a more dynamic and decentralized collaboration and information sharing (see Chapters 6, 7, and 9) as well as ensuring the quality of products (Chapter 7 and 8). Improving connectivity as well as data quality seems to be needed to ensure federated PED and ultimately JISR (Chapters 6, 7 and 8). On a positive note, the results also suggest that proper preparation nationally (see Chapter 9) could ensure that collaboration is possible among nations.

11.3 LIMITATIONS

To be sure, there were a number of limitations associated with this study that need to be addressed in future developments both theoretically and methodologically. First, as with most forms of research, there is a degree of artificiality. During UV18, operator fatigue was not an issue as it would be during real-life operations. The lack of impact of fatigue during UV18 was primarily due to there not being a night shift, which is very different from regular combat operations. The UV18 event was conducted during regular daytime work hours. Accordingly, the operators were not impacted by irregular sleep patterns nor extended periods of exposure to artificial light which can have negative impacts on health. This is an issue that could be studied during future UV events. Second, low operator response is always problematic for interpreting and generalizing results. During UV18, operator response was low which restricts the types of analyses that can be conducted and the statistical robustness and reliability of the analyses that can be conducted. It is suggested that follow-up research with larger samples be conducted to obtain more robust results for great generalizability. Third, changes were made to the questionnaires on site. This meant a shortening of the post-trial survey, so that some measures were cut altogether while others were abbreviated and some altered. It was deemed that many of these changes may have hampered the validity and reliability of the measures, and it is therefore advised that future research in military ISR contexts use the original measures. Fourth, for the most part, with the exception of the work conducted in Chapter 9 on Task Switching, the variables studied in UV18 and BQ19 were based on subjective data: the operators' perceptions and beliefs about HF issues in JISR operations. As such, they data might not reflect object reality. However, perceptions, especially those based on experience, are nevertheless relevant. The rating data in this study provides insights into the impact of various technologies and procedures on HF and the extent to which HF are even studied in the JISR CD&E process. Moreover, subjective data can lead to more rigorous objective studies to better understand the issues raised by the operators' perceptions on a given topic. Indeed, perceptions are at the basis of an extensive part of human factors research.

In general, the theoretical model we put forward should be updated as more knowledge is gathered through exercises and field experiments as well as conceptual work. Along all the variables we examined work could be done conceptually to discuss what aspects of for example situation awareness and leadership are particularly important in a JISR context. Specifically related to coordination more could be learnt from examining not only the intervening mechanisms and output of coordination, but also concepts and tools for identifying interdependencies among PED-Cells. Related to trust this could also be developed further within the JISR context and previous chapters discuss several extensions of this. Data quality is also a core concept but at the same time requires careful discussion related to its nuances in the JISR setting; for example, how are novel sensor capabilities incorporated into JISR and how can this be best conceptualized. Lastly, task load of the human operator can change in both positive and negative directions as technology is introduced. Concepts theories and tools that increase the understanding of under what conditions game-changing Artificial Intelligence (AI) technologies, such as those doing imagery analysis, are most useful, would be needed in the future to take full advantage of these technologies.

11.4 HF METHODOLOGY FOR JISR CD&E

The primary finding from this study is that HF play an important role in JISR operations. Our research has shown that not only do JISR operators believe that HF are an important component of effective and efficient JISR operations, but HF are impacted by a variety of technical and non-technical aspects of JISR operations. Improving the HF component within JISR operations is a key element of ensuring effective and efficient operator performance during JISR operations. Accordingly, a HF research methodology should be an integral part of all future JISR CD&E events. While there cannot be one HF research methodology that would encompass and satisfy all JISR CD&E events, efforts should be made to develop a HF research methodology that examines the impact of the primary point of interest(s) of a JISR CD&E event on the HF aspects of operator performance. The research reported here is deemed useful for military decision makers and researchers in ISR and human factors related research; the theory and results may improve the general understanding of individual, organizational, and cultural issues in military ISR. The method part expands the available metrics for collecting relevant data to improve our knowledge of human issues related to ISR operations both in national and international contexts.

The findings from this study reinforce the notion that HF are an important component of effective and efficient JISR operations. Specifically, an important component to improving JISR operations is having an understanding of how and in what ways different technologies, procedures and the interaction of these factors impact the human operator on different HF dimensions. A HF research methodology acts as a form of quality control on the new technologies, procedures, structures, etc. being examined in JISR CD&E event. Specifically, as a quality control mechanism, a HF research methodology provides an examination of how new ideas and technologies impact a variety of HF issues that are integral to JISR operator performance. For example, researchers can study how such HF issues as data quality, trust, situation awareness, workload, coordination, and information sharing are impacted by new technologies, leadership structures and procedures, etc. which ultimately impact decision making which is arguably the single most important task in JISR operations. In this way, a HF research methodology can help to design new technologies and procedures to optimize human performance.

Going forward, we can apply the findings from this study to future work in the JISR CD&E process as well as in other joint processes [1]. To be sure, a HF evaluation methodology involves a focus on the operators' perceptions of the effectiveness of an ISR concept. This HF evaluation can be divided into hard and soft elements (see Figure 11-1) where the hard elements refer to the operators' perception of the quality, quantity, completeness, and latency of the data they receive from the ISR system(s) and concept(s). In contrast, the soft elements are concerned with the meta-cognitive aspects of the decision-making process. Accordingly, the evaluation of these soft elements assesses the operators' trust in the system and others as well as their views on whether the system can meet the information requirements of the various groups involved in the operation. The evaluation would also examine the operators' assessments of the ISR concept to use different combinations of ISR platforms at any given time, organizational structures, the concept's ability to facilitate the development of a shared Common Operating Picture (COP) and SA, and how well the concept facilitates efficient dissemination of information and coordination among entities. Moreover, since much of JISR operations occur within multi-national contexts; this part of the HF evaluation can examine the operators' views on how differing cultural issues impact JISR operations.

With regard to the hard elements of the HF evaluation, quality of information refers to the resolution of the information presented to the operators which could be examined using data quality metrics. The operators would rate the degree to which the information presented was completed in a clear and unambiguous manner and they would be asked to evaluate the appropriateness of the delivery mode of information given a certain operational context. The evaluation of the quantity of information presented to the operators will focus on the amount of information that the operators receive in an effort to assess the perceived cognitive workload associated with a particular ISR concept. The issue of completeness of information will focus on the extent to which gaps in information occur as a result of combining data or information from various ISR platforms.

In this sense, completeness refers to gaps in information presentation and is not related to issues of latency. Finally, the operators will be asked to evaluate the latency associated with the amount of time it takes to receive information after it has been requested.

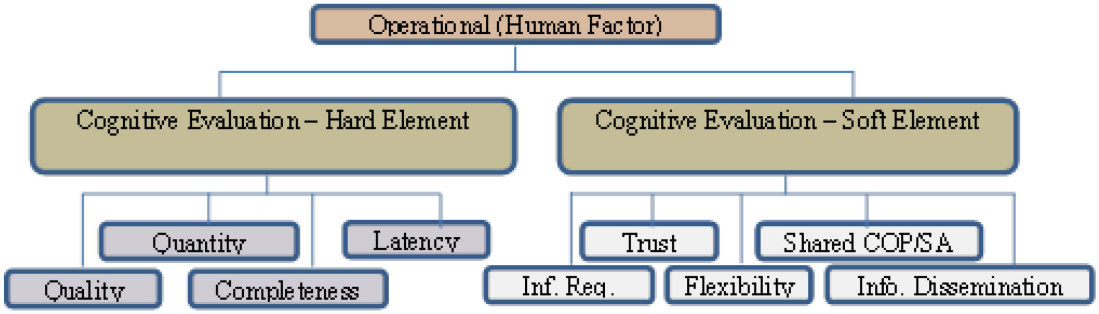

Figure 11-1: Operational (Human Factors) Effectiveness Evaluation Criteria and Sub-Criteria Hierarchy.

As noted above, the soft elements of the HF evaluation represent a meta-cognitive perception of the ISR concept. Trust, whether in humans or technology, denotes a certain degree of dependence on the human or technology to deliver or provide a reliable and expected output. When people have trust in technology, their time can be allocated to other aspects of their task thereby facilitating timely and accurate task outcomes. Therefore, the ability to develop and maintain trust in a technology or technological system is a crucial facilitating factor for successful outcomes. Examining whether the ISR concept meets the information requirements of the various groups involved in the operation addresses whether the concept can facilitate the way the participating groups organize themselves, technically share information, think about planning and decision making, and communicate (interact) with other audiences. Probing the operators' perception about the flexibility to utilize different combinations of ISR platforms at any given time assesses the ISR concept's responsiveness to unscheduled re-tasking/use of different ISR platforms. Of particular importance in this evaluation is to assess the ISR concept's ability to facilitate a shared COP and ultimately shared SA to ensure synchronization of effort to make possible the achievement of military goals while mitigating collateral damage and fratricide. Finally, an examination of the ISR concept's ability to efficiently disseminate information will allow evaluators to determine the extent to which operators have to push or pull information to make decisions individually or in a team. This last element impacts on the timeliness associated with decision making.

JISR is a part of command and control and a generic activity in all military operations. Involving exercise of authority over assigned resources. JISR focus on how data acquiring and analysis is directed. It is a complex work setting. We have taken a human factors approach theoretically and methodologically to this activity. JISR is multivariable activity involving many human and technological aspects. It is made up of interacting hard and soft elements. To improve JISR it requires a systemic approach to acquire a sound scientific understanding and to gather and analyze data that could be used for identifying gaps and suggest improvements. The theories and methods we have used decompose a range of issues pertaining to JISR operations from the human operator side. The research group was multi-disciplinary in order to bring to bear different complementary perspectives on this critical topic. Based on the different researchers' initial knowledge we synthesized and developed a research model of human factors in JISR based on and extending prior research models developed by NATO research groups. Crucially our work was exploratory and "in the wild." We use an abstract, task environment, but partly realized in a field exercise, where humans and technology cooperate to achieve their goals in JISR. We validated the model in several ways, both initially through a study aimed at capturing operator's perception of what HF issues may be important in JISR, holistically through a field study within a JISR-cell (PED-Cell), as well as in more specific studies concerning parts of the model. Largely our model captures crucial aspects of human factor in JISR.

JISR operations nationally and in a NATO context has for a long time been driven by technological developments. This will continue, as the field of data fusion, and analysis is rapidly developing. However, JISR is also fundamentally a human endeavor: JISR is a fundamental part of officers' command and control toolbox. Ensuring that this toolbox is updated with the most powerful equipment to facilitate the optimal use of new technology will be key in the coming years. This report document and suggest ways in which humans play a key role in the JISR process and highlight some ways in which humans can improve their effectiveness within the JISR enterprise. Related to several issues such as coordination, trust, information sharing and perceived data quality the report highlights needs for improvement in how JISR is done. Integrating human and non-human aspects of JISR operations will be increasingly important, and we believe, necessitate a thorough understanding of human as well as technological functioning. This report can thus stand as a stepping stone for future development and improvement in the area of joint process across and within nations.

11.5 REFERENCES

[1] Jassemi-Zargani, R., Kashyap, N., and Lichacz, F.M.L. (2013). ISR Concept Evaluation Environment for Addressing NEC Situational Awareness Requirements. NATO SCI-254 Symposium. DRDC Ottawa SL-2013-040, May 2013.

Annex A – PRE-TRIAL HUMAN FACTORS SURVEY (UV18)

Based on your experiences in JISR operations, please respond to the following statements by placing the number next to the response that best describes your opinion or situation: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Human Factors 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
I am aware of the existence of a Human Factors JISR evaluation framework.
A Human Factors JISR doctrine exists.
A Human Factors Lessons Learned capability is maintained for JISR operations.
A Human Factors Lessons Learned capability would benefit JISR operations.
Understanding the Human Factors issues that impact decision making is essential to effective and efficient JISR operations.
Knowledge of Human Factors issues is essential to effective and efficient JISR operations.
Human Factors issues are examined during JISR Concept Development & Evaluation processes.
Human Factors research should be part of any ISR Concept Development & Evaluation process.
Situational Awareness 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Situation awareness is critical to successful JISR operations.
It is important for you in your work to be aware of other staff members' tasks and responsibilities.
There are often misunderstandings between units/PED-Cells regarding each cell's role in the JISR operations.
It is important to understand all of the issues that can impact situation awareness during JISR operations.
Research to improve situational awareness research should be part of any JISR Concept Development & Evaluation process.
Workload 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
I typically have the resources to respond quickly and accurately to time critical responses.
I am often frustrated with the amount of work that I am assigned.
I rarely have enough time to accomplish my tasks.
We have enough staff to accomplish our tasks efficiently and effectively during JISR operations.
Issues pertaining to Workload are studied in JISR CD&E trials.
Issues pertaining to workload should be studied in JISR CD&E trials.

Organizational Structure: **The formal system of tasks, processes and authority relationships** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Organizational structure is critical to successful JISR operations.
Organizational structure is critical to information sharing (flow) throughout the TCPED process.
Organizational structure is critical for quick decision making.
Organizational structure is critical for situational awareness.
The effect of organizational structure on JISR operator performance is studied during JISR CD&E trials.
The effect of organizational structure on JISR analyst performance should be studied during JISR CD&E trials.
Visualization 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
The manner in which data is presented is critical to successful JISR operations.
Being able to modify data visualization to meet the needs of the JISR operators is important to facilitate effective and efficient JISR operations.
Data visualization is important for maintaining SA.
Data visualization is important for information sharing.
Data visualization is important for decision making.
Different forms of data visualization presentations are studied during JISR CD&E trials.
Different forms of data visualization should be studied during JISR CD&E trials.
Trust 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Trust is important to successful JISR operations.
Trust between individuals in the JISR process is important to successful performance.
Trust in data analyses (in data analyses between decision maker, operator, and intelligence officers) is important to successful JISR operations.
Trust in international partners is important to successful JISR operations.
Trust in different branches of the military is important to successful JISR operations.
The impact of trust on JISR operations is studied during JISR CD&E trials.
The impact of trust on JISR operations should be studied during JISR CD&E trials.
Trust **How confident are you that:** 1. Very confident 2. Confident 3. Neutral 4. Doubtful 5. Very doubtful
Your colleagues in your nation/PED-Cell will share important information with you?

Your colleagues in your nation/PED-Cell will assist you when you need help?
Your colleagues in your nation/PED-Cell will fulfill their responsibilities?
Your colleagues in other nations/PED-Cells will share important information with you?
Your colleagues in other nations/PED-Cells will assist you when you need help?
Your colleagues in other nations/PED-Cells will fulfill their responsibilities?
Information Sharing 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Technical difficulties are a problem for information sharing.
Low English proficiency is a problem for information sharing during multination JISR operations.
Differences in national cultures is a problem for information sharing.
In JISR operations national caveats hinder information sharing.
National caveats for information exchange reduce the ability to develop shared awareness.
Time constraints are a problem for information sharing.
Lacking knowledge about who needs information is a problem in JISR operations.
Differing priorities across units/PED-Cells is a problem for information sharing.
Differing security/classification concerns are a problem for information sharing in JISR operations.
High workload impedes information sharing.
I have access to key personnel for rapid information exchange.
Exploring ways to improve information sharing is studied during JISR CD&E trials.
Exploring ways to improve information sharing should be studied during JISR CD&E trials.
Information Management 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Information management is critical to successful JISR operations.
The information flow within JISR operations is well managed.
In JISR operations national caveats impair the ability to make quick decisions.
Lessons learned are integrated into the problem-solving process.
The JISR environment has a formal mechanism for capturing lessons learned.
Information management is studied during JISR CD&E trials.
Information management should be studied during JISR CD&E trials.

Leadership: **By leadership we mean how the leader communicates and interacts with his subordinates** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Leadership style is critical to successful JISR operations.
Leadership style impacts information sharing.
Leadership style impacts situational awareness.
Leadership style impacts decision-making.
The impact of leadership style on JISR operations is studied in JISR CD&E trials.
The impact of leadership style on JISR operations should be studied in JISR CD&E trials.
Cognition (NFC) 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
I would prefer complex to simple problems.
I like to have the responsibility of handling a situation that requires a lot of thinking.
Thinking is not my idea of fun.*
I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.*
I try to anticipate and avoid situations where there is a likely chance that I will have to think in depth about something.*
I find satisfaction in deliberating hard and for long hours.
I only think as hard as I have to. *
I prefer to think about small, daily projects to long-term ones.*
I like tasks that require little thought once I've learned them.*
The idea of relying on thought to make my way to the top appeals to me.
I really enjoy a task that involves coming up with new solutions to problems.
Learning new ways to think doesn't excite me very much.*
I prefer my life to be filled with puzzles that I must solve.
The notion of thinking abstractly is appealing to me.
I would prefer a task that is intellectual, difficult and important to one that is somewhat important but does not require much thought.
I feel relief rather than satisfaction after completing a task that required a lot of mental effort.*
It's enough for me that something gets the job done; I don't care how or why it works.*
I usually end up deliberating about issues even when they do not affect me personally.

Culture:				
Please think of an ideal job, disregarding your present job, if you have one. In choosing an ideal job, how important would it be to you to ... (please choose one answer in each line across):				
1. Of utmost importance	2. Very important	3. Of moderate importance	4. Of little importance	5. Of very little or no importance
Have a boss (direct superior) you can respect.				
Be consulted by your boss in decisions involving your work.				
How often, in your experience, are subordinates afraid to contradict their boss?				
1. Never	2. Seldom	3. Sometimes	4. Usually	5. Always
To what extent do you agree or disagree with each of the following statements? (please choose one answer in each line across):				
1. Strongly Agree	2. Agree	3. Neutral	4. Disagree	5. Strongly Disagree
An organization structure in which certain subordinates have two bosses should be avoided at all cost.				
One can be a good manager without having a precise answer to every question that a subordinate may raise about his or her work.				
A company's or organization's rules should not be broken – not even when the employee thinks breaking the rule would be in the organization's best interest.				
How often do you feel nervous or tense?				
1. Always	2. Usually	3. Sometimes	4. Seldom	5. Never
All in all, how would you describe your state of health these days?				
1. Very good	2. Good	3. Fair	4. Poor	5. Very Poor

Annex B – POST-TRIAL HUMAN FACTORS SURVEY (UV18)

Based on your experiences in JISR operations, please respond to the following statements by placing the number next to the response that best describes your opinion or situation: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Organizational structure 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Work in this exercise organization is concentrated within few hierarchical levels.
There are few decision-making levels in this exercise organization.
The information needs to travel through few hierarchic levels in this exercise organization.
Responsibility is distributed on a few hierarchic levels in this exercise organization.
From your standpoint in this exercise, how would you describe the organizational structure in general? 1. Very hierarchical 2. Hierarchical 3. Neither hierarchical nor flat 4. Flat 5. Very Flat
Organizational processes **From your standpoint in this exercise, how would you describe the following organizational processes in terms of centralization/decentralization in this trial's organizational structure?** 1. Very centralized 2. Centralized 3. Neither centralized nor decentralized 4. Decentralized 5. Very decentralized
Work processes.
Decision processes.
Information sharing processes.
Distribution of responsibilities.
Processes in general.
Flexibility **From your standpoint in this exercise, how would you describe the following organizational processes in terms of rigidity/flexibility?** 1. Very rigid 2. Rigid 3. Neither rigid nor flexible 4. Flexible 5. Very Flexible
Work processes.
Decision processes.
Information sharing processes.
Distribution of responsibilities.
Processes in general.

Obstacles to information sharing **From your standpoint, how often do the following conditions represent obstacles to information sharing during this exercise?** 1. Never 2. Rarely 3. Sometimes 4. Often 5. Very Often
Technical difficulties.
Procedural inefficiencies.
Low English proficiency of participants.
Differences between PED-Cells.
Differences in national culture.
Time constraints.
Approachability of the commander.
Lacking knowledge about who needs the information.
Differing priorities.
Political constraint/control.
Security issues.
Document classification.
System classification.
Mismatch between the actual work processes and the work processes embedded in the collaborate technology.
Information sharing **Indicate which answer best describes your perception based on the role that you have in this exercise:** 1. Very content 2. Somewhat content 3. Neutral 4. Somewhat discontent 5. Very discontent
How content are you with the amount of information that you receive?
How content are you with the contents of the information that you receive?
How content are you with the information that you give overall?
Shared awareness of tasks and responsibilities **Indicate to what degree you agree or disagree with the following statements based on the role that you have in this exercise:** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
In our nation/PED-Cell, we often experience misunderstandings with each other.
In our nation/PED-Cell, we are aware of each other's areas of responsibility.
In our nation/PED-Cell, we are unsure about how to execute shared tasks with each other.

In our nation/PED-Cell, we do not know each other's roles pertaining to executing shared tasks.
In our nation/PED-Cell, we often experience misunderstandings with other nations/PED-Cells.
Our nation/PED-Cell and the other nations/PED-Cells are aware of each other's areas of responsibility.
In our nation/PED-Cell, we are often unsure about how to execute shared tasks with other nations/PED-Cells.
Our nation/PED-Cell and the other nations/PED-Cells do not know what each other's roles are in relation to executing shared tasks.
In the joint task force headquarter the teams/functions (J2, J3 etc.) worked together in a well-coordinated fashion.
Decision making **Indicate which answer best describes your perception based on the role that you have in this exercise:**
To what degree are decisions made too fast/slow or in a perfect pace? 1. Far too slow/fast 2. Too slow/fast 3. Somewhat too slow/fast 4. A bit too slow/fast 5. Perfect pace
How do you perceive the decision quality? 1. Very good 2. Quite good 3. Neither good nor poor 4. Quite poor 5. Very poor
How successful do you perceive decisions to be? 1. Very successful 2. Quite successful 3. Neither successful nor unsuccessful 4. Quite unsuccessful 5. Very unsuccessful
Trust **How confident have you been that:** 1. Very confident 2. Confident 3. Neutral 4. Doubtful 5. Very doubtful
Your colleagues in your nation/PED-Cell share important information with you?
Your colleagues in your nation/PED-Cell assist you when you need help?
Your colleagues in your nation/PED-Cell fulfill their responsibilities?
Your colleagues in other nations/PED-Cells share important information with you?
Your colleagues in other nations/PED-Cells assist you when you need help?
Your colleagues in other nations/PED-Cells fulfill their responsibilities?
Competence **Please relate to the current exercise and indicate to what degree you agree or disagree with the following statements:** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
We, in our nation/PED-Cell, experience that we have the necessary competence to perform our work.
We, in our nation/PED-Cell, experience that everyone in our nation/PED-Cell know their job.

We, in our nation/PED-Cell, experience that everyone in our nation/PED-Cell understand how our work is contributing to the JISR processes.
We, in our nation/PED-Cell, have a good understanding of the current JISR processes.
We, in our nation/PED-Cell, experience that other nations/PED-Cells have the necessary competence to perform their work.
We, in our nation/PED-Cell, experience that other nations/PED-Cells know their job.
We, in our nation/PED-Cell, experience that other nations/PED-Cells understand how their work is contributing to the JISR processes.
We, in our nation/PED-Cell, experience that other nations/PED-Cells have a good understanding of the current JISR processes.
Job involvement **Please state; in what degree do you:** 1. In a very low degree 2. In a low degree 3. In a medium degree 4. In a high degree 5. In a very high degree
Experience that the Ped-Cell/National products are important to you?
Experience that the UV18 outcomes are important to you?
Feel responsible for the Ped-Cell/National products?
Feel responsible for the UV18 outcomes?
Feel motivated to go out of your way to contribute to the Ped-Cell/National products?
Feel motivated to go out of your way to contribute to the UV18 outcomes?

Annex C – EDITED POST-TRIAL SURVEY (UV18)

Based on your experiences in JISR operations, please respond to the following statements by placing the number next to the response that best describes your opinion or situation: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Organizational structure 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Work in this trial's organizational structure is concentrated within few hierarchical levels.
There are few decision-making levels within this trial's organizational structure.
Information needs to travel through few hierarchical levels in this trial's organizational structure.
Responsibility is distributed across a few hierarchical levels in this trial's organizational structure.
In general, how would you describe the organizational structure in this trial? 1. Very hierarchical 2. Hierarchical 3. Neither hierarchical nor flat 4. Flat 5. Very Flat
Organizational processes: Decentralization 1. Very centralized 2. Centralized 3. Neither centralized nor decentralized 4. Decentralized 5. Very decentralized
In terms of centralization/decentralization, how would you describe the work processes within this trial's organizational structure?
In terms of centralization/decentralization, how would you describe the decision processes within this trial's organizational structure?
In terms of centralization/decentralization, how would you describe the information sharing processes within this trial's organizational structure?
In terms of centralization/decentralization, how would you describe the distribution of responsibilities within this trial's organizational structure?
Flexibility 1. Very rigid 2. Rigid 3. Neither rigid nor flexible 4. Flexible 5. Very Flexible
In terms of rigidity/flexibility, how would you describe the work processes within the trial's organizational structure?
In terms of rigidity/flexibility, how would you describe the decision processes within this trial's organizational structure?
In terms of rigidity/flexibility, how would you describe the information sharing processes within this trial's organizational structure?
In terms of rigidity/flexibility, how would you describe the distribution of responsibilities within this trial's organizational structure?

Obstacles 1. Never 2. Rarely 3. Sometimes 4. Often 5. Very Often
How often did technical difficulties represent an obstacle to information sharing during this trial?
How often did procedural inefficiencies represent an obstacle to information sharing during this trial?
How often did low English proficiency of participants represent an obstacle to information sharing during this trial?
How often did differences between PED-Cells/operational components represent an obstacle to information sharing during this trial?
How often did differences in national culture represent an obstacle to information sharing during this trial?
How often did time constraints represent an obstacle to information sharing during this trial?
How often did the approachability of the commander represent an obstacle to information sharing during this trial?
How often did lacking knowledge about who needs the information represent an obstacle to information sharing during this trial?
How often did differing priorities represent an obstacle to information sharing during this trial?
How often did political constraints/control represent an obstacle to information sharing during this trial?
How often did security issues represent an obstacle to information sharing during this trial?
How often did document classification represent an obstacle to information sharing during this trial?
How often did system classification represent an obstacle to information sharing during this trial?
How often did mismatches between real world processes and the simulated processes represent an obstacle to information sharing during this trial?
Information sharing **Indicate which answer best describes your perception based on the role that you have in this exercise:** 1. Very content 2. Somewhat content 3. Neutral 4. Somewhat discontent 5. Very discontent
How content are you with the amount of information that you received?
How content are you with the contents of the information that you received?
How content are you with the information that you shared?

Shared awareness **Indicate to what degree you agree or disagree with the following statements based on the role that you have in this exercise:** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
In PED-Cell/operational component, we often experience misunderstandings with each other.
In our PED-Cell/operational component, we were aware of each other's areas of responsibility.
In our PED-Cell/operational component, we were unsure about how to execute shared tasks with each other.
In our PED-Cell/operational component, we did not know each other's roles pertaining to executing shared tasks.
In our nation/PED-Cell, we often experienced misunderstandings with other PED-Cells/operational components.
Our PED-Cell/operational component and the other PED-Cells/operational components were aware of each other's areas of responsibility.
Our PED-Cell/operational component and the other PED-Cells/operational components did not know what each other's roles were in relation to executing shared tasks.
Decision making **Indicate which answer best describes your perception based on the role that you have in this exercise:**
From the perspective of your position, at what pace were decisions made? 1. Too slow 2. Somewhat too slow 3. Perfect pace 4. Somewhat too fast 5. Too fast
From the perspective of your position, how do you perceive the success of the decisions made? 1. Very successful 2. Quite successful 3. Neither successful nor unsuccessful 4. Quite unsuccessful 5. Very unsuccessful
Trust 1. Very confident 2. Confident 3. Neutral 4. Doubtful 5. Very doubtful
How confident are you that your colleagues in your PED-Cell/Operational component shared important information with you?
How confident are you that your colleagues in your PED-Cell/Operational component assisted you when you needed help?
How confident are you that your colleagues in other PED-Cells/Operational component shared important information with you?
How confident are you that your colleagues in other PED-Cells/Operational components assisted you when you need help?

Competence 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
In our PED-Cell/operational component, we had the necessary competence to perform our work.
The members of other PED-Cells/operational components had the competence to do their work.

Annex D – BOLD QUEST 2019 SURVEY (POST EXERCISE)

Bold Quest 2019. NATO Human Factor and Medicine Panel Survey

Contact information (completed surveys may be sent to): Sigmund Valaker NOR sigmund.valaker@ffi.no

FFI, Insituttveien 20, PB 25, 2007 Kjeller, Norway

By filling out this survey you provide input to the NATO Human Factors and Medicine Panel 276 on Human Factors and ISR Concept Development and Evaluation. **It is preferable that the survey is answered toward the end of the Bold Quest exercise. Both participants in PED-Cells and other nodes can answer.**

We collected data at the Unified Vision 18 exercise and the data collection at Bold Quest 19 is an important follow up on this effort. The goal of using these responses is to help develop a Human Factors Evaluation Methodology for JISR Concept Development & Evaluation Research. A final report from the group will be available in 2020.

Cognitive human factors research is about the role of humans in complex systems and the design of equipment, processes, and facilities to improve human performance with an understanding of the limits of human cognitive performance. You will be asked to respond to comments that look at the organizational structure, information management and quality, visualization capabilities, processes, workload, personnel, and training within JISR operations.

Participation is voluntary and you are free to withdraw at any time. Your anonymity and privacy will be maintained. **There will be NO identifying information collected (i.e., you will not be asked to provide your name, personal record identifier or service number)**. Your decision to participate in this survey will in no way affect your employment status or your position. Information you provide will not be used for performance evaluation purposes. You are not obliged to answer any questions that you feel are objectionable or which make you uncomfortable.

Thank you so much for responding!

Date of survey completed:

Demographics

- Gender (male/female/other):
- Age:
- Nationality:
- First language/native English:
- Highest completed formal education:
- Military (army, Air force, navy, marine, other) /civilian:
- Rank:
- In what PED-Cell (or other type of node) do you work in BQ 2019?
- How long have you worked in ISR operations (months)? other (if pertinent)
- In preparation for BQ 2019 did you train together with your PED-Cell (or another node)? Alternatives: yes, no

Think about the work during BQ 19.

How many exploitation tasks did your PED-Cell accomplish for each day? (make a note of day and number of tasks accomplished):

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
I would prefer complex to simple problems.					
I like to have the responsibility of handling a situation that requires a lot of thinking.					
Thinking is not my idea of fun.*					
I would rather do something that requires little thought than something that is sure to challenge my thinking abilities.*					
I try to anticipate and avoid situations where there is a likely chance that I will have to think in depth about something.*					
I find satisfaction in deliberating hard and for long hours.					
I only think as hard as I have to.*					
I prefer to think about small, daily projects to long-term ones.*					
I like tasks that require little thought once I've learned them.*					
The idea of relying on thought to make my way to the top appeals to me.					
I really enjoy a task that involves coming up with new solutions to problems.					
Learning new ways to think doesn't excite me very much.*					
I prefer my life to be filled with puzzles that I must solve.					
The notion of thinking abstractly is appealing to me.					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought.					
I feel relief rather than satisfaction after completing a task that required a lot of mental effort.*					
It's enough for me that something gets the job done; I don't care how or why it works.*					
I usually end up deliberating about issues even when they do not affect me personally.					

Based on your experiences in Bold Quest 2019, please respond to the following statements by choosing the response that best describes your opinion or situation:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
The tasks were difficult to complete.					
There is a good integration of the joint targeting process and the JISR process.					
The IRM CM system supported the awareness of the capacity of the different nodes/PED-Cells for processing, exploitation, or dissemination.					
I knew the position of all objects in the operation area.					
I knew which objects where friendly and enemy.					
I could project the future positions of enemy objects.					

Please tell us how much effort was spent on the following activities in the training period and until now, to facilitate smooth interactions between the different nodes/ PED-Cells.

	-4 Little or No Effort	**-3**	**-2 Some Effort**	**-1**	**0 Moderate Effort**	**1**	**2 Significant Effort**	**3**	**4 Intensive Focused Effort**
Helping personnel in each location to understand the decision-making procedures used by personnel in the other location.									
Using technologies that enable personnel in one location to observe the work-in-progress in other locations.									
Encouraging and facilitating personnel in one location to adopt the vocabulary used by personnel in other locations.									
Developing/adapting an IT communication network.									
Training personnel in remote collaboration.									
Encouraging and facilitating personnel from one location to contact the other location whenever they feel the need (e.g., telephone, chat etc.)									

	-4 Little or No Effort	-3	-2 Some Effort	-1	0 Moderate Effort	1	2 Significant Effort	3	4 Intensive Focused Effort
Simplifying linkages between processes at one location and linked activities on another location.									
Adapting the processes on one location to be done remotely so that need for interactions between the processes at this location and activities in other locations are minimized.									
Partitioning the process at one location into portions with low and high level of interaction.									

The Intelligence Requirement Management and Collection Management (IRM CM) system refers to the computer system you use to send and receive information that concerns intelligence requirement management and collection management. There may be a dedicated IRM CM system such as ICMT, or you may use other systems to handle IRM CM such as email.

	1 Strongly Disagree	2	3	4	5	6	7	8	9 Strongly Agree
Rapid communication in both directions is possible with the IRM CM system.									
The IRM CM system can carry many simultaneous conversations.									

	1 Strongly Disagree	2	3	4	5	6	7	8	9 Strongly Agree
The number of ways information can be communicated using the IRM CM system is high.									
I can edit my message before sending it using the IRM CM system.									
During a conversation, the IRM CM system allows me to process a message multiple times.									

Think about your node/PED-Cell and the control over the node/PED-Cells work.

	1 Fully Autonomous	2	3	4	5	6	7 Completely Controlled by the Headquarters (Simulated or Real)
In carrying out the nodes work/PED process was:							

Think about the work within your node/PED-Cell.

	1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree
Changes in the work approach or direction in one part of the node/PED-Cell led to changes in the other parts of the node/PED-Cell.							

	1 Strongly Disagree	2	3	4	5	6	7 Strongly Agree
There was a need to talk to personnel in one part of the node/PED-Cell about the node/PED process so that they could adjust their direction.							

Think about the different ways of communicating, or types of information systems, you used and rate how often you used them during the exercise period for Bold Quest 2019.

	1 Never	2 Once During the Exercise	3 1 – 4 Times During the Exercise	4 Once a Day During the Exercise	5 2 – 5 Times a Day	6 More than Five Times a Day
Face-to-face.						
Email.						
Radio/telephone.						
Chat.						
Command and control information systems.						
Specialized ISR systems such as tacitview, soccet gxp, dot matrix, etc.						
CSD.						
IRM/CM tools.						

Think about the work today within your node/PED-Cell and the collaboration among different teams in the node/PED-Cell (e.g., HUMINT team/role, IMINT team/role, GMTI team/role etc.) when answering the following questions:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
The teams worked together in a well-coordinated fashion.					
The teams had very few misunderstandings about what to do.					
We accomplished the task(s) smoothly and efficiently.					

Think about the work with other nodes/PED-Cells (e.g., federated PED) when answering the following questions:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
The nodes/ PED-Cells worked together in a well-coordinated fashion.					
The nodes/PED-Cells had very few misunderstandings about what to do.					
The nodes/PED-Cells accomplished the task(s) smoothly and efficiently.					

Shared awareness of tasks and responsibilities

Indicate to what degree you agree or disagree with the following statements based on the role that you have in this exercise:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
In our nation/PED-Cell, we often experience misunderstandings with each other.					
In our nation/PED-Cell, we are aware of each other's areas of responsibility.					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
In our nation/PED-Cell, we are unsure about how to execute shared tasks with each other.					
In our nation/PED-Cell, we do not know each other's roles pertaining to executing shared tasks.					
In our nation/PED-Cell, we often experience misunderstandings with other nations/PED-Cells.					
Our nation/PED-Cell and the other nations/PED-Cells are aware of each other's areas of responsibility.					
In our nation/PED-Cell, we are often unsure about how to execute shared tasks with other nations/PED-Cells.					
Our nation/PED-Cell and the other nations/PED-Cells do not know what each other's roles are in relation to executing shared tasks.					

The question below concerns data and metadata quality.

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Is the data for your node or PED-Cell regarded complete with not anything missing and it is of sufficient breadth and depth?					

The questions below concern information sharing.

	1 Very content	2 Somewhat content	3 Neutral	4 Somewhat discontent	5 Very discontent
How content were you with the amount of information that you received?					
How content were you with the contents of the information that you received?					
How content were you with the information that you shared?					

From your standpoint, how often did the following conditions represent obstacles to information sharing during Bold Quest 2019?

	1 Never	2 Rarely	3 Sometimes	4 Often	5 Very often
Technical difficulties.					
Procedural inefficiencies.					
Low English proficiency of participants.					
Differences between PED-Cells/operational components.					
Differences in national culture.					
Time constraints.					
Approachability of the commander.					
Lacking knowledge about who needs the information.					
Differing priorities.					
Political constraint/control.					
Security issues.					
Document classification.					
System classification.					
Mismatches between real world processes and the simulated processes.					

Organizational Structure

In general, how would you describe the Bold Quest 2019 organizational structure?

	1 Very hierarchical	2 Hierarchical	3 Neither hierarchical nor flat	4 Flat	5 Very flat

Please rate the following statements from the perspective of your position.

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Work in Bold Quest was organized with the use of few hierarchical levels relative to the organization's size.					
There were few decision-making levels in Bold Quest relative to the organization's size.					
The information needed to travel through many hierarchical levels in Bold Quest relative to the organization's size.*					
There were many levels of responsibility in Bold Quest relative to the organization's size.*					

Organizational Processes

From the perspective of your position in Bold Quest 2019, how would you describe the following organizational processes in terms of centralization/decentralization?

	1 Very centralized	2 Centralized	3 Neither centralized nor decentralized	4 Decentralized	5 Very decentralized
Work processes.					
Decision processes.					
Information sharing processes.					

	1 Very centralized	2 Centralized	3 Neither centralized nor decentralized	4 Decentralized	5 Very decentralized
Distribution of responsibilities.					
Processes in general.					

Flexibility

From the perspective of your position in Bold Quest 2019, how would you describe the following organizational processes in terms of rigidity/flexibility?

	1 Very Rigid	2 Rigid	3 Neither Rigid nor Flexible	4 Flexible	5 Very Flexible
Work processes.					
Decision processes.					
Information sharing processes.					
Distribution of responsibilities.					
Processes in general.					

Decision making

From the perspective of your position in Bold Quest 2019, please indicate which answer best describes your perception:

To what degree were decisions made too fast/slow or in a perfect pace?

	1 Far too slow/fast	2 Too slow/fast	3 Somewhat too slow/fast	4 A bit too slow/fast	5 Perfect pace

How did you perceive the decision quality?

	1 Very good	2 Quite good	3 Neither good nor poor	4 Quite poor	5 Very poor

How successful did you perceive decisions to be?

	1 Very successful	2 Quite successful	3 Neither successful nor unsuccessful	4 Quite unsuccessful	5 Very unsuccessful

Trust

How confident have you been that:

	1 Very confident	2 Confident	3 Neutral	4 Doubtful	5 Very doubtful
Your colleagues in your nation/PED-Cell shared important information with you?					
Your colleagues in your nation/PED-Cell assisted you when you need help?					
Your colleagues in your nation/PED-Cell fulfilled their responsibilities?					
Your colleagues in other nations/PED-Cells shared important information with you?					
Your colleagues in other nations/PED-Cells assisted you when you need help?					
Your colleagues in other nations/PED-Cells fulfilled their responsibilities?					

Competence

Please relate to Bold Quest 2019 and indicate to what degree you agree or disagree with the following statements:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
We, in our nation/PED-Cell, experienced that we had the necessary competence to perform our work.					
We, in our nation/PED-Cell, experienced that everyone in our nation/PED-Cell knew their job.					
We, in our nation/PED-Cell, experienced that everyone in our nation/PED-Cell understand how our work is contributing to the JISR processes.					
We, in our nation/PED-Cell, had a good understanding of the current JISR processes.					
We, in our nation/PED-Cell, experienced that other nations/PED-Cells had the necessary competence to perform their work.					
We, in our nation/PED-Cell, experienced that other nations/PED-Cells knew their job.					
We, in our nation/PED-Cell, experienced that other nations/PED-Cells understand how their work is contributing to the JISR processes.					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
We, in our nation/PED-Cell, experienced that other nations/PED-Cells had a good understanding of the current JISR processes.					

Work involvement

Please state: to what degree do you:

	To a very low degree	To a low degree	To a medium degree	To a high degree	To a very high degree
Experience that the PED-Cell/National products are important to you?					
Experience that the Bold Quest 2019 outcomes are important to you?					
Feel responsible for the PED-Cell/National products?					
Feel responsible for the Bold Quest 2019 outcomes?					
Feel motivated to go out of your way to contribute to the PED-Cell/National products?					
Feel motivated to go out of your way to contribute to the Bold Quest 2019 outcomes?					

The questions below concern data and metadata quality.

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Is the data in your node or PED-Cell available, or easily or quickly retrievable?					
Is the volume of data in your node or PED-Cell appropriate for the task at hand?					
Is the data at hand for your node or PED-Cell regarded as true and credible?					
Is the data for your node or PED-Cell concise and compactly represented due to specifications (in EX handbook)?					
Is the data for your node or PED-Cell consistent and represented in the same format due to your expectations?					
Is it easy to manipulate (if data needs to be changed or corrected) and apply the data to different tasks?					
Is the data at hand for your node or PED-Cell regarded as correct and reliable?					
Is the data at hand for your node or PED-Cell in appropriate languages, symbols, and units, and the definitions are clear?					
Is the data at hand for your node or PED-Cell unbiased, unprejudiced, and impartial?					
Is the data for your node or PED-Cell applicable and helpful for your task at hand?					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Is the data for your node or PED-Cell highly regarded in terms of its source and/or content?					
Is the data for your node or PED-Cell secured to which access to data is restricted appropriately to maintain its security?					
Is the data for your node or PED-Cell sufficiently up-to-date for the task at hand?					
Is the data at hand for your node or PED-Cell easy to understand?					
Is the data at hand for your node or PED-Cell beneficial and provides advantages from its use?					

Questions concerning the application system.

Describe role, the task. and application system you were using during UV18 trial:

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
Overall, I am satisfied with how easy it is to use this application for the task or tasks at hand according to my role in the exercise.					
It was simple to use this application for the task or tasks dedicated my role.					
I could effectively complete the tasks and daily vignettes using this application when in this role.					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
I was able to complete the tasks and daily vignettes quickly using this application when in this role.					
I was able to efficiently complete the tasks and daily vignettes using this application when in this role.					
I felt comfortable using this application for the tasks at hand in the daily vignettes when in this role.					
It was easy to learn to use this application for the tasks when in this role.					
I believe I could become productive quickly using this application for the tasks at hand in the daily vignettes when in this role.					
The application gave error messages that clearly told me how to fix problems when operating the application for the tasks at hand in the daily vignettes and when in this role.					
Whenever I made a mistake using the application, I could recover easily and return to the tasks.					
The information (such as online help, on-screen messages, and other documentation) provided with the application was clear.					

	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
The information provided (such as online help, on-screen messages, and other documentation) was effective in helping me complete the tasks when in this role.					
The organization of information (such as online help, on-screen messages, and other documentation) was effective in helping me complete the tasks when in this role.					
The organization of information (such as online help, on-screen messages, and other documentation) on the application screens was clear and instructive in helping me complete the tasks dedicated my role during daily vignettes.					
The interface of this application was pleasant helping me complete the tasks during daily vignettes.					
I liked using the interface of this application.					
This application has all the functions and capabilities I expect it to have supporting the tasks during daily vignettes when in this role.					
Overall, I am satisfied with this application supporting the tasks when in this role.					

Annex E – UV18 DAILY SURVEYS

Daily Human Factors Survey 1 **June 18 UV 18**
Think about the work today within your PED-Cell and the collaboration among different teams in PED-Cell (e.g., HUMINT team, IMINT team, GMTI team etc.) when answering the following questions: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
The goals of my team are not the same as the other teams' goals.
The goals of my team are not compatible with the other teams' goals.
The goal priority of my team, are not the same as the other teams' goals priority.
The goal priority, are incompatible with the other teams' goal priority.
How many exploitation tasks did your PED-Cell accomplish today?
(For the question above) Fill in how many: _____
The following questions are about how you individually felt during today's vignette 1. Very Low, 2., 3., 4., 5., 6., 7., 8., 9., 10., 11., 12., 13., 14., 15., 16., 17., 18., 19., 20. Very High
How mentally demanding was the task?
How physically demanding was the task?
How hurried or rushed was the pace of the task?
How successful were you in accomplishing what you were asked to do?
How hard did you have to work to accomplish your level of performance?
How insecure, discouraged, irritated, stressed, and annoyed were you?
Think about how the JISR process is linked to other processes 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
There is a good integration of the joint targeting process and the JISR process.

Daily Human Factors Survey 2 **June 19 UV 18**				
Think about the work today within your PED-Cell and the collaboration among different teams in PED-Cell (e.g., HUMINT team, IMINT team, GMTI team etc.) when answering the following questions: 1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
Today's task(s) was difficult to complete.				
How many exploitation tasks did your PED-Cell accomplish today?				
(For the question above) Fill in how many: _____				
The intelligence requirement management and collection management (IRM CM) system refers to the computer system you use to send and receive information that concerns intelligence requirement management and collection management. There may be a dedicated IRM CM system such as ICMT, or you may use other systems to handle IRM CM. 1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
The IRM CM system supported the awareness of the capacity of the different PED-Cells for processing, exploitation or dissemination.				
Please tell us how much effort was spent on the following activities in the training period and until now, to facilitate smooth interactions between the different PED-Cells.	-4. Little or no effort	-3., -2. Some effort	-1., 0. Moderate effort	1., 2. Significant effort	3., 4. Intensive focused effort
Helping personnel in each location to understand the decision-making procedures used by personnel in the other location.					
Using technologies that enable personnel in one location to observe the work-in-progress in other locations.					
Encouraging and facilitating personnel in one location to adopt the vocabulary used by personnel in other locations.					
Developing/adapting an IT communication network.					
Training personnel in remote collaboration.					
Encouraging and facilitating personnel from one location to contact the other location whenever they feel the need (e.g., telephone, chat etc.)					
Think about the communication in general (within your PED-Cell as well as with other PED-Cells). 1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
When sending messages, we added explanatory information.				
We often added information to explain what we meant.				
Think about how the JISR process is linked to other processes 1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
Requests for information that originate from the joint targeting process, is answered with the desired level of quality using the JISR process.				

Daily Human Factors Survey 3 **June 20 UV 18**
Think about the work today within your PED-Cell and the collaboration among different teams in PED-Cell (e.g., HUMINT team, IMINT team, GMTI team etc.) when answering the following questions: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
In the PED-Cell team members were able to share new cues (e.g., ad hoc and/or dynamic taskings) that signal need for change in interpretation of the target area.
In the PED-Cell team members were able to interpret the new cues in a good way.
In the PED-Cell team members were able to formulate a plan (e.g., CXP) by deciding on a course of action, setting goals, and clarifying member roles and responsibilities.
In the PED-Cell team members were able to formulate a plan by prioritizing tasks, clarify performance expectations and share information related to task requirements.
In the PED-Cell team members were able to do the processes necessary to fulfill the plan by enacting individual activities (i.e., such as processing, exploiting and disseminating information).
In the PED-Cell team members were able to do the processes necessary to fulfill the plan by enacting team activities (i.e., such as processing, exploiting and disseminating information).
In the PED-Cell team members were able to reflect on past activities.
In the PED-Cell team members were able to change our way of working.
How many exploitation tasks did your PED-Cell accomplish today?
(For the question above) Fill in how many:_____
Think about the collaboration with other PED-Cells when answering the following questions: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
It was easy for one PED-Cell to share our interpretation of new cues with other PED-Cells.
It was easy for one PED-Cell to share our plans with other PED-Cells.
In the PED-Cell team members could easily work together with other PED-Cells. (such as processing, exploiting and disseminating information together).

Daily Human Factors Survey 4 **June 21 UV 18**
Think about the work today within your PED-Cell and the collaboration among different teams in PED-Cell (e.g., HUMINT team, IMINT team, GMTI team etc.) when answering the following questions: 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
Today's task(s) was difficult to complete.
The teams worked together in a well-coordinated fashion.
The teams had very few misunderstandings about what to do.
We accomplished the task(s) smoothly and efficiently.
How many exploitation tasks did your PED-Cell accomplish today?
(for the question above) Fill in how many: _____
The following questions ask about your situation awareness with respect to the vignette played today. Indicate for what vignette number your answer belongs to. (respondents fill in by text)
What are the names of the collector assets available?
How many objects are there in your area of responsibility (friendly, neutral and potential enemy)?
Who is in charge of the enemy group (e.g., terrorist task force)?
Where are the enemy group (e.g., terrorist task force) located?
Where does the enemy (e.g., terrorist task force) want to go?
Why is the enemy (e.g., terrorist task force) using the force composition they do?
Think about your answers to the situation awareness. 1. 0 – 10 %, 2. 11 – 20 %, 3. 21 – 30 %, 4. 31 – 40 %, 5. 41 – 50 %, 6. 51 – 60 %, 7. 61 – 70 %, 8. 71 – 80 %, 9. 81 – 90 %, 10. 91 – 100 %
What is the probability of your answers being correct?

Daily Human Factors Survey 5 **June 22 UV 18** **Think about the work today within your PED-Cell and the collaboration among different teams in PED-Cell (e.g., HUMINT team, IMINT team, GMTI team etc.) when answering the following questions:** 1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree		
The teams worked together in a well-coordinated fashion.		
The teams had very few misunderstandings about what to do.		
We accomplished the task(s) smoothly and efficiently.		
	PED-Cell lead	_____
	HUMINIT team	_____
	Biometrics Team	_____
	IMINT Team	_____
	MASINT Team	_____
	GMTI Team	_____
	SIGINT-ELINT Team	_____
(for the question above mark the team(s) you are in regular contact with)		
Which of the teams in your PED-Cell do you have regular contact with (such as for aligning work activities, negotiating common efforts, resolving common problems)?		
How many exploitation tasks did your PED-Cell accomplish today?		
(for the question above) Fill in how many: _____		
Think about the work within your PED-Cell and the collaboration with other PED-Cells when answering the following questions:		
Which other PED-Cells do you have regular contact (such as for aligning work activities, negotiating common efforts, resolving common problems)?		
(for the question above) Fill in which PED-Cells: _____		
The following questions ask about your situation awareness with respect to the vignette played today. Indicate for what vignette number your answer belong to. (respondents fill in by text)		
How many objects are there in your area of responsibility (friendly, neutral and potential enemy)?		
Who is in charge of the enemy group (e.g., terrorist task force)?		
Where are the enemy group (e.g., terrorist task force) located?		
Where does the enemy (e.g., terrorist task force) want to go?		
Why is the enemy (e.g., terrorist task force) using the force composition they do?		

The questions below concern data and metadata quality				
1. Strongly Disagree	2. Disagree	3. Neutral	4. Agree	5. Strongly Agree
Is the data for your node or PED-Cell regarded complete with not anything missing and it is of sufficient breadth and depth?				

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14. Abstract

The NATO HFM RTG-276 Panel titled Human Factors and ISR CD&E was established to identify Human Factors (HF) issues critical to effective Joint and ISR operations within a NATO operational level Headquarters (HQs). More precisely, the goals of the HFM RTG-276 were: 1) To gauge current knowledge about HF research in the ISR CD&E process; 2) To identify critical HF to effective JISR operations within a simulated NATO JISR operation; 3) To further validate a model of organizational effectiveness for understanding, explaining, and measuring different aspects of HF issues in JISR operations; and 4) To make recommendations regarding improvement of education and training of NATO and partner countries' militaries for ISR CD&E coalition operations.

Broadly, the findings revealed that HF issues are an important component of effective and efficient JISR operations. It was discovered that the federation and coordination between nations can be improved by improving the way information is shared and through the reduction of coordination needs during the execution of operations. The research showed that individual, organizational, and cultural issues are important for improving the effectiveness of ISR operations. An understanding of the various dimensions of data quality is important for information quality management during ISR operations. Finally, the researchers used observational data and interviews within one French PED cell to provide further validation of the theoretical framework used to guide this research.

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