NORTH ATLANTIC TREATY ORGANISATION

RESEARCH AND TECHNOLOGY ORGANISATION

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RTO TECHNICAL REPORT **TR-SAS-050**

Exploring New Command and Control Concepts and Capabilities

(Exploration de nouveaux concepts de commandement et contrôle et de leurs capacités)

This Report documents the findings of SAS-050.

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The Research and Technology Organisation (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

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- 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 bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

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Exploring New Command and Control Concepts and Capabilities

(RTO-TR-SAS-050)

Executive Summary

The ability to represent and explore Command and Control (C2) approaches and new network-centric command concepts has become a priority area for NATO Nations and other countries undergoing transformation.

In 2003, SAS-050 was formed to explore new approaches to Command and Control. The group's primary goal was to develop a conceptual model of C2 and demonstrate its utility in capturing our knowledge regarding C2; and supporting exploratory analysis. The SAS-050 Conceptual Model is intended to serve as a point of departure for researchers, analysts, and experimenters engaging in C2-related research, conducting analyses of C2 concepts and capabilities, and designing and conducting experiments. Ultimately the model will assist the decisionmaker in understanding Command and Control concepts and the implications of different approaches to Command and Control.

The group built a model consisting of a Reference Model, a Value View, and a generic process view. The Reference Model contains over 300 variables and a selected subset of the possible relationships among them. The Reference Model serves as a checklist to ensure that adequate attention is afforded to important variables and relationships. The definitions and accompanied measures provided are meant to be tested in practice and built upon. The Value View posits links in the value chain that lead from characteristics of the force and its approach to C2, to measures of mission and policy effectiveness, and finally to agility.

This report provides an in-depth discussion of the SAS-050 Reference Model and the Value View. Several chapters focus on specific sections of the reference model (C2 Approach, the Information Domain, Individual Characteristics and Behaviours, Team Characteristics and Behaviours, and Decisionmaking, Actions, Effects, and Consequences). These chapters are followed by an explanation of the group's approach to validating the model. The paper discusses key variables and relationships within the model, identifies tools that can explore the nature of the relationships among variables, and describes the results of case studies and peer review conducted to test and identify advantages and limitations of the model.

In response to SAS-050 recommendations, SAS-065 has been created as a follow-on effort. Under the chairmanship of Dr. David S. Alberts of the United States, this group is working to apply the C2 Conceptual Reference Model to NATO Network Enabled Capability (NEC) and develop an NEC Maturity Model.

Exploration de nouveaux concepts de commandement et contrôle et de leurs capacités

(RTO-TR-SAS-050)

Synthèse

La capacité de représenter et d'explorer des concepts de C2 dans la nouvelle optique de commandement basée sur des opérations réseau centrées est devenue une priorité pour les nations de l'OTAN et d'autres pays en pleine transformation.

En 2003, SAS-050 a été institué pour explorer de nouvelles méthodes de commandement et de contrôle. L'objectif principal du groupe a été de développer un modèle conceptuel de C2 et de démontrer son utilité pour appréhender nos connaissances sur le C2, tout en prenant en compte une analyse exploratoire. Le modèle conceptuel de SAS-050 est destiné à servir de point de départ aux chercheurs, analystes et expérimentateurs, engagés dans des recherches, analysant les concepts et capacités, concevant et expérimentant sur le C2. A terme, ce modèle aidera le décisionnaire à comprendre les concepts et implications des différentes approches du commandement et contrôle.

Le groupe a élaboré un modèle composé d'un Modèle de Référence, d'une Analyse de Valeur et d'une vision générique du processus. Le Modèle de Référence comprend plus de 300 variables et un sous-ensemble sélectionné des rapports possibles entre elles. Le Modèle de Référence sert de liste de vérification pour s'assurer qu'une attention adéquate a bien été portée aux variables et à leurs rapports importants. Les définitions et mesures les accompagnant sont incluses pour tests concrets et servir de base de construction. L'Analyse de Valeur (AV) énonce le principe de rapports entre la chaîne de valeurs ; L'AV va, des caractéristiques de la force et de son approche du C2, à l'efficacité de la mission et de la politique, pour aboutir à la souplesse.

Ce rapport présente une discussion approfondie du Modèle de Référence SAS-050 et de l'Analyse de Valeur. Plusieurs chapitres se concentrent sur des sections spécifiques du modèle de référence (Approche du C2, Domaine des Informations, Caractéristiques Individuelles & Comportements, Caractéristiques de l'Équipe & Comportements, Prise de décisions, Actions, Effets & Conséquences). Ces chapitres sont suivis d'une explication de l'approche du groupe dans sa validation du modèle. Ce document discute des variables-clé et des rapports à l'intérieur du modèle ; il identifie les outils permettant d'explorer la nature des rapports entre les variables ; il décrit les résultats des études de cas et prend en compte la revue par des pairs menée pour tester et identifier les avantages et limites du modèle.

En réponse aux recommandations du SAS-050, le SAS-065 a été créé en tant qu'effort de suivi. Sous la présidence américaine du Dr. David S. Alberts, ce groupe travaille à appliquer le Modèle Conceptuel du C2 à la capacité réseau de l'OTAN (NEC) et à développer un modèle mature.

Chapter 1 – INTRODUCTION

BACKGROUND

NATO, its member Nations, other countries, and organisations of all types have, to varying degrees, embarked on a journey of transformation with the goal of fully leveraging the concepts and capabilities of the Information Age. Whether it is called Network-Enabled Capability (as it is in NATO), Network Centric Operations, Network Enabled Defence, or Edge Organisations, this transformation is predicated upon a set of network-centric tenets.

The tenets that form the intellectual foundation for these ongoing transformations are:

- A robustly networked force (enterprise) enables the widespread sharing of information.
- Widespread information sharing and collaboration in the information domain improves the quality of awareness, shared awareness, and collaboration (C2 and operations processes).
- This, in turn, enables self-synchronisation.
- This results in a dramatic improvement in operational effectiveness and agility.

The approach that is taken to Command and Control (C2) directly affects how decisions are allocated, the nature of C2 processes, and the distribution of information. As such, C2 is at the heart of transformation.

GOALS AND OBJECTIVES

Because C2 is the heart of an Information Age Transformation, understanding the implications of existing and new approaches to C2 is on the critical path of transformation roadmaps and progress depends on achieving this understanding. This is because the ability to represent C2 in general, and new network-centric command concepts specifically, is a prerequisite for our ability to understand, explore, and assess emerging concepts of operation and transformational capabilities.

SAS-050 was formed to explore new approaches to Command and Control and the group adopted the following specific goals and objectives:

- Develop a conceptual model (CM) identifying the key variables and the relationships among them.
- Identify tools that can explore the nature of the relationships among these variables.
- Apply the model and tools to a test case.
- Conduct a peer review of the model.
- Disseminate the model and the group's findings.

MEMBERSHIP

Because interest in new approaches to C2 is global and because coalition operations are most successful when the functions associated with C2 are performed well, membership in SAS-050 was open to non-NATO nations. Thus representatives from NATO members Canada, Denmark, Germany, Italy, Portugal, Norway,

the Netherlands, the United Kingdom, and the United States were joined by representatives from Australia and Sweden. The members of SAS-050 are presented in Figure 1-1.

Name	Nation	Organization
Dr. David Alberts	US	OSD NII, Chair SAS-050
Mr. Graham Cookman	UK	AMS
Mr. Natalino Dazzi	IT	Orizzonte Sistemi Navali S.p.A.
Dr. Lorraine Dodd	UK	QinetiQ
Ms. Petra Eggenhofer	GE	ITIS University of the Federal Armed Forces, Germany
Mr. Geir Enemo	NO	FFI
Mr. Fernando Freire	PO	Academia Militar
Dr. Anne-Marie Grisogono	Australia	DSTO
Dr. Richard Hayes	US	EBR
Dr. Gary Horne	US	Marine Corps Warfighting Lab
Dr. Reiner Huber	GE	IT IS Universitiat der Bundeswehr
Mr. Reinhard Hutter	GE	IABG
Mr. Gert Jensen	DK	DDRE
Ms. Sarah Johnson	US	MITRE
Mr. Nickolas Lambert	NL	NATO C3 Agency/C3I Analysis and Support Branch
Mr. Viggo Lemche	DK	DDRE
Ms. Danielle Martin	US	EBR
Mr. Graham Mathieson	UK	DSTL
Dr. Daniel Maxwell	US	Innovative Decisions, Inc.
Dr. James Moffat	UK	DSTL
Mr. Allen Murashige	US	Hq USAF/XIW
Mr. Klaus Niemeyer	GE	IABG
Mr. Arne Norlander	SE	Swedish Defense Research Agency
Maj. Paulo Nunes	PO	Academia Militar
Dr. Paul Phister	US	AFRL
Mr. Valdur Pille	CA	DRDC-Valcartier
Mr. Dieter Rathmann	GE	EADS Dornier
Mr. Xander Roels	NL	TNO-FEL
CPT Jens Roemer	GE	IT IS Universitiat der Bundeswehr
Mr. Gunther Schwarz	GE	EADS Dornier
Mr. Mark Sinclair	US	EBR
M.Sc. Mink Spaans	NL	TNO Defence, Safety & Security
Ms. Kristi Sugarman	US	EBR
LTC (Ret) Klaus Titze	GE	IT IS Universitiat der Bundeswehr
Mr. Rick van der Kleij	NL	TNO Human Factors

Figure 1-1: SAS-050 Members.

PRODUCT AND INTENDED USES

The main product of SAS-050 was a conceptual model of Command and Control. This model consists of a Reference Model, a Value View, and a generic process view.

The Reference Model contains over 300 variables and a selected subset of the possible relationships among them that were felt to be important to understand Command and Control and the implications of different approaches to Command and Control. The Value View posits links in the value chain that lead from characteristics of the force and its approach to C2 to measures of mission and policy effectiveness, and finally to agility.

The SAS-050 Conceptual Model is intended to serve as a point of departure for researchers, analysts, and experimenters engaging in C2-related research, conducting analyses of C2 concepts and capabilities, and designing and conducting experiments. The Reference Model serves as a checklist to ensure that adequate attention is afforded to important variables and relationships. The definitions and accompanied measures provided are meant to be tested in practice and built upon.

CAVEATS

It is in the nature of a conceptual model and its instantiations to never be "finished." That is, the model represents, at any given point in time, the state of our knowledge and because this state is incomplete and constantly improving, the model will be in a constant state of change. Having stated this, the SAS-050 Conceptual Model represents a significant step forward for the C2 community. For the first time, we have a model that accomplished C2 professionals from NATO and non-NATO countries accept as a basis for exploration and investigation. While referred to later as the Conceptual Model, the product of SAS-050 is best understood as a Reference Model that provides a detailed specification of variables and the relationships between those variables.

In building this model, SAS-050 made improvements in the state of the art in many different areas. However, the most significant improvements were focussed in the area of team characteristics and behaviour. This was because, although the literature about Network Centric Warfare and Operations has, since its inception, stressed the need to understand key concepts like shared awareness and self-synchronisation (a manifestation of team behaviour), sufficient time and energy has not yet been focussed on these concepts to have determined the details of the value chain and the identity of the variables that "moderate" or influence the relationships among the links in the value chain.

Thus, the work of SAS-050 in team characteristics and behaviours is both incomplete and relatively immature. Many of the concepts that apply to individuals (e.g., awareness) have a team or group counterpart (e.g., shared awareness). These team counterparts, while they are similar, are not identical to their individual partners and much work will be needed to better measure and understand them.

MAP TO CONCEPTUAL REFERENCE MODEL

A major portion of this report is devoted to an in-depth discussion of the SAS-050 Reference Model and the Value View. This discussion is organized as follows:

- C2 Approach (Chapter 3)
- Information Domain (Chapter 4)

- Individual Characteristics and Behaviours (Chapter 5)
- Team Characteristics and Behaviours (Chapter 6)
- Decisionmaking, Actions, Effects, and Consequences (Chapter 7)
- Value View (Chapter 8)

The Value View chapter of this report is followed by a discussion of the group's approach to validating the model, including the results of two case studies.

Chapter 2 – KEY TERMS AND OVERVIEW OF CONCEPTUAL MODEL

The conceptual model developed by SAS-050 consists of a set of variables and relationships key to understanding Command and Control. To orient ourselves and those who wish to understand our efforts and the products of our efforts, we offer the following definitions of key terms.

DEFINITIONS OF KEY TERMS

An understanding of how SAS-050 views C2, what SAS-050 considers a model to be, how we thought about the properties of a C2 Approach, and hence the differences that could exist from one approach to another is needed if one is to understand the model that was produced. Accordingly, this section discusses the nature of C2, what constitutes an approach to C2, what we mean by a "model," and the nature of specific kinds of models.

COMMAND AND CONTROL

In any rapidly evolving field (and Command and Control is certainly undergoing major changes in basic concepts and capabilities), definitions are problematic. Command and Control has been defined by some in terms of how it is done in a given organisation or collection of organisations. These organisation-specific definitions are not helpful when the focus of the effort is on new concepts and approaches. For a C2 definition to be useful to SAS-050, it needs to focus on why one does C2 and what functions an instantiation of C2 needs to accomplish to achieve its purposes.

First, C2 is scalable. C2 occurs at many levels of an organisation. C2, at the enterprise level, shapes the force (or the enterprise) determining the purpose of the organisation, its priorities, and ultimately the capabilities it has. Thus, C2 at the enterprise level determines what is possible.

C2 at the mission level is about employing the assets of an organisation – its people, systems, materiel, and its relationships with others – in the pursuit of mission-specific goals and objectives (intent).

APPROACH TO COMMAND AND CONTROL

There are a great many possible approaches to accomplishing the functions that we associate with Command and Control. Developing the "option space" for Command and Control requires that the major differences between possible approaches are identified and that these differences are anchored at the ends of the spectrum of options for each of these dimensions.

SAS-050 adopted three major axes or dimensions of Command and Control. These relate to the way (1) decision rights are allocated across an enterprise, (2) the permissible interactions among entities within the enterprise and permissible interactions between enterprise entities and others, and (3) the way information flows and is disseminated.

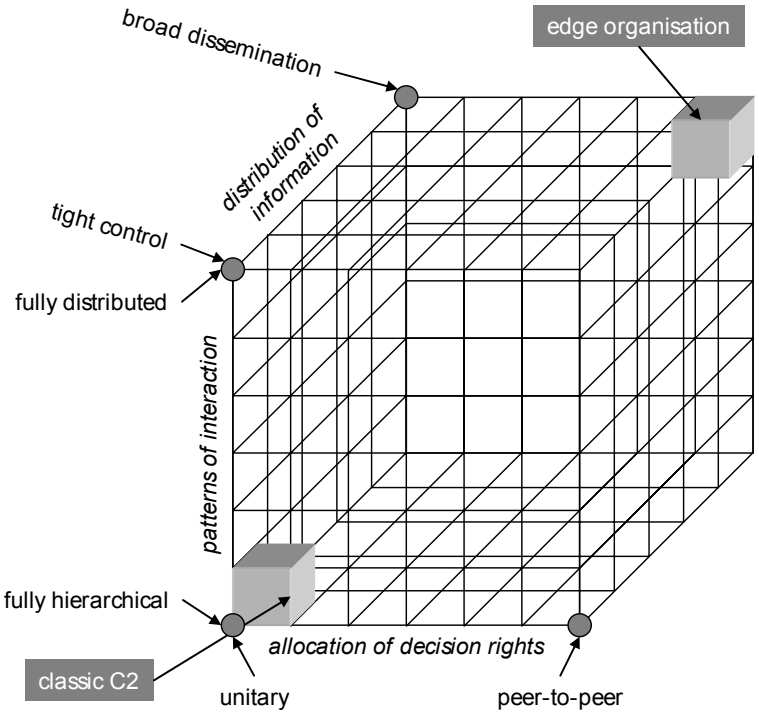

Figure 2-1: Depicts the C2 Approach Space Formed by these Dimensions.

Note that classic C2 is located in a relatively small area in one corner of this space, while edge approaches are located in a relatively small area in the opposite corner of the space. In between are approaches that possess some of the characteristics of both.

Understanding the range of possibilities, the attributes of different classes of C2 Approaches and the relative suitability of selected approaches for specific missions and circumstances, is essential to the transformation of NATO to NNEC or the various network-centric transformations that NATO members' nations are currently undertaking.

Points in this C2 Approach Space map to a certain range of values for a set of C2 Approach variables that are contained in the Reference Model. The values of these variables represent the controllable independent variables for research, analysis, or experimental activities.

MODELS

A model is an abstraction of reality for a purpose. Thus, building a model requires that one selects a subset of *variables and relationships* that represent reality "well enough."

Variables and Relationships

The variables found within the model are factors, characteristics, or attributes of an entity that can take on different values. In this model, this would include an individual, group, system or environmental attribute. The variables within the model have a number of relationships that reflect connections between and among other variables. In this case, these connections are in the form of influences.

For example, the formula we know for speed as a function of acceleration and time is an oversimplification that is well suited for some purposes but not well suited for others. For this reason, all models are wrong, some are useful, and some we cannot live without.

Models consist of a set of variables deemed relevant and a subset of the relationships among them. There are different types of variables that are important to understanding and using a model. Independent variables act to influence or determine the values of dependent variables. This distinction is not absolute but relative to one's view because in real life there are very few variables that do not influence something and are not influenced by something. Those variables that represent inputs to the model are thought of as independent variables, while the outputs of a model are considered to be the dependent variables. Some of a model's outputs are intermediate outputs in that they are items of interest in themselves (for a given purpose), while at the same time they influence other items of interest or variables that, in turn, influence items of interest downstream. There is also a distinction between controllable and uncontrollable variables. These labels are a reflection of both reality and the constraints that are imposed. For example, for a particular study it may be assumed that the nature of an organisation is fixed, that it is for the study an uncontrollable independent variable. Of course, organisations can be changed and hence in another study this variable may be considered to be a controllable variable.

In order to best define the group's objectives and form a team vision, a set of criteria for a conceptual model of C2 was developed. These criteria were used to guide the group in constructing a useful conceptual model of C2 and to help communicate their efforts to the broader community. Progress was measured using the criteria so that areas of the model in need of further development were easily identified. As noted earlier, the product ultimately reached the stage where it was best understood as a Reference Model rather than a fully developed concept model.

C2 CONCEPTUAL MODEL OVERVIEW

The purpose of the C2 Conceptual Model developed by SAS-050 is to support the exploration of new, networked-enabled (or network-centric / power to the edge) approaches to Command and Control and compare their characteristics, performance, effectiveness, and agility to traditional approaches to Command and Control. Specifically, the model must be able to trace the implications of certain value ranges for the C2 Approach variables (those that correspond to selected C2 Approaches).

Figure 2-2 below depicts, in schematic form, the "story" that SAS-050 has developed regarding the impact of a particular approach to C2 on C2 processes and the operations undertaken by the enterprise.

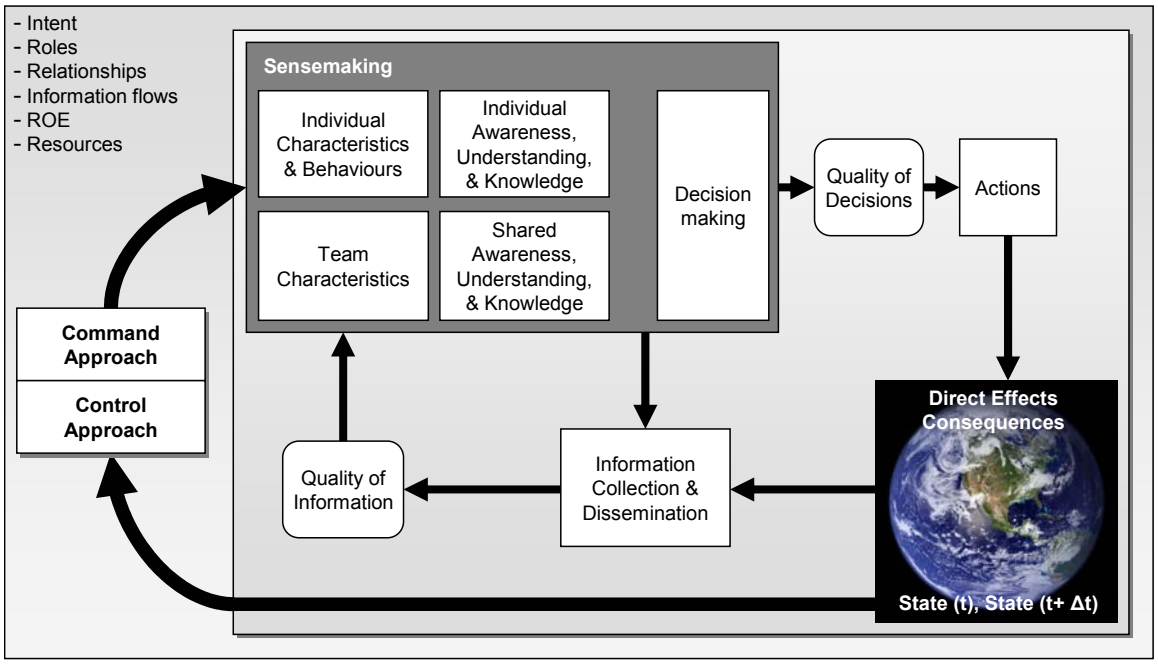

Figure 2-2: C2 Approach.

The selection of a C2 Approach corresponds to a set of decisions regarding the distribution of decision rights. Thus how intent is developed and communicated is a function of the C2 Approach that has been chosen. The Sensemaking process involves both individual and team sensemaking. The selection of a C2 Approach determines what information is available to individuals and the nature of the interactions among individuals within and across teams. Awareness, understanding, and ultimately decisions are the products of sensemaking. By affecting the flows of information, the allocation of decision rights, and the pattern of interactions among enterprise members (and other entities), the C2 Approach affects the nature of the awareness, understanding, and the decisions made by individuals and teams. Actions follow (the execution of these actions is similarly affected by the selection of a C2 Approach) and these actions result in direct effects and the cascade of consequences of the direct effects in the real world. As a result, the state of the world at time *t* is altered. This dynamic process continues as the altered world state is sensed and information regarding the state at time *t* plus delta *t* is collected and disseminated.

As SAS-050 members thought about this generic C2 process, its members identified variables that were important in understanding each aspect of this process. The variables that were identified form the basis for the SAS-050 C2 Conceptual Model. Given the large number of variables involved, it is difficult to visualize or explain this model. For this purpose, a number of views or selected subsets of variables and instantiations needed to be constructed. Initially, a variety of tools were utilized to depict the model views. Ultimately, the group found that they were best able to capture the conceptual model by creating their own tools using UML and MYSQL software.

VIEWS AND INSTANTIATIONS

At the heart of the SAS-050 Conceptual Model is its Reference Model. The Reference Model identifies over 300 variables and key relationships between and among them that were felt, by the members of SAS-050,

to have first order effects on the performance of C2 processes and the value of Command and Control. This Reference Model is intended to serve as a checklist or point of departure for researchers, analysts, and experimenters in their efforts to understand and/or assess C2-related capabilities. In any analysis, it is important to know what differences that may exist between alternatives are significant. This comes down to what really matters. The Value View contains a subset of variables from the Reference Model and the relationships among them that collectively form a value chain for C2. Each of the variables is a measure of quality, performance, effectiveness, or value.

The relationships between the variables in the Value View need to be instantiated by empirical evidence. Such evidence can come from a variety of sources that include instrumented reality, designed experiments, and simulations. Real or simulated C2 systems, organisations, processes, and supporting tools form the environments (virtual, constructive, or real) that offer the opportunity to generate data that, when appropriately analysed, contribute to the body of knowledge in general and to determining the relationships that exist among the variables in the Reference Model and the Value View. A model of C2 capabilities, organisations, and processes (and there are of course many instances of these) is a subset of the variables and relationships identified in the Reference Model. Such a subset is called a *process view*.

Figure 2-3 depicts the relationships among the value and process views and the conceptual Reference Model. The Reference Model feeds both the value and process views. Note that there are multiple instantiations of the process view. This is because there are many different ways Command and Control precepts and principles can be implemented and each process view represents one of these ways. The process views, as representations of a scenario-based reality, provide data that populate the Value View and correspond to the value that is associated with a particular process view. When one integrates over process views, a general model of the value chain is obtained.

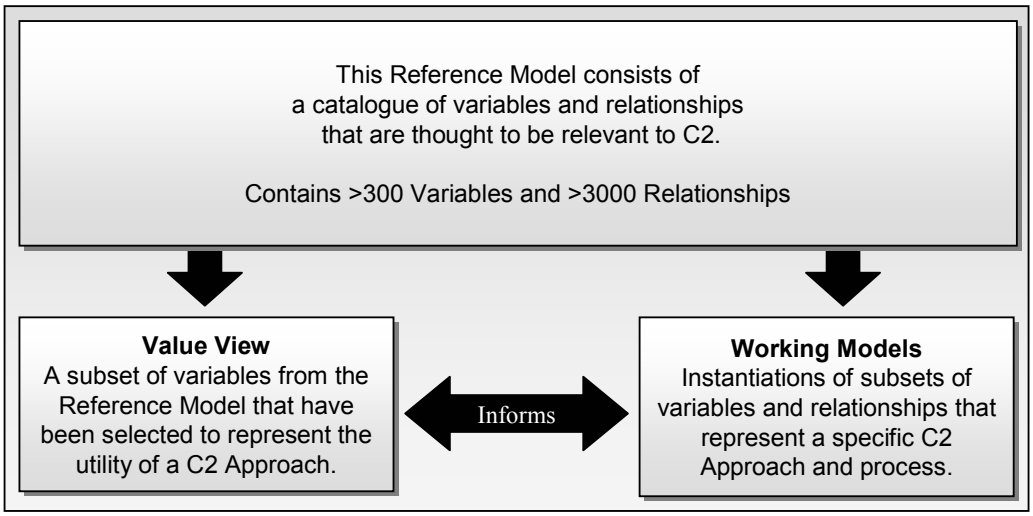

Figure 2-3: Relationships among the Value and Process Views of the C2 Model.

VALUE VIEW

A clear understanding of what makes C2 valuable and how it contributes to mission effectiveness and force agility is necessary to understand the merits of various approaches to C2.

Figure 2-4 represents a value chain formed out of selected variables from the Reference Model. These correspond to the tenets that form the basis for the ongoing Information Age transformation of defence establishments and military forces, of which NNEC is an instance of interest.

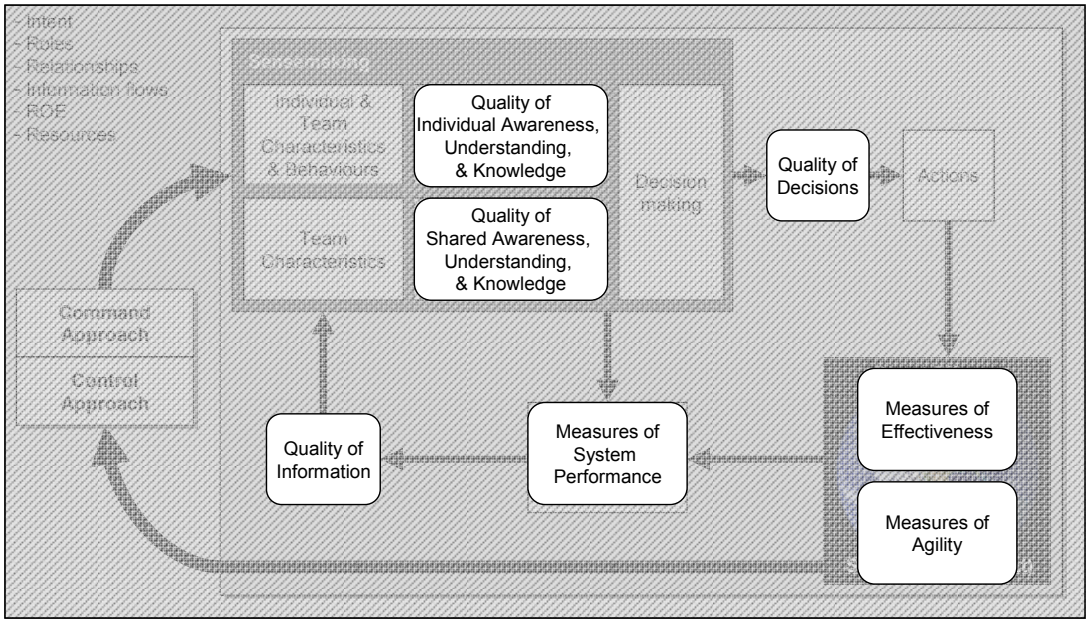

Figure 2-4: The Value Chain.

Chapter 3 – C2 APPROACH

INTRODUCTION

In order to identify the range of possible approaches to Command and Control, the Working Group had to specify the factors that determine the essence of these two interrelated functions. While both the U.S.[1] and NATO[2] have formal definitions of "Command and Control," these have been developed for legal and institutional purposes. As a result, they are politically rather than scientifically correct. They are not well suited to support research and development efforts. Indeed, these institutional definitions are typical products of consensus building and largely reflect what is considered current best practice, which developed during the Industrial Age. Hence, they do not leave room for approaches that are radically different from the established way of doing business. For example, they fail to distinguish between the functions of "command" and "control." They also assume that the processes associated with these two concepts are the same throughout the force and across time, despite the fact that we know that there are significant differences in the way they occur across echelons, functions, and classes of situations. Moreover, these traditional definitions focus on the formal and legal distribution of authority and responsibility despite the fact that military forces are heavily impacted by informal organisations and linkages. Finally, they assume specific structures that are hierarchical and depend on a unitary command function, thus ignoring a host of potential alternatives.

THREE FUNDAMENTAL DIMENSIONS

Drawing on the experience and expertise of the Working Group and examining a number of historical systems, three fundamental dimensions that govern command and control were identified. These are the:

- Allocation of decision rights;
- Patterns of interaction among the actors; and
- Distribution of information.

All three of these factors deal with the reality within the system, not the theory behind it. For example, the allocation of decision rights includes the informal way the system functions, not just the formal structure. Similarly, the patterns of interaction deal with those that actually occur, not those that are supposed to occur. Finally, the distribution of information is the realistic one in the force, not the ideal called for by doctrine, tactics, techniques, and procedures. All three of these factors also are important for both the function of command and the function of control, though they mean somewhat different things in those two arenas.

[1] The Department of Defense defines "command and control" as "the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission. Also called C2." Department of Defense Dictionary of Military and Associated Terms. Joint Publication 1-02. http://www.dtic.mil/doctrine/jel/doddict/data/. (April 07, 2005)

[2] NATO defines "command and control" as "the functions of commanders, staffs, and other command and control bodies in maintaining the combat readiness of their forces, preparing operations and directing troops in the performance of their tasks. The concept embraces the continuous acquisition, fusion, review, representation, analysis and assessment of information on the situation; issuing the commander's plan; tasking of forces; operational planning; organizing and maintaining cooperation by all forces and all forms of support; organizing command and control; preparing subordinate command and control bodies and forces for combat operations; supervising and assisting subordinate commanders, staffs and forces; the direct leadership of troops during performance of their combat missions." http://www.nato.int/docu/glossary/eng/15-main.pdf (April 07, 2005)

All three may be impacted by culture, level, or training, or the technologies available to support communication and collaboration.

Figure 3-1 shows the three dimensions as though they were orthogonal dimensions and formed a cube. The allocation of decision rights can range from unitary (one actor hold all the rights) to peer-to-peer (equal rights for all). Patterns of interaction can range from fully hierarchical through fully distributed. The distribution of information can range from totally controlled through broad dissemination in which every actor has access to every item.

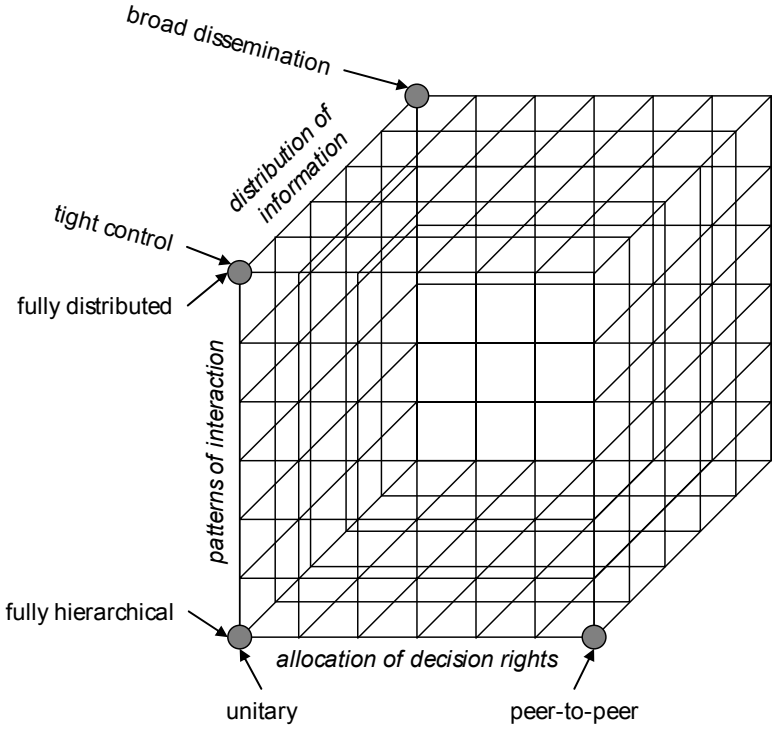

Figure 3-1: Depicts the C2 Approach Space Formed by these Dimensions.

The allocation of decision rights is the fundamental way that authority and responsibility are distributed within the force. For any given actor, this means the decisions that are assigned, as well as those that are permitted under some circumstances, as well as those the actor participates in but does not dominate. Decisions here include determining the occasion or opportunity for making a decision as well as the decision (choice among alternatives) itself. The control function deals with those decisions that are prohibited to some actors. For example, the use of special weapons systems may require the approval of particular levels of command and therefore be prohibited to others.

Patterns of interaction may also be required, permitted, or (control function) prohibited. These may be limited by the infostructure available as well as doctrine, culture, or other factors. The patterns of interaction are heavily influenced by the allocation of decision rights and have some influence on that factor (particularly in terms of informal interactions) as well. This deals with the reach (number and variety of participants in the interaction), richness (the breadth and quality of the content involved), as well as the quality of the interactions (media, availability, continuity, etc.) themselves.

The distribution of information also has positive (command) and negative (control) meaning. Here again, it is useful to think of information sharing that is required, permitted, and prohibited. This distribution is heavily impacted by both the allocation of decision rights and the patterns of interaction. Over time, it also feeds back to impact those two factors. Hence, these three factors (a) form a mutually reinforcing syndrome over time and (b) are far from independent from one another.

TWO SOURCES OF DYNAMICS

The fundamental dimensions determining a C2 Approach are not, however, static. They vary across at least two dimensions: function and time. The functional variation is the more obvious; different approaches to C2 are often apparent in operations and logistics, but may also occur in air and ground operations, special forces and conventional forces, and so forth. However, forces also change their C2 Approach over time. For example, during a crisis, the C2 Approach may be tightly centralized (narrow allocation of decision rights, continuous and doctrinally specified patterns of interaction, tight control over information) and emphasize control. However, if war breaks out, many of these constraints (for example, rules of engagement that restrict decision options) may suddenly be removed.

Indeed, dynamics across the three fundamental dimensions of C2 Approach and the ability of a particular force to operate differently over time and across function are key indicators of the capacity for agility. In particular, the capacity for adaptation (change in organisation and work process in response to differing conditions in the operating environment) is directly reflected in the range of C2 Approaches a given force is capable of adopting. In the Industrial Age force, this range is relatively narrow because it is optimized against a particular type of adversary and set of battlespace conditions. In more Information Age forces, a wide range of C2 Approaches is enabled by the types of personnel, training, technologies, leadership, organisation, and doctrine employed. These more agile forces also have the ability to recognize a need or opportunity to make meaningful adaptations and to act efficiently.

TWO SIDES OF THE COIN

As noted earlier, the three fundamental dimensions deal with both the function of command and the function of control. Within the SAS-050 Conceptual Model, Command Approach is a composite variable made up of:

1) Allocation of Decision Rights;
2) Patterns of Interaction Enabled;
3) Information Distribution;
4) Dynamics Across Purpose (Command); and
5) Dynamics Across Time (Command).

Not surprisingly, Control Approach also includes:

1) Restrictions on Decision Rights;
2) Patterns of Interaction Not Allowed;
3) Restrictions on Information Distribution;
4) Dynamics Across Purpose (Control); and
5) Dynamics Across Time (Control).

In addition, the extent of Constraint Enforcement and Selectivity are also classed as parts of the Control Approach.

CONCLUSION

At its core, the C2 Approach deals with the allocation of decision rights, the patterns of interaction, and the distribution of information that characterises the force. These three core factors are dynamic; they may differ over time and across function, even within the same force. The range of values that are possible for a particular mission capability package determines its agility in the Command and Control functions.

Chapter 4 – THE INFORMATION DOMAIN

APPROACH

The top level view of the Conceptual Model is shown in Figure 4-1. This chapter discusses the information domain portion of the conceptual model as highlighted in the white boxes in the figure below.

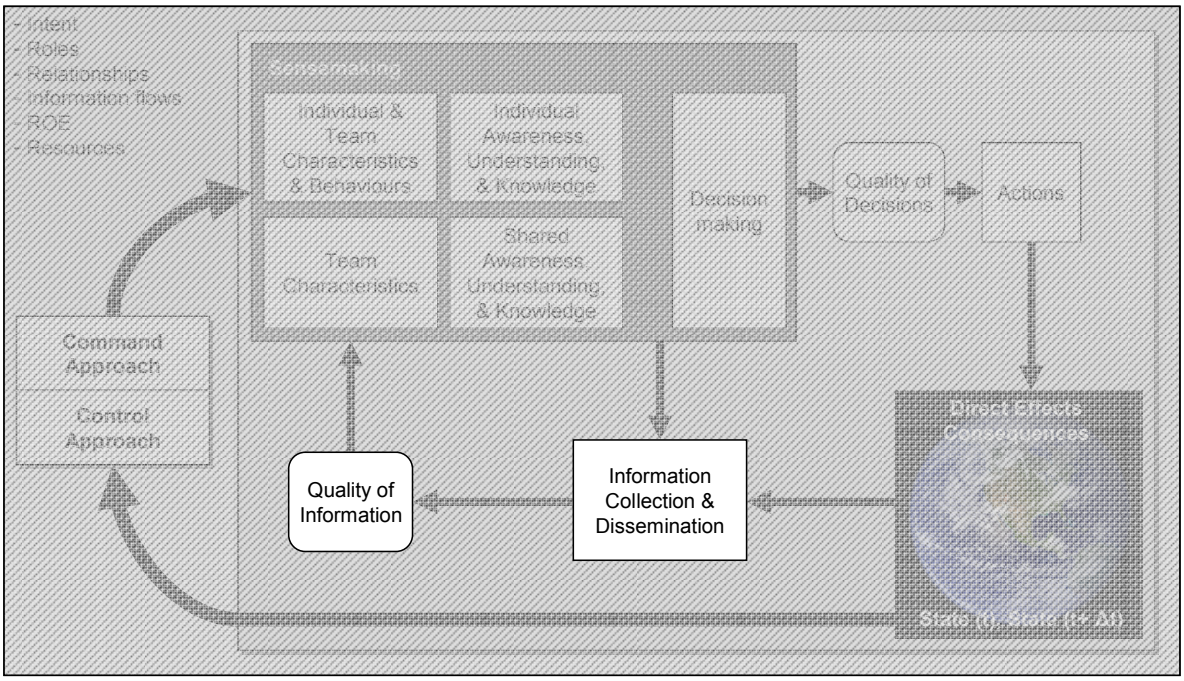

Figure 4-1: Information Domain Aspects in the Top Level View of C2 Conceptual Model.

The working group's aim was to ensure that the model adequately reflected a complete and robust set of information-related variables (sufficient to cover all the likely applications of the C2 Conceptual Model) and to suggest links between the variables (as supported by evidence where possible).

Figure 4-2 centres on the Quality of Information, a measure of merit of the product of the Information Domain. Also depicted in Figure 4-2, within dotted lines, are the C2 Approach and the Sensemaking Process. The C2 Approach establishes many of the conditions that affect Information Domain resources and processes, while the Sensemaking Process relies heavily on Information Domain products. The Distribution of Information, a key dimension of the C2 Approach, is a major determinant of the Quality of Information. The Distribution of Information is influenced by the characteristics of the Network, as well as the other dimensions of C2. The characteristics of the Network also influence Collaboration, which in turn influences the Quality of Information. Collaboration is affected by the Situational Characteristics, which also affect the nature of the information sources that are needed and/or available. Information Sources also directly affect the Quality of Information.

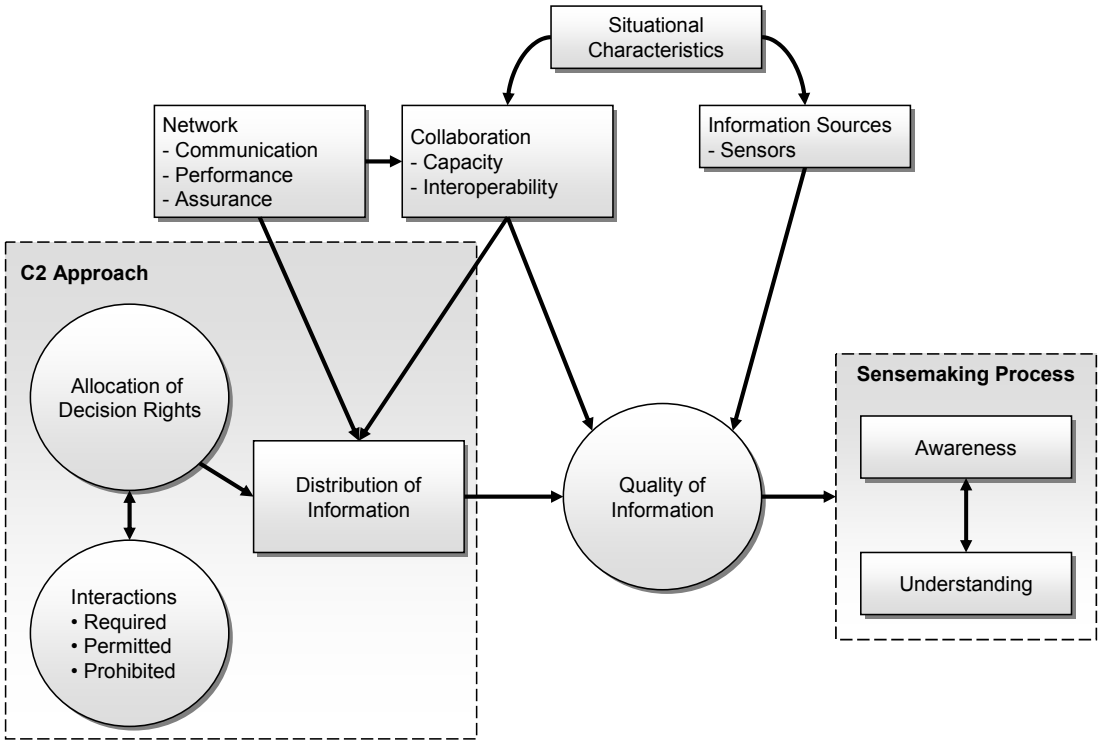

Figure 4-2: Variables that Contribute to Quality of Information.

The nature and characteristics of Information Sources are subdivided in the C2 Conceptual Reference Model into databases, direct sensing, indirect sensing, information source characteristics, open sources, and task currency/latency.

- *Databases* are collections of information organized in a structured fashion.
- *Direct sensing* takes place when humans experience an object or event in the physical domain with one of their senses (such as seeing, hearing, or smelling), and the sensing registers directly in the cognitive domain.
- *Indirect sensing* is to become aware of and perceive by involving intermediate or intervening parts or pathways.
- *Information source characteristics* are the traits of tools used to develop facts, data, or instructions in any form or medium.
- *Open sources* refers to the willingness and ability of an individual to change their understanding of a situation when confronted with new or contradictory information.
- *Task currency/latency* is the time lag of information.

Sensors, direct or indirect, are often employed to gather information about the situation. The composite variable, Sensors, consists of the attributes of mobility, resolution, sensor coverage (spatial), sensor coverage (medium), sensor coverage (spectrum), and sensor persistence.

- *Mobility* is the *e*xtent to which a sensor is able to move from place to place while retaining its ability to fulfil its primary mission.

- *Resolution* is the measurement of the smallest detail that can be distinguished by a sensor system under specific conditions.
- *Sensor coverage (spatial*) is the sequence or range of values (e.g., frequency, optical, infrared) that a sensor exhibits in order to observe, analyze, and report targets of interest.
- *Sensor coverage (medium)* is the sequence or range of values (e.g., frequency, optical, infrared) that a sensor exhibits in order to observe, analyze and report targets of interest.
- *Sensor coverage (spectrum)* is the sequence or range of values (e.g., frequency, optical, infrared) that a sensor exhibits in order to observe, analyze and report targets of interest.
- *Sensor persistence* is a compound attribute that addresses the percentage of time an area is covered along different dimensions of the spectrum.

There are a number of uncertainties that can and do affect the characteristics of the situation that, in turn, influence the nature and availability of information. S*ituational characteristics* are subdivided into ambiguity of situation, complexity of situation, equivocality of situation, uncertainty of situation, situational familiarity, and temporal focus.

- *Ambiguity of situation* is the inability to make sense out of a situation, regardless of available information.
- *Complexity of situation* is being faced with a situation made up of an interrelated set of variables, solutions, and stakeholders, each individually understood but which together exceed the processing capacity of the individual, the team, or organisation to synthesize.
- *Equivocality of situation* is having multiple interpretations of the same information.
- *Uncertainty of situation* is not having sufficient information to describe a current state or to forecast future states, preferred outcomes, or the actions needed to achieve them.
- *Situational familiarity* is the characteristic of having encountered or seen, or having knowledge of a situation.
- *Temporal focus* is the time into the future of an understanding or plan.

Available information, to be useful, must be distributed. The Distribution of Information depends, in part, on the characteristics of the network that is subdivided into: communication systems characteristics, information richness, information transfer approach, network reach, network richness, and quality of visualization.

- *Communication systems characteristics* have the following distinguishing traits: reach, reliability, robustness, richness of a communication system.
- *Information richness* measures the quality of the information content used by actors.
- *Information transfer approach* is the movement and distribution of information.
- *Network reach* is the number and variety of people, work stations, or organisations that can share information.
- *Network richness* is the quality and breadth of the information found in the network.
- *Quality of visualization* is the ability to capture the full richness of the insights, particularly risk and uncertainty (e.g., depicts the distribution rather than just the statistical) that are derived in assessments.

Verification of the information is necessary to generate trust and confidence in the information. The variables found within *information assurance* are authentication, confidentiality, information pedigree, integrity, network assurance, network availability, network reliability, network redundancy, network sustainability, non-repudiation, and privacy.

- *Authentication* is a security measure designed to protect a communications system against acceptance of a fraudulent transmission or simulation by establishing the validity of a transmission, message, or originator.
- *Confidentiality* is information or material that requires protection from unauthorized disclosure that could reasonably be expected to cause damage to national security.
- *Integrity* is that quality or condition of being whole or undivided, complete.
- *Non-repudiation* is the inability to avoid responsibility for inserting data, information, or knowledge into the information domain.
- *Information pedigree* is the extent to which you know where information came from.
- *Privacy* is a system in which no one except authorized users has access and each user's access is appropriate for their roles and responsibilities.
- *Network assurance* is the degree of confidence in the ability of force entities to have good connectivity. This includes the security, privacy, and integrity of the network and its contents.
- *Network availability* is the percentage of time that all authorized users have access to the network. This is necessary if current information is to be shared and if the user community is to develop trust and confidence in using the information in the system.
- *Network redundancy* is multiple ways to get at the same information or to get from point A to point B in a network. This helps in the availability of the system, where if part of the network goes down, then there are other means of accessing or getting to a certain part of the network.
- *Network reliability* is an attribute of any network that consistently produces the same results, preferably meeting or exceeding its specifications.
- *Network sustainability* is the ability to maintain the necessary level and duration of operational activity to achieve military objectives. In a network context, sustainability is a function of the ability to manage, maintain, and restore the network and network components.

The processing of information also relies on the *performance of information equipment*, which is subdivided into quality of communications equipment, quality of computing equipment, quantity of communications equipment, and quantity of computing equipment.

- *Quality of communications equipment* is the subjective assessment of the quality of available tangible forces, materiel, and other assets.
- *Quality of computing equipment* is the subjective assessment of the quality of computing hardware and associated equipment.
- *Quantity of communications equipment* is the number of available tangible forces, materiel, and other assets.
- *Quantity of computing equipment* is the number of computing hardware and associated equipment.

Information-related processing and analysis involves collaboration among individuals and organisations. Collaboration is dependant upon the collaboration environment that is available. This in turn depends on the capabilities and reliability of the network. Collaboration involves actors sharing data, information, knowledge, perceptions, or concepts when they are working together toward a common purpose.[1] *Collaboration* is subdivided into collaboration capacity, collaboration completeness, collaboration mechanism, collaboration participants, continuity of interactions, frequency of interactions, and interaction quality.

- *Collaboration capacity* is the team members' ability to work together towards a common purpose.
- *Collaboration completeness* includes collaboration about capabilities, environment, forces, intentions, and mission.
- *Collaboration mechanism* is a system that enables collaboration.
- *Collaboration participants* is the ability of team members to work together towards a common purpose.
- *Continuity of interactions* is an uninterrupted succession or flow of mutual or reciprocal actions or influences.
- *Frequency of interactions* is the rate of interactions over time. It should be noted that time scale depends on level of modelling, e.g. tactical seconds/minutes/ hours... enterprise months/years.
- *Interaction quality* is the usefulness of actively sharing information, developing awareness, and understanding and/or making decisions (developing plans) in a collaborative environment.

Collaboration and interoperability go hand-in-hand and affect the ability of mission participants and the systems that support them to work together. This needs to occur at a number of levels or layers to enable entities to communicate, share information, and collaborate with one another.[2] *Interoperability* is subdivided into system semantic interoperability, data interoperability, human semantic interoperability, communications interoperability, and quality of interactions.

- *System semantic interoperability* is consistency of meaning across systems.
- *Data interoperability* represents a level of interoperability in which data from one system can be used directly as data in another system, without translation or transformation.
- *Human semantic interoperability* is consistency of meaning across individuals.
- *Communications interoperability* is the condition achieved among communications-electronic systems or items of communications-electronic equipment when information or services can be exchanged directly and satisfactorily between them and/or their users.
- *Quality of interactions* is the usefulness of actively sharing information, developing awareness, and understanding and/or making decisions (developing plans) in a collaborative fashion.

Information quality consists of nine attributes or variables including information accuracy, information completeness, information consistency, information correctness, information currency, information precision, information relevance, information timeliness, information uncertainty, information service characteristics, information sharability, and information source characteristics.

[1] Alberts, Garstka, Hayes and Signori, *Understanding Information Age Warfare*. p. 185.

[2] Alberts and Hayes, *Power to the Edge*. pp. 107-108.

- *Information accuracy* is the degree to which information quality matches what is needed.
- *Information completeness* is the extent to which information relevant to ground truth is collected.
- *Information consistency* is the extent to which information is consistent with prior information and consistent across sources.
- *Information correctness* is the extent to which information is consistent with ground truth.
- *Information currency* is the difference between the current point in time and the time the information was made available.
- *Information precision* is the level of measurement detail of information item.
- *Information relevance* is the extent to which information quality is relevant to the task at hand.
- *Information timeliness* is the extent to which currency of information is suitable to its use; the relationship between availability of the information and when it is needed.
- *Information uncertainty* is a fundamental attribute of war and pervades the battlefield in the form of unknowns about the enemy, the surroundings, and our own forces.
- *Information service characteristics* describe a range of processing services support than might be provided to the force for continuance of operations where each alternative builds on the previous one.
- *Information sharability* is the extent to which an element of information is in a form or format understandable by all nodes in a network.
- *Information source characteristics* are the traits of tools used to develop facts, data, or instructions in any form or medium and all information sources are reporters.

If the information is shared among individuals, it takes on new qualities. *Shared information quality* is subdivided into shared information accuracy, shared information completeness, shared information consistency, shared information correctness, shared information currency, shared information precision, shared information relevance, shared information timeliness, and shared information uncertainty.

- *Shared information accuracy* is the appropriateness of precision of shared information for a particular use.
- *Shared information completeness* is the extent to which relevant shared information is obtained.
- *Shared information consistency* is the extent to which shared information is consistent within and across communities of interest.
- *Shared information correctness* is the extent to which shared information is consistent with ground truth.
- *Shared information currency* is the time lag of shared information.
- *Shared information precision* is the level of granularity of shared information.
- *Shared information relevance* is the proportion of shared information that is related to task at hand.
- *Shared information timeliness* is the extent to which currency of shared information is suitable to its use.
- *Shared information uncertainty* is the subjective assessment of confidence in shared information.

Chapter 5 – INDIVIDUAL CHARACTERISTICS AND BEHAVIOURS

INTRODUCTION

This chapter and the one that follows (*Team Characteristics and Behaviours*) address the variables and the relationships between and among them that describe human characteristics and behaviours that may affect the quality of decisionmaking in command and control processes. The quality of decisionmaking ultimately depends upon the quality of shared understanding that in turn is based on the awareness shared by the team members regarding the capabilities, environment, forces/actors, intentions, and the nature of the mission.

Shared awareness and understanding are developed in social processes of interaction among team members (as well as the interactions among these members), and they depend on the quality of the awareness and understanding of the individual team members. Individual awareness and understanding are the result of cognitive processes in which available information is processed by individual team members embedded in the social interaction processes of the team (that comprise Sensemaking). Both the social and the cognitive processes are shaped by the characteristics and behaviours of the team and its members.

Figure 5-1 highlights the role that individual characteristics and behaviours play within the C2 Model.

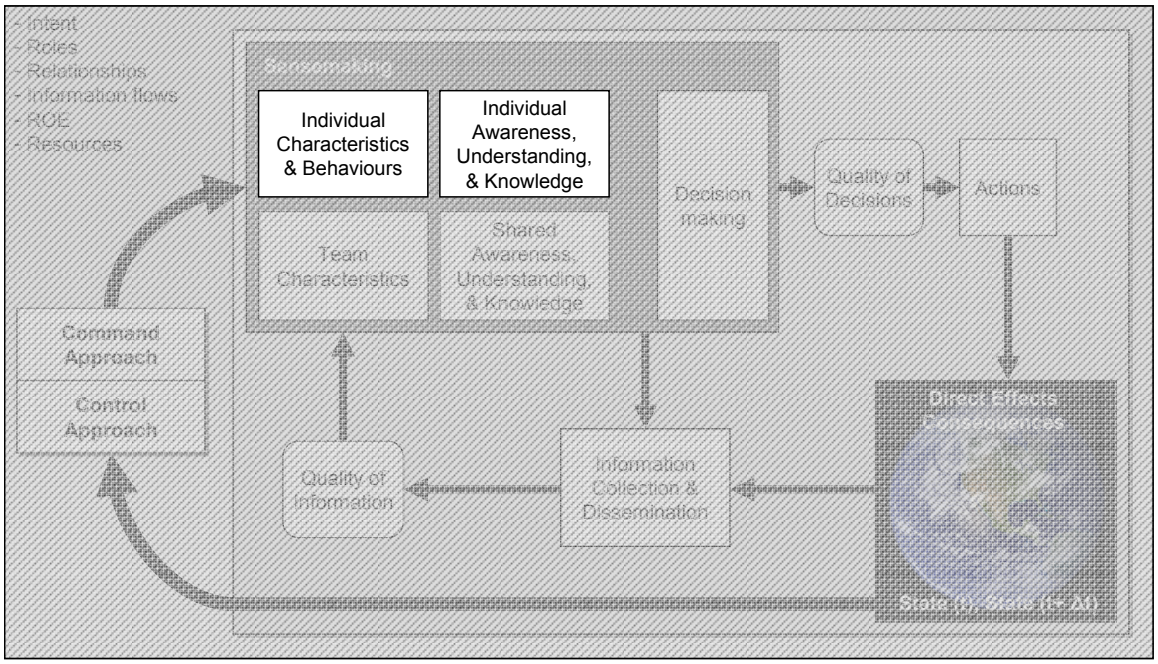

Figure 5-1: Overview of C2 Model Highlighting Individual Characteristics and Behaviours.

This chapter discusses variables that describe key cognitive issues involved in individual sensemaking. Understanding individual characteristics and behaviours requires an understanding of the following:

- Mental Models
- Awareness and Understanding

- Quality of Plan
- Task Performance

Variables related to Decisionmaking, which is also a key part of sensemaking, are described elsewhere in the report (see Chapter 8).

MENTAL MODELS

The concept of Mental Models is key to the way we have described sensemaking and the factors that influence it. The simple Awareness-Understanding-Action model that pervades much of the C2 literature focuses on the impact of Information as the chief driver of decisions. By introducing the Mental Model as a shaping and moderating influence in cognition, we have highlighted the need to consider the impact of other factors, such as cognitive abilities, personality traits, training and experience.

Mental Models are deeply integrated in individual understanding. The process of sensemaking has, at its core, the construction of Mental Models, and understanding can be thought of as the mapping of relevant Mental Models to observed reality. The connection of Mental Models and understanding is bi-directional because Mental Models are the repository of previous understandings, which are drawn down in the process of current understanding and updated for the future by that process.

However the existence of Mental Models has wider impacts. They shape the process of observation itself, impacting directly upon awareness. In a very real sense, we are incapable of becoming aware of phenomena for which we do not posses Mental Models. This reveals the criticality of training and experience to the cognitive process. Similarly, we cannot act with any deliberation or expertise without having formed Mental Models that allow us to connect actions with intents.

Mental Models are characterised by the following three variables: *Mental Models Richness*, *Mental Models Relevance,* and *Mental Models Confidence*. Figure 5-2 depicts important relationships between these and other variables.

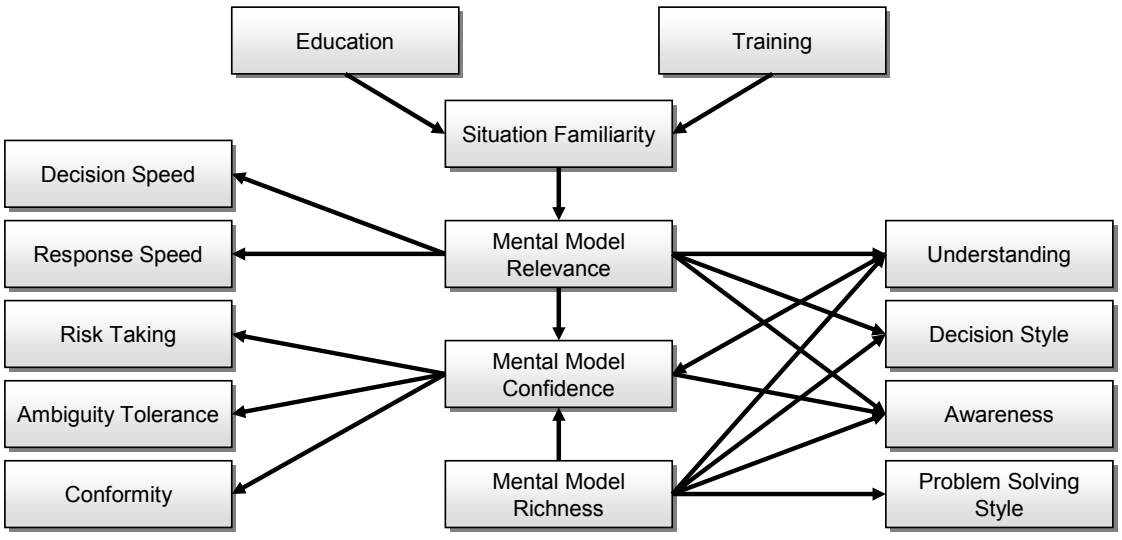

Figure 5-2: Mental Models.

Richness refers to the breadth and depth of the Mental Models an individual can bring to bear. Richness is influenced by a variety of *individual characteristics* and directly impacts upon a range of characteristics of *awareness* and *understanding*, including *correctness* and *accuracy*, as well *problem solving style* and *decision style*.

Relevance refers to the extent to which the Mental Model in use is appropriate to the situation and task at hand. In line with naturalistic decisionmaking theories, this is influenced by *situation familiarity*, which in turn depends upon *training* and *education*. *Relevance* directly affects, amongst other things, *awareness*, *understanding*, *decision style*, *decision speed* and response *speed*.

Confidence refers to the degree of subjective confidence that the Mental Model in use is appropriate to situation and task. This subjective confidence is influenced by, but not wholly dependent upon, the Mental Model's *Richness* and *Relevance* variables, as well as aspects of *understanding*. It directly affects *awareness uncertainty, understanding uncertainty, ambiguity tolerance,* and various behavioural factors, such as *conformity* and *risk taking*.

AWARENESS AND UNDERSTANDING

Both *awareness* and *understanding* are characterised by variables representing their *accuracy, completeness, consistency, correctness, currency, precision, relevance, timeliness,* and *uncertainty*. Specific relationships between these characteristics are identified in the Reference Model, and there is a general flow of effect from *awareness* to *understanding* moderated by *Mental Models* and a range of *individual and team variables*. Variables in the *understanding* group have direct impacts on behavioural variables, as indicated in the discussion above.

QUALITY OF PLAN

Quality of Plan is characterised by the variables representing their *accuracy, completeness, consistency, correctness, currency, feasibility, precision, relevance, timeliness,* and *uncertainty*. The Quality of Plan is influenced by *quality of command intent* and in turn influences the *accuracy, completeness, consistency, correctness, currency, precision, relevance, timeliness,* and *uncertainty of actions.*

TASK PERFORMANCE

Task Performance refers to task issues related to execution and contain the variables *individual task efficiency, individual task quality*, *task competence, task efficiency, task speed,* and *task understanding*.

Individual task efficiency is the degree to which an individual exhibits a high ratio of output to input in performing a task, while individual task quality is how well an individual performs a task.

Task efficiency is the degree to which the performance of a task exhibits a high ratio of output to input, *task competence* is the degree to which the knowledge required to execute a specified task is held by the individual or team, *task speed* is the time an individual spends performing a task, and *task understanding* is the extent to which the individual or team understands what is required to execute the specified task.

VARIABLES: INDIVIDUAL CHARACTERISTICS AND BEHAVIOURS

The variables discussed in this section fall into the five intermediate variables:

- Behaviour
- Individual Cognitive Abilities
- Personality and Values
- Physical Abilities
- Dynamic factors/State

Table 5-1 below gives an overview of the structure of these individual variables. A complete description of the variables follows below.

Table 5-1: Individual Characteristics and Behaviours

Behaviours	Individual Cognitive Abilities	Personality and Values	Physical Abilities	Dynamic Factors/ State
Memory performance Response speed Risk taking Self-monitoring Adaptive behaviour Conformity Cooperative behaviour Extra-role behaviour	General intelligence Cognitive capacity Cognitive complexity Cognitive flexibility	Emotional stability Conscientiousness Agreeableness Openness to experience Extraversion Decision style Problem solving styles Ambiguity tolerance Field dependence Impulsivity Levelling Locus of Control Relation to environment Repression Risk propensity Role of emotion Self-efficacy Self-esteem Trust propensity Willingness to interact	Physical strength Physical flexibility Other physical abilities Motor skill	Blood sugar level Physical health Sleep deprivation Alertness Stress level Anxiety Mental health Mood Motivation Trust Commitment/ Loyalty Position-based power

PHYSICAL ABILITIES

The domain of Physical Abilities can be differentiated into the variables *physical strength, physical flexibility, other physical abilities*, and *motor skill*.

Each of the first three variables is composed of a number of distinct constituents that have been found to determine the performance of physical tasks (Fleishman, 1979). *Physical strength* is composed of dynamic strength, trunk strength, static strength, and explosive strength. *Physical flexibility* consists of extent flexibility and dynamic flexibility. Finally, *other physical abilities* that account for physical performance are body coordination, balance, and stamina. These variables together influence an individual's *motor skill,* a skill required for proper use of one's muscles. However, motor skill also depends upon the proper functioning of the brain, skeleton, joints, and nervous system.

INDIVIDUAL COGNITIVE ABILITIES

Cognitive Abilities are characterised by the variables *general intelligence*, *cognitive capacity*, *cognitive complexity*, and *cognitive flexibility*.

General Intelligence is composed of a number of distinct factors. A most frequently used intelligence model suggests seven so-called "primary mental abilities" (tracing back to the work by Thurstone, 1938; see also Dunnette, 1976). These mental abilities include number aptitude, verbal comprehension, perceptual speed, inductive reasoning, deductive reasoning, spatial visualization, and memory. *Cognitive capacity* refers to the amount of information the human brain can hold and process within a given time (Simon, 1982). *Cognitive complexity* is the degree to which a person is able to differentiate cognitive elements, and the degree to which these elements can be integrated or related to each other (Van Hiel & Mervielde, 2003). *Cognitive flexibility* involves the willingness and ability of an individual to change their understanding of a situation when confronted with information that apparently contradicts their current understanding of the situation.

PERSONALITY AND VALUES

Variables that describe an individual's personality and values include personality traits, styles referring to an individual's approach to process information, and values held by an individual. The literature proves that these variables are crucial for information processing and decision processes. Personality factors and styles as well as personally held values are typically quite constant for a specific individual and can hardly be changed, and if they change only very slowly.

The psychological research literature contains a large number of personality theories, each having its own set of different personality dimensions. For the purpose at hand, the most useful personality theory refers to the "Big Five" model (e.g. McCrae & Costa, 1987; 2004), which is well validated and known for its high relevance in the field of performance (e.g. Judge & Bono, 2001; Salgado, 1998; Barrick & Mount, 1991; Hough, 1992; Tett, Jackson & Rothstein, 1991; Socan & Bucik, 1998; Spector, Schneider & Vance, 2000; Lauriola & Levin, 2001a, 2001b; Rose, Murphy, Byard & Nikzad, 2002; Ross, Rausch & Canada, 2003). The Big Five model contains five personality traits.

- *Emotional stability*: the opposite of the trait *Neuroticism,* which is more frequently discussed in the literature, characterised by nervousness, tenseness, moodiness, and temperamentality.
- *Conscientiousness:* characterised by organisation, thoroughness, reliability, practicality, and the absence of carelessness and negligence.

- *Agreeableness:* characterised by kindness, generosity, warmth, unselfishness, and trust.
- *Openness to experience:* characterised by imagination, curiosity, and creativity; the opposite of shallowness and imperceptiveness.
- *Extraversion* (Colman, 2001).

Extraversion (an individual's style to interact with their environment, characterised by awareness and reliance on the environment for stimulation and guidance, an action-oriented, sometimes impulsive way of meeting life, frankness, ease of communication and sociability) is also a component of the Myers-Briggs personality concept (Myers & McCaulley, 1992), together with its constituent dimensions.

- Sensing vs. Intuition: sensing refers to perceptions observable by way of the senses; intuition refers to the perception of possibilities, meanings, and relationships by way of insight.
- Thinking vs. Feeling: thinking is the function that links ideas together by making logical connections, it relies on principles of cause and effect and tends to be impersonal; feeling is the function by which one comes to decisions by weighing relative values and merits of the issues, it relies on an understanding of personal values and group values and is thus more subjective than thinking.
- Judging vs. Perceiving: in the perceptive attitude, a person is attuned to incoming information, in the judging attitude, a person is concerned with making decisions, seeking closure, planning operations, or organizing activities.

Furthermore, individuals differ in their Decision styles (a decision style is a habitual, albeit learned, approach to effecting a choice and then acting on that choice; Connor & Becker, 2003) in that they tend to decide:

- Analytically (high ambiguity tolerance, orientation to task and technical concerns; performance is achieved by analysis, planning, forecasting);
- Behaviourally (low ambiguity tolerance, orientation to people and social concerns; performance comes from focusing on people and their needs);
- Conceptually (high ambiguity tolerance, orientation to people and social concerns; performance is achieved by exploring new options, forming new strategies, being creative, and taking risks); or
- In a directive way (low ambiguity tolerance, focus on task and technical concerns; implementation of operational objectives in a systematic and efficient way).

An individual's Problem solving style may be either divergent, which means that a large number of potential solutions are produced for a specified problem, thereby often generating novel ideas and solutions, or convergent, in that information and knowledge focussed on a single solution to a problem are brought together or synthesized (Reber, 1995).

Ambiguity tolerance refers to the degree to which one is able to tolerate lack of clarity in a situation or stimulus (Reber, 1995).

The greater an individual's *field dependence*, the harder he/she will find it to differentiate perceptual and other experiences from their backgrounds or contexts (Colman, 2001).

Impulsivity is the tendency to respond spontaneously without deliberation, especially in situations of uncertainty, whereas the opposite, reflectivity, refers to the tendency to consider *deliberate* over *alternative* solutions to problems (Colman, 2001).

Levelling is the tendency to smooth over the unusual, irregular, or novel aspects of a situation or an event such that details are glossed over and that a homogeneous, less incongruous version ends up in memory than what was objectively presented. The reverse tendency is sharpening, in which details are (over-)emphasized and accentuated (Reber, 1995).

Locus of control (LOC) is an attribute characterised by the expectancy about the relationship between behaviour and its consequences. Individuals with internal LOC tend to expect reinforcements to be the consequences of their own efforts or behaviour; people with external LOC expect them to be the consequences of chance, luck, fate, or the actions of powerful others (Colman, 2001).

Relation to environment refers to an individual's style of interacting with their social environment; the ends of the continuum are "desire to control the environment" and "willingness to adapt to the environment."

Repression is a characteristic mode of reacting to threatening stimuli or ideas. Repressors tend to react by blocking, denial, and repression whereas sensitizers tend to react by approaching, facilitating, and increasing vigilance, i.e. confronting the threatening stimuli directly (Colman, 2001).

Risk propensity is an individual's natural inclination or preference for being exposed to possible harm or loss.

Role of emotion ranges from "neutral interactions" to "emotional interactions." "Neutral interactions" refer to the assumption that it is not appropriate to express emotions in social interactions; "emotional interactions" refer to the assumption that it is appropriate to express emotions in social interactions.

Self-efficacy is an individual's sense of their abilities, of their capacity to deal with the particular sets of conditions that life puts before them.

Self-esteem can be understood as a situation-unspecific generalization of situation- or task-specific self-efficacy and is defined as an individual's evaluation of him- or herself (Reber, 1995).

Trust propensity refers to the extent to which an individual is basically willing to rely on others (subordinate, superior, peers) and to be vulnerable to the consequences of their actions.

Willingness to interact refers to the disposed or inclined willingness to act on others.

Personal values are closely linked to an individual's personality and exert a significant impact on the individual's attitudes, intentions, and actual behaviours. A number of highly relevant values have been identified by extensive research (cf. Hofstede, 1980, 1991). The personal values included in the model are:

- Individualism (the extent to which a person perceives himself/herself as independent from others and their attitudes and opinions);
- Power distance (the degree to which one accepts that power is distributed unequally);
- Temporal orientation (the orientation towards future rewards, as opposed to short-term orientation which stands for fostering of virtues related to the past and present);
- Achievement orientation (preference of values such as assertiveness, the acquisition of money and material goods, and competition); and
- Nurturing (orientation toward relationships and concern for the welfare of others).

VARIABLES: INDIVIDUAL STATE/DYNAMICS

As opposed to the variables that characterise and describe an individual's personality and values, the values of variables related to dynamic human factors determine an individual's state and depend largely on the situational context, and thus are subject to permanent change. Also, they can be influenced more easily by leadership and understanding. The following dynamic human factors have been found to be highly relevant in the context at hand.

Blood-sugar level is the level of blood glucose. Too high a blood sugar level leads to hyperglycaemia, whereas too low a blood sugar leads to hypoglycaemia.

Physical health is the ability to cope with everyday activities, the state of fitness and well being, and the absence of illness.

Sleep deprivation refers to the condition of being deprived of sleep either under experimental or unusual real-life conditions.

Alertness is a state characterised by the preparedness to recognize and to react to stimuli. It can be differentiated into continuous alertness (the selective recognition of and reaction to continuously or frequently occurring stimuli) and vigilance (the recognition of and reaction to irregularly and infrequently occurring events).

Stress level is the extent to which an individual experiences psychological and physical strain or tension that has been generated by physical, emotional, social, economic, or occupational circumstances, events, or experiences that are difficult to manage or endure (Colman, 2001).

Anxiety is an affective state characterised by apprehension, dread, distress, and uneasiness (Reber, 1995).

Mental Health is the state of well being in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community (WHO, 2001).

Mood refers to a relatively short-lived, low-intensity emotional state (Reber, 1995).

Motivation involves the driving forces responsible for the initiation, persistence, direction, and vigour of goal-directed behaviour, including biological drives, e.g. hunger, thirst, sex, self preservation, and social forms of motivation, e.g. need for achievement or need for affiliation (Colman, 2001).

Trust describes the extent to which an individual relies on specified others, e.g. subordinates, superiors, peers, and is prepared to make him or herself vulnerable to the consequences of their actions (Mayer, Davis & Schoorman, 1995).

Commitment/Loyalty is the degree to which an individual identifies with their organisation or group and its goals and wishes to maintain membership (Robbins, 2003).

Position-based power refers to the extent of an individual's legal power based on their holding a position of authority (Robbins, 2003).

VARIABLES: INDIVIDUAL BEHAVIOURS

Variables that characterise and describe an individual's behaviours result to a large extent from dynamic factors, personality variables, values as well as cognitive and physical abilities, leadership, and training. Identified as particularly relevant, the following variables were included in the model.

Memory performance is the correctness and extent of recall of cognitive contents previously encoded.

Speed of response refers to the speed with which an individual reacts to a cue and with which a person completes a response following response initiation (Luciano, Wright, Geffen, Geffen, Smith & Martin, 2004).

Risk taking is the degree to which an individual willingly undertakes actions that involve a significant degree of risk (Reber, 1995).

Self-monitoring describes self-observation and control of one's expressive behaviour and self-presentation (Colman, 2001).

Adaptive behaviour refers to any process whereby behaviour or subjective experience alters to fit in with a changed environment or circumstances or in response to social pressure (Colman, 2001).

Conformity is the tendency to attempt to act in ways consistent with the majority (Reber, 1995).

Cooperative behaviour is in effect when individuals work in common with commonly agreed-upon goals and possibly methods, instead of working separately in competition (Wikipedia Dictionary, 2005).

Extra-role behaviour involves activities that are essential for organisational effectiveness but are discretionary in nature, e.g. acting courteously and helping others (Becker & Kernan, 2003).

Chapter 6 – TEAM CHARACTERISTICS AND BEHAVIOURS

This chapter addresses Team Characteristics and Behaviours in the context of the sensemaking processes associated with C2, as depicted in Figure 6-1.

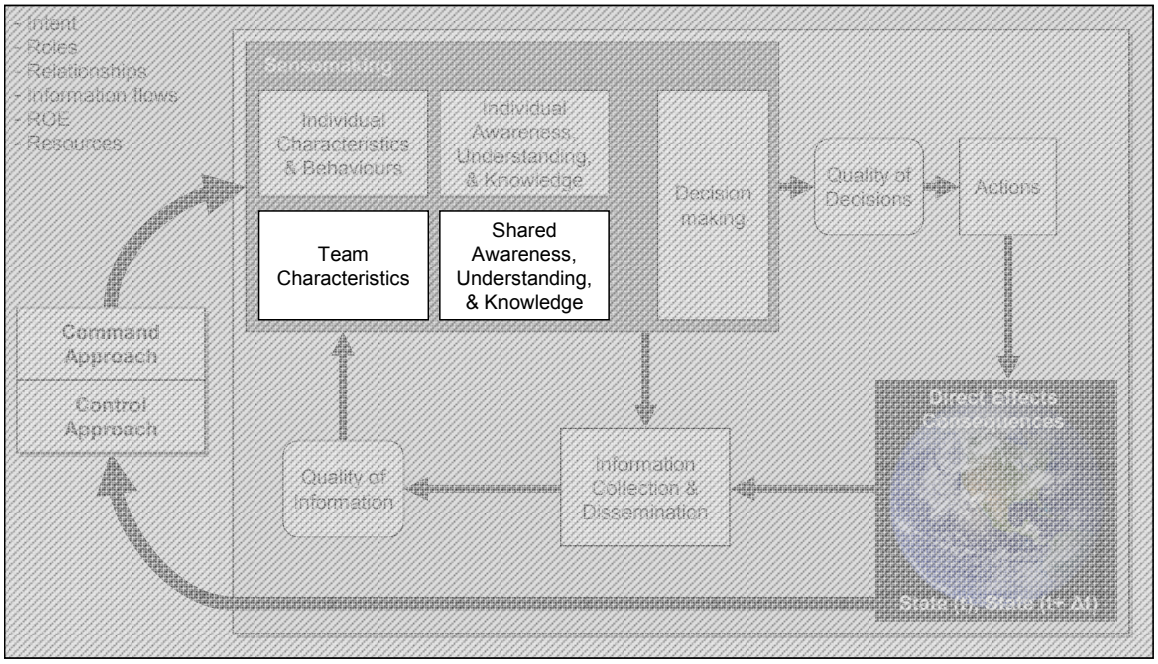

Figure 6-1: Overview of C2 Model Highlighting Team Characteristics and Behaviours.

The discussion begins with "The Team Space," the nature of groups of individuals as a function of scale, persistence, and cohesion. It then addresses team-specific characteristics including Team Structure, Dynamics, and Culture. This chapter next addresses the team counterparts of individual information, awareness, and understanding: shared information, shared awareness, and shared understanding. The chapter concludes with a discussion of the fields of study that are useful in developing and understanding team characteristics and behaviours.

THE TEAM SPACE

As it is meant to support the instantiation of conceptual models of Command and Control for any one of the known C2 concepts, and on all levels of scale (see Grisogono: Criteria for a good model), the team definitions found in organisational psychology literature must be expanded to fit the scope of the Reference Model.

Kreitner et al. (1999) define a team as a "small group with complementary skills who hold themselves accountable for common purpose, goals, and approach." Other definitions stress the synergy aspect of teamwork, considering a team as a group of people whose individual efforts result in a (synergistic) work performance that is greater than the sum of the individual contributions. In contrast, in a work group, members interact to share information and make decisions to help each group member perform within his/her area of

responsibility whereby the performance cannot be expected to reflect more than the sum of the efforts of the individual group members.

Contrary to these definitions that imply, either explicitly or implicitly, that teams and groups are small in terms of the number of members and differ mainly by the degree and type of cooperation of their members, it is proposed to apply the term *team* in a more comprehensive sense and distinguish among team types by means of appropriate attributes. Also, in military organisations the term *team members* may also apply to aggregations of individuals. Figure 6-2 shows where military teams are located in the three dimensional team space spanned by the variables persistence, cohesion, and scale.

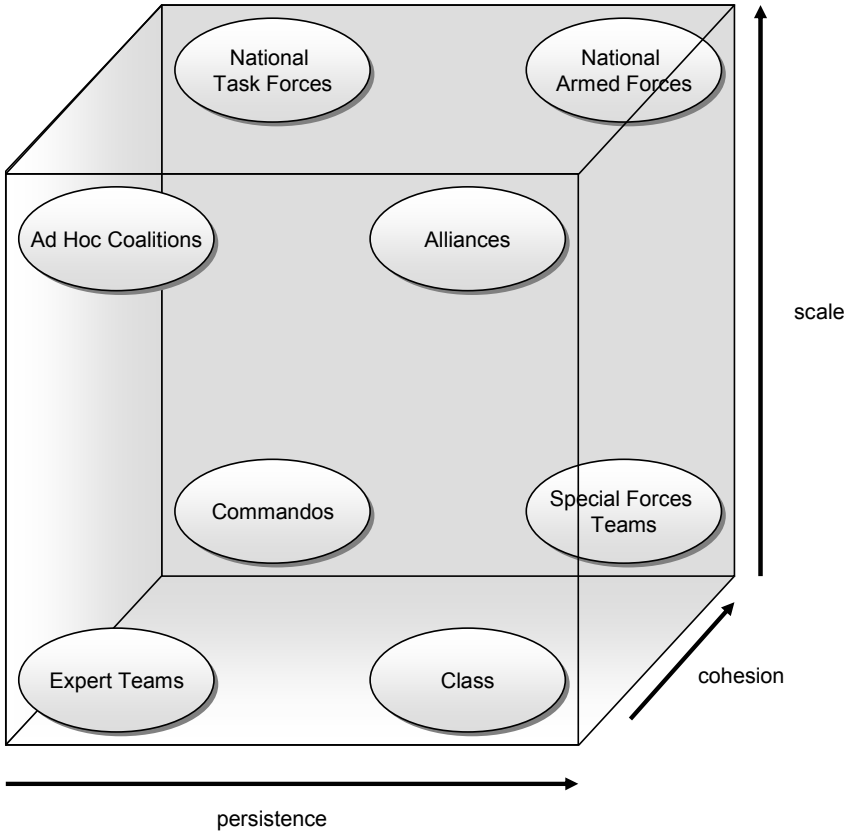

Figure 6-2: Team Space.

Some Team examples:

National armed forces represent permanent institutions (high persistence) of relatively large size (scale), characterised by common goals and purpose as well as unity of command (high degree of cohesion).

National task forces may be large in scale and need to have a high degree of cohesion, but are normally of low persistence due to the temporary nature of the task assigned to them.

Alliance forces are similar to national armed forces with regard to persistence and scale. However, cohesion is more or less limited depending mainly on cultural and doctrinal differences, and sometimes on political differences among allies as well.

Ad hoc coalitions may be large in scale, formed for a mission of limited duration (small persistence) from militaries of several nations with different military cultures, and not experienced in combined operations (little operational cohesion).

Expert teams are small, composed of experts from different domains (little cohesion) and interacting temporarily to find solutions to a complex problem.

Commandos are a kind of military expert team, however, with a high degree of cohesion by virtue of common purpose and mutual interdependence in accomplishing high risk assignments.

Special forces teams are dedicated to specialized missions requiring intensive training and experience, must be formed permanently, and must have a high degree of cohesion for the same reasons as for commandos.

Class XX, such as the graduating class *XX* from a General Staff College, persists as a virtual team or network with low physical cohesion throughout the careers of its members.

TEAM CHARACTERISTICS

The concept of Team Characteristics pertains to variables that are specific attributes of teams of interacting individuals and includes:

- Team structure;
- Team dynamics; and
- Culture.

Team structure and dynamics taken together comprise team characteristics. Table 6-1 lists the variables included in the team characteristics and culture.

Table 6-1: Team Characteristics and Culture

Team Characteristics	Culture
Homogeneity	Individualism
Interdependence	Power distance
Team shape	Temporal orientation
Team scale	Uncertainty avoidance
Role clarity	Achievement orientation
Hardness	Nurturing orientation
Goal consistency	Norm strength
Persistence	Source of status
Intra-group conflict	
Cohesion	
Group pressure	

The composite variable “Team Characteristics” refers to the organisational and functional design of teams and their composition. It includes the following eight variables:

Goal Consistency is described as the consistency among the purposes for which resources are expended in order to achieve a desired objective or end-state (Merriam-Webster, 1986).

Homogeneity refers to the consistency of attitudes, values, and beliefs among members of a team.

Interdependence is the degree to which team members have to rely on each other.

Team Shape (Robbins, 2003) is a basic category of organisational structure that is generally described in terms of work specialisation (the degree to which tasks in the team are subdivided into separate jobs), span of control (the number of subordinates a manager can efficiently and effectively direct), centralisation (the degree to which decisionmaking is concentrated at a single point in the team), formalisation (the degree to which jobs within the organisation are standardized), and communication network complexity (the proportion of accessible interpersonal communication links of the overall number of possible links between two individuals of a team).

Team Scale describes the number of individuals in a team who interact dynamically, interdependently, and adaptively toward a common and valued goal.

Role Clarity refers to the unambiguous knowledge of what tasks an individual and the other team members have been assigned and are expected to accomplish.

Hardness refers to the fact that as participants develop stronger relationships with each other through repeated or continued team interaction, the links between the participants become stronger (Perry, Boob & Signori, 2004).

Persistence refers to a team's existing for a long time or continuously (Merriam-Webster, 1986).

Intra-Group Conflict is characterised by disagreement among team members about task content, different viewpoints, ideas, opinions, values ("task conflict"), and/or interpersonal incompatibilities, including tension, animosity, and annoyance ("relationship conflict," Jehn, 1995).

Cohesion is the degree to which group members are attracted to each other and motivated to stay in the group (Robbins, 2003).

Group Pressure refers to the degree to which team members exercise force on each other to act in unique way.

CULTURE

The composite variable "Culture" includes a number of cultural values that have been well validated in the international context (Hofstede, 1980, 1991). As attributes of a society, they provide a cultural frame for socialisation of individuals, as well as for the organisational cultures of institutions, forces, and enterprises and impact on their approaches to design organisational structures, processes, and Command and Control approaches, and to put leadership and guidelines for collaboration into effect. The culture variables capturing the cultural values of a society are described as follows:

Individualism is the degree to which a society encourages individuals to perceive themselves as independent from others and their attitudes and opinions, and to prefer acting as individuals rather than as group members. The opposite end of the continuum, *Collectivism*, prioritises group goals over individual interests.

Power Distance refers to the degree to which a society considers it acceptable that power in institutions and organisations is distributed unequally.

Temporal Orientation is characteristic of a society that focuses on future rewards, as opposed to *Short-Term Orientation*, which stands for fostering of virtues related to the past and present.

Uncertainty Avoidance is the extent to which it is common in a society to feel threatened by uncertain and ambiguous situations and to try to avoid them. Uncertainty avoidance encourages a preference of structured over unstructured situations.

Achievement Orientation is the degree to which goal accomplishment is appreciated in a society and qualities such as assertiveness, the acquisition of money and material goods, and competition are valued.

Nurturing Orientation characterises a society that values the development of satisfactory interpersonal relationships and showing concern for the welfare of others.

Source of Status refers to whether individuals are assigned a high status through achievement or through their formal position or rank.

Norm Strength is the degree to which it is expected that team or society members comply with a generally accepted standard of behaviour.

SHARED INFORMATION, AWARENESS, AND UNDERSTANDING

The concepts of shared information, shared awareness, and shared understanding are key to the C2 Conceptual Model. These concepts are performance properties of a team or group of individuals at a given point in time. Operationally defining these requires that one construct some function of all of the individual states of information, awareness, and understanding. The function selected needs to take into consideration the "qualifiers" depicted in Figure 6-3.

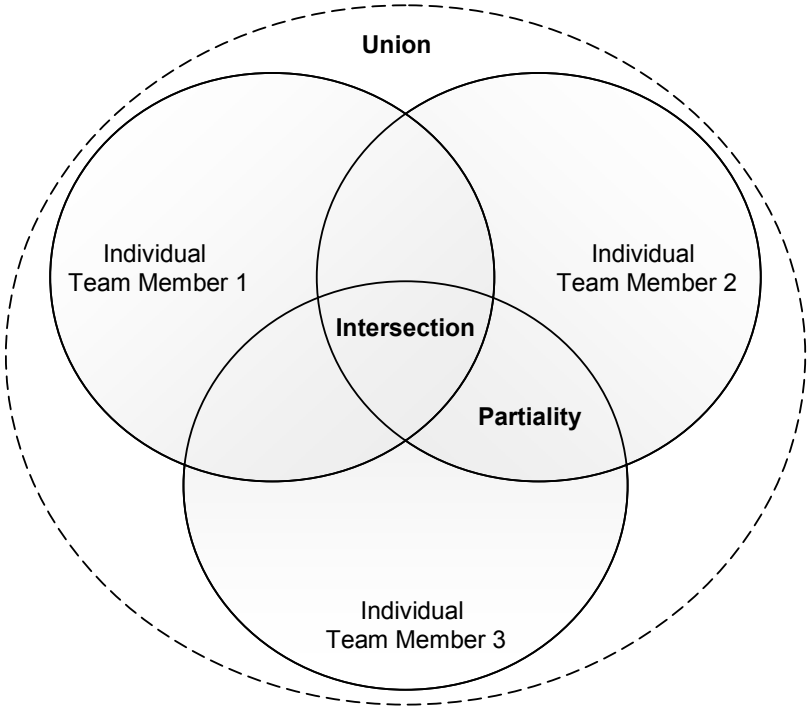

Figure 6-3: Qualifiers.

Union refers to the sum of all elements held by any actor within a team.

Partiality refers to the elements commonly held by two or more actors within a team.

Intersection refers to the elements commonly held by all individual actors within a team.

In order to illustrate the application of these qualifiers, Figure 6-4a depicts a snapshot of a local situation as it may have evolved during the simulation using the agent-based model PAX (see Chapter 10-7: Example Applications) of a typical peace support mission in which three Blue actors (A, B, C) are tasked to monitor Green actors suspected to be terrorists. The circles around A and B, and the partly blocked circle around C indicate the *individual* awareness of each of the participants. Figures 6-4b through 6-4d show the situational awareness of (the number of) Green actors when applying the three qualifiers. *Union* implies that all of the ten Green actors are in the field of vision of any Blue actor, *Partiality* implies that three actors are in the intersection of the fields of vision of actors A and B, and *Intersection implies* that one Green actor is in the field of vision of all three Blue actors.

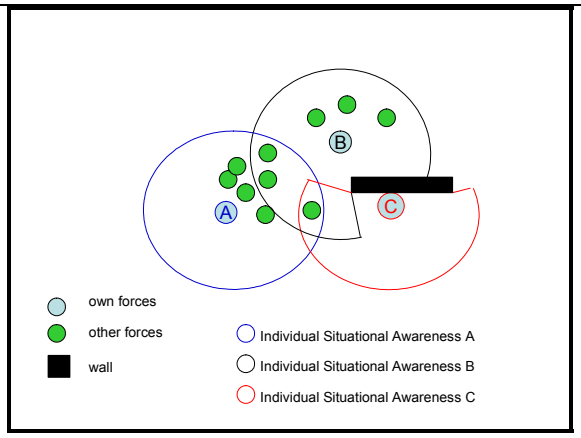

Figure 6-4a: Showing Individual Situation Awareness of A, B, and C.

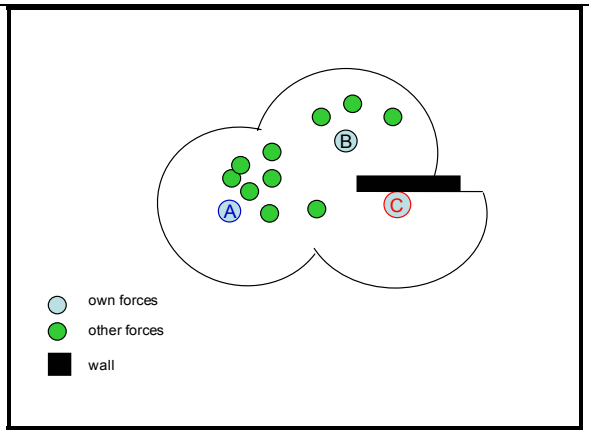

Figure 6-4b: Union of Situational Awareness of the Team Comprising A, B and C.

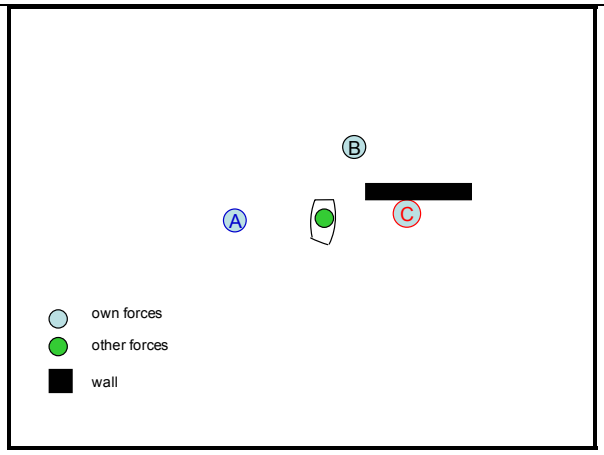

Figure 6-4c: Intersection of Situational Awareness of the Team Comprising A, B and C.

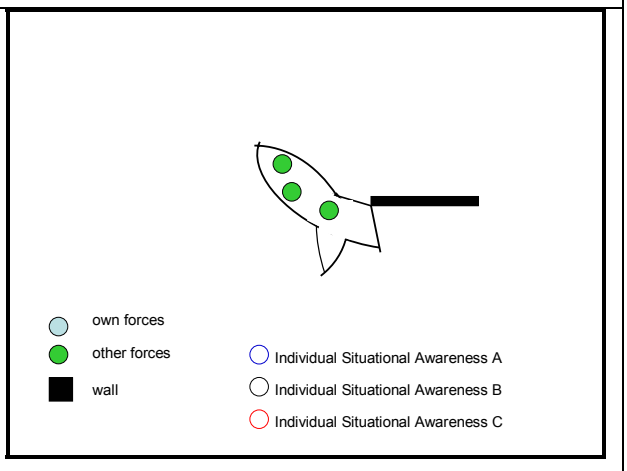

Figure 6-4d: Partiality of Situational Awareness of the Team Comprising A, B and C.

Figure 6-4: Snapshot of PSO Scenario Indicating Variations in Situational Awareness.

This example illustrates the principal benefit of sharing information among team members, and how SAS-050 has not developed a one-size-fits-all function that translates individual awareness, understanding, or information into shared awareness, understanding, or information respectively. However, due to the limitations in the fields of vision of team members, situational awareness of the team may differ significantly depending on the degree to which awareness can or needs to be shared by team members.

SCIENCE DOMAINS OF INTEREST

The study of variables for describing human characteristics and behaviour, and the relationships between them, is a prime object of human and organisational science research. Figure 6-5 presents an overview of the principal scientific disciplines that are of interest to those trying to characterise and understand individual and team behaviours.

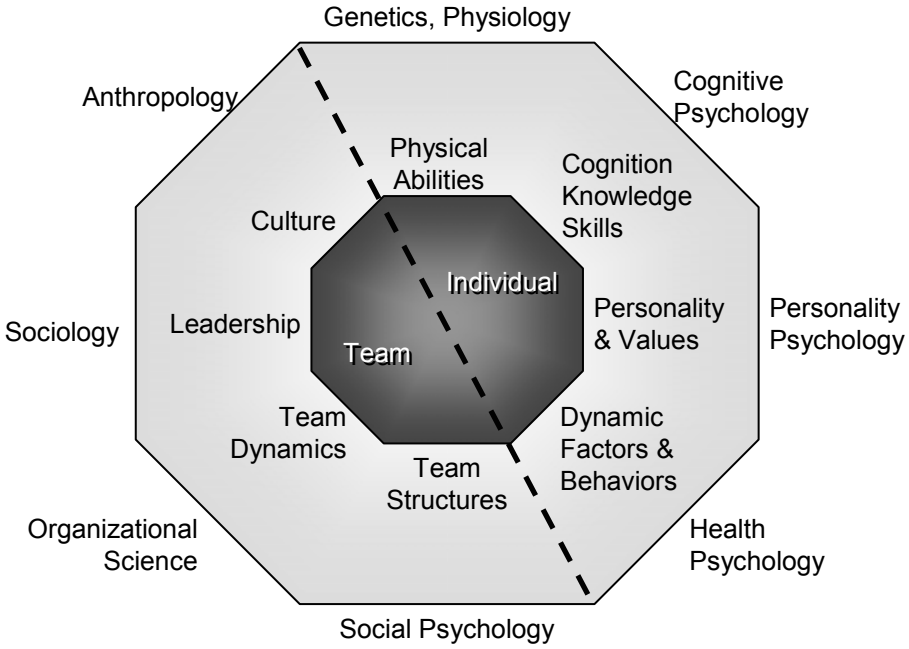

Figure 6-5: ITCB-Related Science Domains.

Chapter 7 – ACTIONS, EFFECTS, AND CONSEQUENCES

INTRODUCTION

This chapter discusses those areas of the Reference Model covering Actions and their effects and consequences on the variables in the State(t). These areas are highlighted below in Figure 7-1.

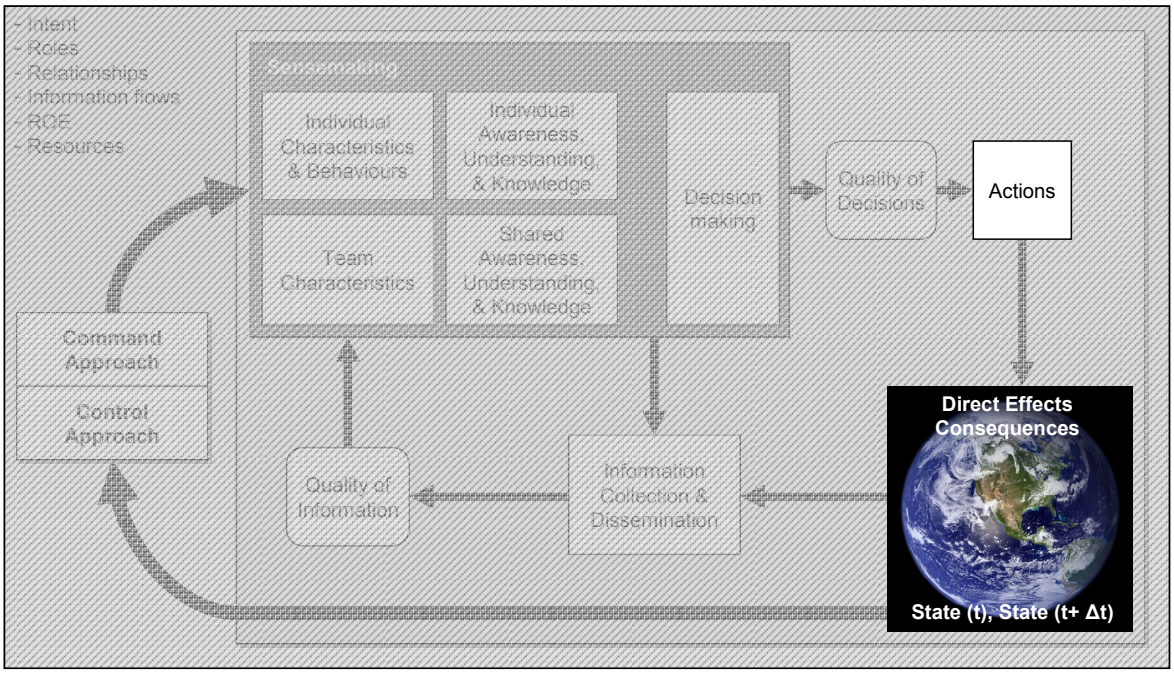

Figure 7-1: Overview of C2 Reference Model Highlighting Actions.

Because the main focus of the SAS-050 work was to develop the C2 aspects of the model, this area is less well developed than the rest. Also, because the C2 Conceptual Model is intended to be generic across different types of activity and context, it has not been appropriate to become too specific in the declaration and connection of actions and their effects or consequences.

The basic building blocks of the model are generic and applicable on all levels of scale. However, the focus of the effort was on the mission and force levels. In the development of the C2 Conceptual Model, it was conceived that C2 activities could be considered as the mechanisms by which the actions of a force are directed to fulfil a plan or satisfy intent. The variables listed under the heading "Actions" are:

Action Accuracy: Extent to which actions executed are directed to the intended purpose.

Action Completeness: Extent to which actions executed encompass the full scope of the plan or order.

Action Consistency: Extent to which actions executed are consistent with actions in an earlier timeframe.

Action Correctness: Extent to which actions are executed without error.

Action Precision: Extent to which actions executed are precisely related to the intended purpose.

Action Timeliness: Extent to which actions are executed at the time required by the plan or order (in the case of self-synchronizing forces the "plan" could be an ad hoc arrangement between peers).

Action Appropriateness: Extent to which actions executed are the appropriate ones to achieve the intended purpose.

Action Efficiency: Extent to which actions executed are efficient in the use of resources.

Action Synchronization: Purposeful arrangement of actions in time, space, and function.

Likelihood of Success: Probability of mission accomplishment.

These variables represent qualities of action and as such are called out in the Value View described in Chapter 8.

The direct effects and consequences of actions are represented in the C2 Reference Model in two ways. Firstly, actions may create a change in the state of the Situation in which C2 is operating and, secondly, they may create changes in the state of the Force under command. Variables describing each of these action impact areas are listed under the State(t) heading (the '(t)' included to indicate the temporal dynamic nature of action and effects, which needs to be properly handled in any case-specific instantiation using the Reference Model as an input).

LINKS INTO (AND OUT OF) ACTION VARIABLES

The details of links to action variables can be found in Chapter 10-3. In general, the Action variables are influenced by Decision variables, which, in turn, are affected by variables from the Information, ITCB, and Knowledge areas. Action variables influence the Likelihood of Success variable, which is defined as the probability of mission success.

Because the Action variables are generic, without implication of the nature or target of the Action, it is not possible to express in the Reference Model explicit links from Actions to Effects, or to identify specific effect variables. However, such connections and identifications need to be made in any case-specific instantiation of a conceptual model based on the C2 Reference Model.

For example, the State(t) area contains variables labelled "Friendly Forces," "Enemy Forces," and "Neutral Forces." Depending upon the nature of the actions taken at a specific time and by a specific agent within a particular case study, these variables will need to be replaced by more specific variables representing the critical aspects of how the forces under study impact other forces and actors.

Chapter 8 – THE VALUE VIEW

INTRODUCTION

The *NATO Code of Best Practice for the C2 Assessment* (Chapter 5, Measures of Merit) states that "the benefits of C2 should be evaluated through their impact on the fulfilment of the military and policy objectives, and the impact of C2 should be measured in terms of specific qualities that are relevant to these objectives." These qualities constitute the Value View; it tells us what matters. By examining the variables that comprise the Value View and the relationships between and among them, expressed in a value chain, an analysis may be made of the factors contributing to the outcome of military missions.

The Value View draws out those variables that reflect the benefits and drawbacks of various approaches to C2. Within the C2 Conceptual Model, these variables both influence and are influenced by others. These influences are what we mean when we refer to relationships between and among Value View variables.

DEFINITIONS

The following terms are important to understanding the Value View.

- *Value*: worth, usefulness, or importance (from an entity's perspective); utility or merit.
- *Value View*: a subset of variables from the Reference Model that have been selected to represent the utility of a C2 Approach.
- *Value Chain*: the relationships between and among (a subset of) the variables in the Value View.
- *Measures of Merit*: degree or grade of excellence; expressed in terms of performance or effectiveness.
- *Measures of Agility*: the ability to be robust, flexible, responsive, innovative, resilient, and adaptive. Characterised by quickness, lightness, ease of movement; nimble; Agile C2 individuals, organisations, C2 systems, and forces have a synergistic combination of the above six attributes, the key dimensions of agility.
- *Composite Variable*: a group of related variables representing a higher level concept. For instance, the quality of information (composite variable) consists of a number of variables such as the accuracy or completeness of that information.

MEASURES OF MERIT

The NATO COBP presents the five-level hierarchy of Measures of Merit depicted in Table 8-1.[1]

[1] NATO Code of Best Practice. p. 92.

Table 8-1: Measures of Effectiveness Categories

Measures of Policy Effectiveness	The degree of success in influencing and determining decisions, actions, and other matters as related to societal and policy outcomes.
Measures of Force Effectiveness	The extent to which military missions are accomplished.
Measures of C2 Effectiveness	Impact of C2 systems within the operational context.
Measures of System Performance	Internal system structure, characteristics, and behaviour.
Dimensional Parameters	Properties and characteristics inherent in the physical C2 systems.

MEASURES OF AGILITY

In addition to Measures of Merit, SAS-050 explicitly considered agility as it applied to:

- Force;
- Command and Control; and
- Organisation.

Each of these aspects of agility has the following attributes:

Table 8-2: Measures of Agility Variables[2]

Adaptiveness	The ability to change work processes and the ability to change the organisation.
Flexibility	The ability to employ multiple ways to succeed and the capacity to move seamlessly between them.
Innovation	The ability to do new things and old things in new ways.
Resilience	The ability to recover from or adjust to misfortune, or a destabilizing perturbation in the environment.
Responsiveness	The ability to react to a change in the environment in a timely manner.
Robustness	The ability to maintain effectiveness across a range of tasks, situations, and conditions.

VALUE CHAIN'S COMPOSITE LEVEL

Figure 8-1 depicts a value chain that includes Qualities of Information, Knowledge/Mental Models, Awareness, Understanding, Decisions, and Execution.

[2] Alberts and Hayes, Power to the Edge. pp. 127-128.

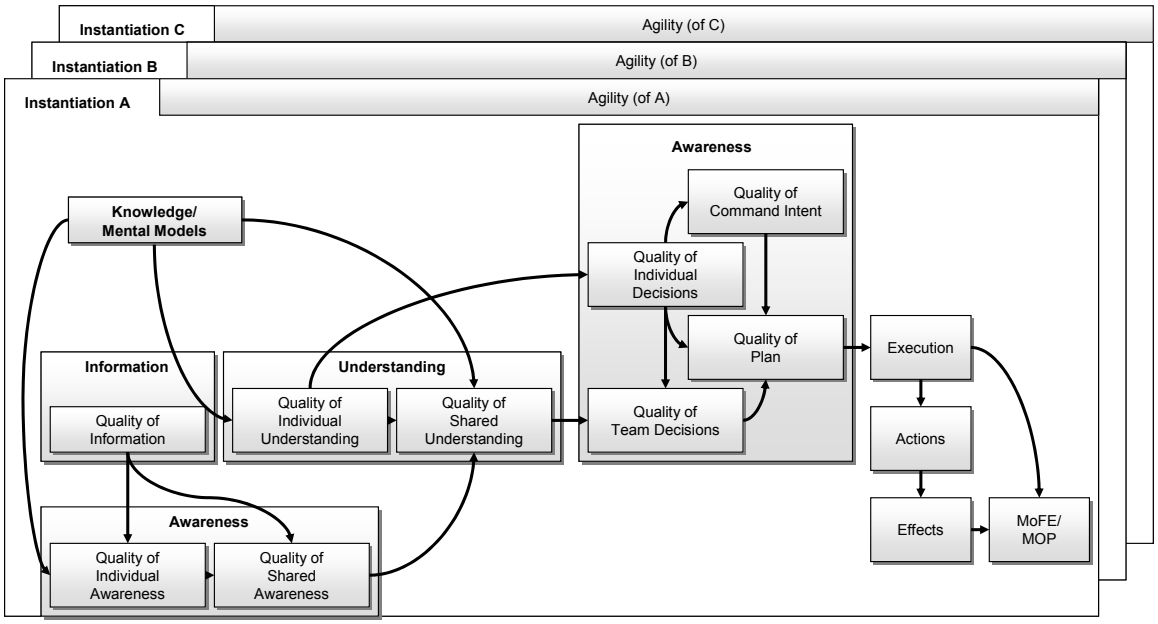

Figure 8-1: The Value View.

ATTRIBUTES OF VALUE RELATED VARIABLES

Value View variables usually have the following attributes:

- *Accuracy*: the degree to which information quality matches what is needed; conformity to fact; the ability of a measurement to match the actual value of the quantity being measured.
- *Completeness*: the state of being entirely whole.
- *Confidence*: trust or faith in a person or thing; a feeling of assurance; the state or quality of being certain.
- *Currency*: time lag.
- *Correctness*: freedom from error.
- *Consistency*: the agreement or logical coherence among things or parts.
- *Precision*: level of granularity.
- *Relevance*: pertinence to the matter at hand.
- *Timeliness*: the extent to which currency is suitable for use.
- *Uncertainty*: not being able to know or predict something.

Some of these are independent of a situation (e.g., currency) while others are in the context of a situation (e.g., timeliness).

All of the quality variables take on the nine attributes above. Many of these variables are illustrated in other chapters throughout this report as indicated below. The quality variables include:

- Quality of Information (Chapter 4)
- Quality of Shared Information (Chapter 4)
- Quality of Plan (Chapter 5)
- Quality of Awareness (Chapter 5)
- Quality of Shared Awareness (Chapter 5)
- Quality of Understanding (Chapter 5)
- Quality of Shared Understanding (Chapter 5)
- Quality of Actions (Chapter 7)
- Quality of Decisions

Quality of Decisions is characterised by variables representing *accuracy, completeness, consistency, correctness, currency, precision, relevance, timeliness,* and *uncertainty*. Collaboration and understanding influence the decision variables, while the decision variables themselves influence quality of command intent and action variables.

SUMMARY

The Value View consists of a set of variables that constitute the C2 Value Chain and serve as a checklist that can be used to identify those most relevant.

Analysts need to take the Value View from the conceptual model and instantiate it in a manner appropriate to the problem to be solved. This instantiation will involve the identification and selection of pertinent variables.

Chapter 9 – GUIDELINES FOR USE

The CM is a set of variables and relationships that represent influences between the variables. In order to carry out the study of a particular C2 concept, there is first a need to instantiate the model so as to capture the factors that contribute to the targeted C2-related outcomes. In some cases, this might be sufficient, but in others there will be a need to develop a more fully formed instantiation of the model.

There are two potential ways to exploit the richness of the CM. In the first case, we start with a customer's problem and then trace this back to the controllable variables in order to understand what the influencing factors are. In the second case, we might want to follow through the effects of a particular intervention from changing a variable to the propagation of this change through other linked variables.

The user of the CM should start by selecting the variables of interest (primary variables) for the study. Then, the user must look at the variables that influence the primary variables by following the relationships in the CM. Not all of these will be relevant for the particular study, but the user should consider each of them carefully as part of the problem formulation process, development of the human and organisational issues, development of the measures of merit, and assessment of risk for the study. The interrelation of these factors is described in the *NATO Code of Best Practice for C2 Assessment* as shown in Figure 9-1.

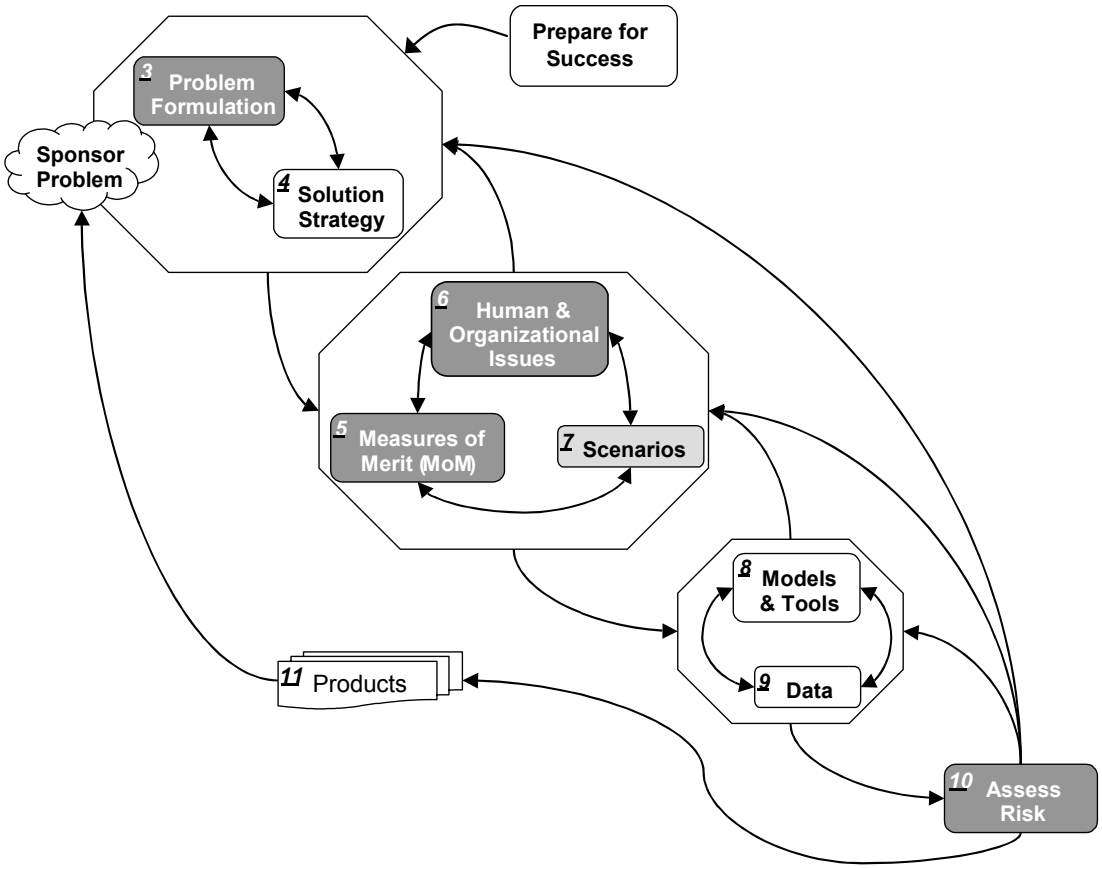

Figure 9-1: Top Level View of COBP for C2 Assessment.

In the first case, the steps Problem Formulation, Human and Organisational Issues, and Measures of Merit are particularly relevant.

PROBLEM FORMULATION

In terms of selecting the primary variables, the user should follow the first stages of the problem formulation process. This involves:

- Identifying the high level measures of merit relevant to the customer's problem;
- Identifying the variables that influence these high level MoMs;
- Determining which of them are controllable and uncontrollable; and
- Determining the primary variables of interest.

In general, this will be an iterative process that should involve close interaction with the customer in order to get to the real issues.

HUMAN AND ORGANISATIONAL ISSUES

The CM contains a rich set of variables describing behaviours and characteristics of individuals and teams. This part of the CM is developed in more detail than other parts because it was recognized to be an important area for current and future C2 concepts and assessments that had not been well represented. The user is encouraged to consider this in detail particularly for analysis where human performance and team behaviour are influencing the overall effectiveness of the system.

MEASURES OF MERIT

Development of the MoM should start with creation of high level MoM as part of the problem formulation process. Subsidiary MoMs should then be created during further iterations of problem formulation. The CM in conjunction with the COBP provides a rich set of potential MoMs from which to choose for the particular instantiation. The CM extends the COBP by briefly discussing the concept of agility, which is particularly important for future scenarios that have rapid dynamic change.

In the second case, the Assessment of Risks is particularly relevant.

ASSESSMENT OF RISKS

Here we are particularly interested in the effects of an intervention through the changing of a specific variable. The CM helps us by looking at the variables dependent on that intervention variable. This results in a cascade of consequences describing the effects of the changed variable.

When instantiating this model, the user has to think about the range of the variables' values and the functional form of their relationships. For that activity, the CM provides a basis in terms of links to the relevant literature, which gives some example applications and experiences of these variables and relationships. In a particular application, there will be other influencing factors, such as time or modelled events that are important in the application and that are not part of the CM. The aim of the CM is thus to ensure that a broad potential range of factors is taken account of when developing the specific instantiation.

Chapter 10-1 – CRITERIA FOR A CONCEPTUAL MODEL OF C2

Early in its deliberations, SAS-050 developed a set of criteria to be used to judge the success of the Conceptual Model of C2 that was developed.

These criteria for success also serve other purposes. They are intended to communicate the aims of the group to a broader audience and to provide a yardstick against which to assess progress towards that vision. Furthermore, they assist in identifying where further development is needed and what directions to take. Finally, the process of developing the criteria helped the group to capture some broader issues that might have been overlooked.

The criteria are grouped into three sets. The first set addresses the scope of the Conceptual Model: what aspects should or should not be included or addressed. The second set addresses some of the essential features that the group sought to incorporate into the model, while the third set addresses a more operational view of the CM by listing some of the ways in which one would like to use it to address C2 problems.

In this section, we will introduce and discuss the success criteria in general terms. They will be used as the group's basis for validation of the model (in Chapter 10-2). They will also be used to review what the Conceptual Model has achieved and to motivate proposals for further work.

CRITERIA RELATING TO SCOPE OF THE CONCEPTUAL MODEL

The intention behind the following six criteria is to ensure that the CM will be generic enough (S1, S4) and complete enough (S2) to not only be able to instantiate known forms of C2 (S3), but to permit the conception and exploration of novel approaches to C2 in a way that respects the minimum necessary constraints (S5 and S6).

Scope

S1

S2

S3

S4

S5

S6

S1. Be applicable at (all) different levels of scale.

S2. Be applicable and relevant to different user groups (tbd).

S3. Be generic enough that the known C2 concepts can be shown to be special cases.

S4. Be comprehensive enough to include all of the known and potentially relevant phenomena and views.

S5. Be clearly anchored in reality at both "input" (what decisions actually do affect outcomes) and "output" (what are the relevant consequences of decisions that are made).

S6. Also anchor the "process" in reality (within the bounds of existing knowledge and research).

DISCUSSION AND CONSEQUENCES OF THE SCOPE CRITERIA FOR THE CM

Criterion S1 arose from the recognition that C2 was a recursive concept that could operate at every scale from individual tactical level decisionmaking to force level strategic and force-shaping planning decisions. It was felt important that the Conceptual Model should not be focussed on a particular level of C2 but should be generic enough to be instantiated at the level(s) of interest.

Levels range from the individual human (soldier, seaman, airman, SF, or marine) or system (weapon, platform, sensor, etc.) through small teams (platoon, aircrew, artillery battery, etc.) through teams of teams (battalion, squadron, novel groupings such as manned-unmanned teams, etc.) up through larger groupings that may either be drawn from single service elements (e.g., Australian Army's Combined Arms Team) or from joint force elements, or even more widely from coalition force elements or from both military and non-military elements. There are also multiple levels of time-scale operating simultaneously with couplings between them so that faster executing loops generate consequences that become inputs to the slower loops, while these in turn create a more slowly changing context for the faster loops. Similarly, there is a range of effects-scales (from local to global) that are partly related to the time-scales (through the rate at which effects propagate), but which could also be thought of in other terms, such as the number of people affected by the effect or its severity.

So it becomes apparent that there are several important dimensions that characterise different aspects of the C2 scale of interest, for example:

- The number of elements that are appropriate to task at that scale;
- The diversity of those elements (single service, joint, coalition, multi-agency…);
- The time-scale over which the model is being applied (which determines which feed-forward and feed-back loops are executing complete cycles within the scale being considered);
- The effects-scale that is being impacted by the decisions being made in that C2 Application; and
- The number of nested levels of detail below the scale at which we are working, etc.

Another aspect of scale is that different levels of scale do not exist independently, but are intrinsically linked through causal and influence networks propagating effects in both directions through the levels and by aggregation upwards and unpacking of detail downwards. The nature of these links and the need to have them captured by the model should be dictated by an appreciation of the applications to which the model will be put.

But as a general observation, many model applications will require the linking of model instantiations at different scales so as to allow the tracing of changes at one level through to manifested consequences at other levels, or conversely the tracing of problems manifested at one level to their contributing causes operating at different levels. So the conceptual model will need not only to be generic enough to be able to be instantiated at different scales, but also to have the means of capturing and representing such causal and influence networks operating through the levels of scale.

Criterion S2 was included to ensure that attention was paid to the eventual users of the Conceptual Model and to their needs for particular functionalities and effective user interfaces. This criterion can only be addressed when the users have been identified and prioritised, but even without known users it stands as a reminder that the CM should be able to support multiple views and tools.

Criterion S3 addresses two aspects of the generality the group has strived for in the context of the relationship between known C2 concepts and the Conceptual Model. On the one hand, recognising that familiarity with existing C2 concepts will sometimes make it difficult to separate the essential aspects of C2 from the biases and assumptions that underlie a particular concept, this criterion requires that it can be explicitly shown how known C2 concepts can be retrieved from the CM by making particular choices of CM variables. On the other hand, because the known C2 Approaches represent a wealth of valuable experience and distillation of lessons learned about C2, the generality and completeness of the CM is served by verifying that all the variables required to specify and distinguish the known C2 concepts are indeed included.

This criterion will also therefore create a set of benchmarks to calibrate the model, and the process of validation should include running some test cases of known C2 concepts such as the six in *Power to the Edge* to identify the degrees of freedom associated with each, the values they should take for each of the test concepts, and in each case, to demonstrate that the resulting instantiation does in fact exhibit the expected properties of the test concept.

Like S2, criterion S4 was included to ensure that attention was paid to areas that might have been overlooked (in this case, to various sources of C2-relevant phenomena and views), so this criterion also supports S3 in seeking to ensure completeness of the model. Obviously, this is an open-ended criterion which can never be completely satisfied because what C2-relevant phenomena and views are known is never complete either.

Criterion S5 is based on an implicit high level model of C2 about decisionmaking in a broad effects-based approach, and therefore the aspects of C2 that matter most are those that ultimately make a significant difference to the outcomes that matter. There are two parts to this: knowing about outcomes (what is required and what matters), and knowing about how various aspects of C2 affect outcomes. So to comply with this criterion, the CM should adequately address the questions of which processes and decisions to pay attention to and what variables influence them (the inputs), and what their consequences are in the outcome space (the outputs). This criterion essentially requires the CM to be adequately connected to the context within which C2 is being exercised.[1]

Specifically, the CM should be able to:

- Represent the structure and content of the space of possible futures including the effects potentially generated by each force (outputs), and also including relative values (desirable to intolerable) attributed to possible effects or outcomes; and
- Represent the structure and content of the space of decisions to be made, and identify those that are significant determinants of the outcomes and are independent of the C2 concept (i.e., inputs to the C2 process).

Compliance with this criterion requires the CM to take the form of a transformation of inputs into outputs, where both are grounded in real-world phenomena.

Similarly, criterion S6 is an extension of criterion S5 and addresses what happens between the inputs and outputs covered by S5. Specifically, this criterion requires the CM to model the transformation process in a way that respects the constraints of what is known to be possible. To assess compliance, a “reality check” of the explicit and implicit models of process in the CM should be performed by C2 and related subject matter experts. Relevant subject fields might include human factors, cognitive, and social sciences.

[1] One of the Peer Review criticisms of the CM was that the hooks were not there for the connection to the context.

CRITERIA RELATING TO FEATURES OF THE CONCEPTUAL MODEL

The next five criteria address some general requirements about clarity, transparency, consistency, efficiency, etc. that the group felt were essential for a Conceptual Model.

Features
F1
F2
F3
F4
F5

F1. Represent clearly what constitutes "success" and "failure" and thresholds of "acceptability."

F2. Make assumptions and value judgments visible and testable/explorable (including identifying weaknesses in them).

F3. Be clear about boundaries of content (what's in/out), application (where it can be used), and interactions across those boundaries (how what's in interacts with what's out).

F4. Be logically consistent (while allowing for modelling of ambiguities and inconsistencies).

F5. Variables should be as mutually exclusive and exhaustive as possible (given the complex highly interdependent nonlinear nature of the space).

DISCUSSION AND CONSEQUENCES OF THE FEATURES CRITERIA FOR THE CM

The first criterion obviously relates to the Value[2] View and requires the ability to assign value (along a continuum from success to failure, and crossing a threshold of acceptability in between) to the outcomes that are produced in the Value variables. The importance of being able to do this derives from the need to explore the consequences of different C2 Approaches in different contexts.

On the other hand, criterion F2 reminds us not to fall into the trap of assuming that assigned values are absolute.

The questions of boundaries and domains of applicability are always critical to the successful use of any model. Criterion F3 requires the CM to support the user in explicitly defining what the limits are and in considering how external influences are to be addressed.

Criterion F4 does not need much justification: inconsistencies in the CM could be problematic in many ways and at worst could render the model misleading. The consistency being referred to is of course that of the logical structure of the CM, not of the values and information taken on in any particular instantiation of the CM, which must retain the potential to display the full spectrum of complex real-world confusion.

[2] This section is really difficult to write clearly because the word "value" has several senses in this context: a label for variables that indicate how something that is appreciated is being created (Value View, value chain); the amount of a measurable variable (the resulting value of a Value variable; and the amount of appreciation attributable to something (the value of SA). So there is value in being able to articulate the value of different values that value variables can take.

Finally, criterion F5 reflects the ideal desire to find the minimal set of variables that span the space we wish to explore. Or as Einstein was alleged to have put it: "Make it as simple as possible, but no simpler."

CRITERIA RELATING TO THE USES OF THE CONCEPTUAL MODEL

These next thirteen criteria are arguably the most important criteria because they describe in detail how the model is envisioned to be applied and therefore they dictate the functional aspects of the model that will be needed to deliver successfully on these uses.

U1. Represent clearly and support the testing and refinement of our understanding of causal and influential relationships between variables.

U2. Lead to a generic framework of metrics (which should relate independent system measures to dependent outcome measures).

U3. Identify the natural modes at all levels (e.g., attractors or stable regions) of the hyper-dimensional space of variables in which the system operates.

U4. Identify the resulting emergent properties at all levels (including the force and policy levels).

U5. Suggest points of influence / pressure points that may affect the -ve (control) and +ve (growth) loops operating to help manage:

- Overall effectiveness;
- Congruence of objectives and intent;
- Synergy of effects and tempo;
- Suppression of unwanted effects;
- All costs and benefits;
- Risk;
- Robustness;
- Sustainability; and
- Adaptation (e.g., learning, agility, flexibility, adaptive evolution of capability).

U6. Help in rapid generation and evaluation of ideas.

U7. Help us reason about conditions or indicators under which particular C2 concepts are more or less applicable.

U8. Help us understand how much is "enough" for enabling properties, and how they are interdependent.

U9. Discover/identify correlations between and among variables.

U10. Support analysis of vulnerabilities and failure modes.

U11. Perform Balance of Investment studies.

U12. Identify important gaps in knowledge and data to be prioritised in further research and experimentation.

U13. Generate customised views for specialist audiences.

These criteria fall naturally into four groups, and the four groups themselves also have a logical relationship building towards our goal of improving overall effectiveness through better C2 effectiveness, as shown in Figures 10-1.1 and 10-1.2.

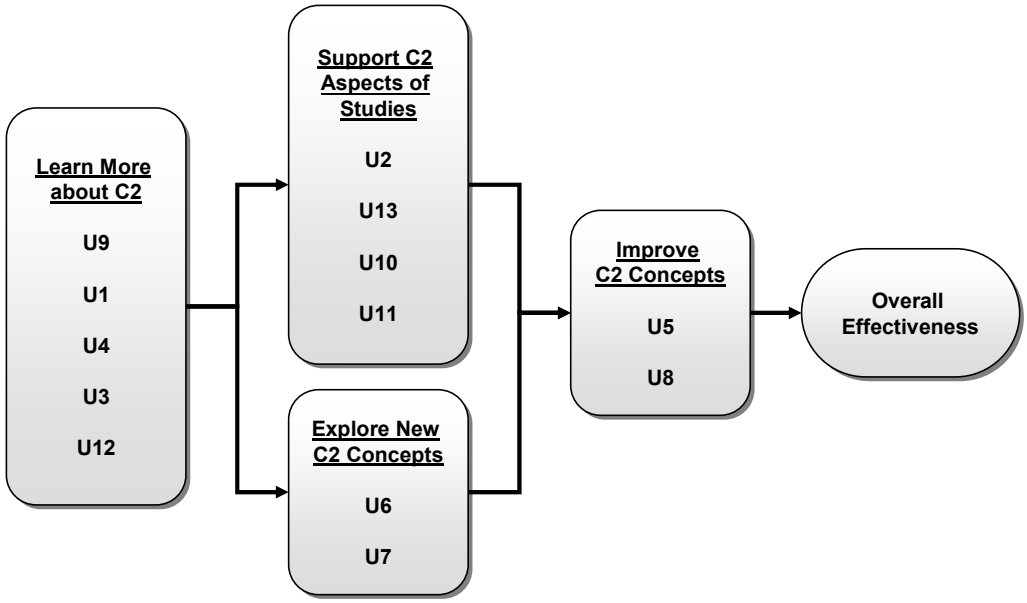

Figure 10-1.1: Logical Relationship of the Four Groups of Uses Criteria.

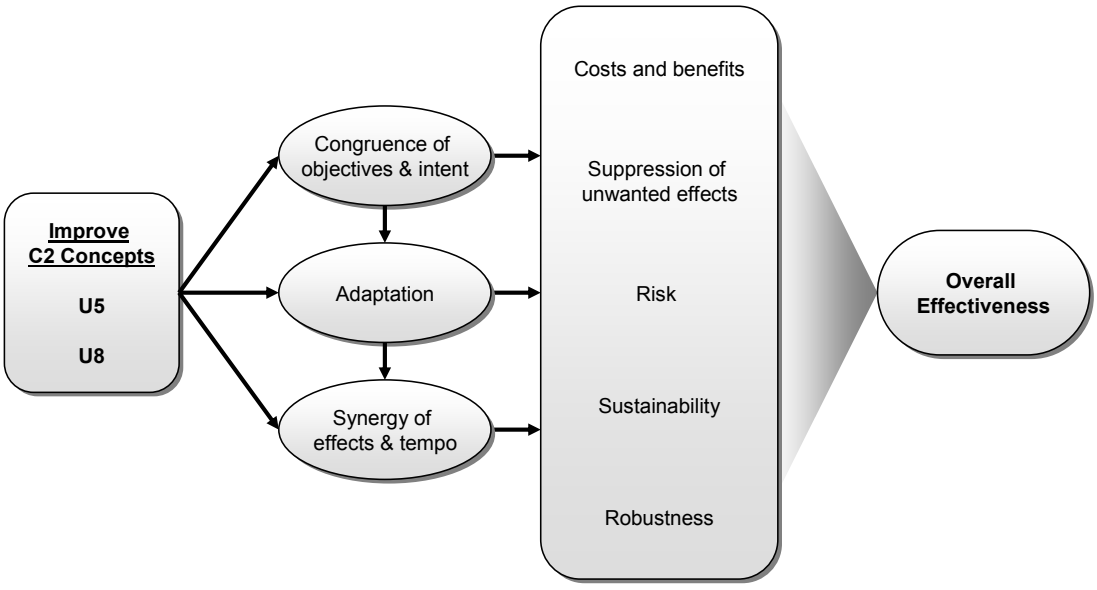

Figure 10-1.2: Improve C2 Concepts.

DISCUSSION AND CONSEQUENCES OF THE USES CRITERIA FOR THE CM

Each of these types of applications of the CM will create its own demands on the structure and functionality of the model. The logical flow of the four groups also implies that the quality of the outcomes that can be supported in improving overall effectiveness will be limited by the quality of our ability to support C2 aspects of studies, and to explore new C2 concepts, and these in turn will be limited by the depth of the learning about C2 that is supported by the first group. In developing the CM to better support that group, one should therefore have an eye upon the flow of benefits to the right.

The four uses relating to learning more about C2 are directly addressed to the CM itself, and seek first to improve the quality of understanding of the variables and their relationships, second to focus on the variables that capture the emergent properties of C2, the force, and the situation it influences, and third to recognise where further research and analysis is needed to extend and deepen the understanding of C2. The central focus on emergent properties and that subset of them that might be called the "natural modes of operation of the system being studied" is entirely appropriate from the point of view of the insights being derived from the science of complexity, and complex adaptive systems in particular, and seeks to build a base from which those insights can be applied and further developed in the context of C2.

The direct consequence for the CM is that an increased emphasis on dynamic properties is needed. To better achieve the intent of these criteria, the CM will need to include variables that capture dynamic emergent properties at multiple levels, including for example, some lower level emergent properties that, under the right conditions, can lead to particular higher level emergent properties that influence value outcomes in significant ways, and also include the more complex and coherent relationships between independent and emergent properties that are in play.

Criterion U2, the first of the four Uses Criteria that address how the CM should seek to support C2 aspects of defence capability studies, requires a generic framework of metrics to be developed from the CM. Such a framework would give guidance as to what sets of variables should be selected in particular studies, how to measure them, which variables need to be controlled for, which represent degrees of freedom to be explored, and which dependent variables need to be monitored as indicators of emergent outcomes, or as ultimate measures of value or effectiveness.

The second of this set of Uses Criteria, U13, is related to S2 (the second of the Scope Criteria that asks the CM to be relevant to different user groups) and requires that the CM be customised for particular purposes. The purposes or users need to be specified to see what the implications for the CM actually are, but one general observation is that open formats that preserve the useful information in the CM would in general be preferred because they would facilitate the importing and exporting of CM data from or into particular tools that may have specialised views or analysis functions desired by different user groups.

The third Criterion, U10, identifies a particular type of analysis that needs to be supported, one that is an important slant to take on any C2 or capability study: the analysis of vulnerabilities and failure modes. This implies that the CM is able to produce representations of instantiations of C2 concepts that lend themselves to analysis by suitable methods, for example making use of existing network analysis tools.

Finally in this set, Criterion U11 emphasises the importance of the CM being able to support Balance of Investment Studies, which require the ability to combine metric frameworks that address two or more capability areas into a common bottom line of impact on overall effectiveness, so that meaningful comparisons can be supported.

Any particular study would certainly rely on functional aspects of the CM addressing each of these four criteria, and indeed on most of the other criteria as well.

The third set concentrates on what is needed in the CM to make it useful for improving the application of C2 concepts so as to increase their contribution to overall effectiveness. While it consists of just two Uses Criteria, U5 and U8, if fully developed these would provide extremely powerful tools.

U5 addresses the exploitation of adaptive mechanisms to foster better outcomes in terms of overall effectiveness through the outcomes in five key contributions to overall effectiveness (costs and benefits, suppression of unwanted effects, risk, sustainability, and robustness) that are in turn driven by the extents to which various aspects of adaptation are successfully exploited. While adaptation is a generic concept that can be implemented in many different ways and at different levels, these criteria do not yet capture the full spectrum of what is going to be possible here, but recognise that the complex nature of the network of interactions that will result from any realistic instantiation of C2 will necessarily create many interdependent feedback loops, and that these will in turn create the possibility of various direct interventions to influence the natural and designed adaptive mechanisms present in the system, or more simply the congruence of (lower level) objectives and (higher level) intent (what one might call vertical alignment) and the synergy of effects and tempo (what one might call horizontal alignment). An alternative route to achieving the latter is through exploitation of adaptation rather than direct intervention, and adaptation itself is critically dependent on the degree to which vertical alignment is achieved because it is the internalised success measures in any adaptive mechanism that are used for guidance in the direction of adaptation – hence the additional two vertical arrows linking these three concepts.

The other member of this set, U8, is important because it addresses an essential distinction between enabling properties and value outcomes: the fact that the former are often variables for which there is a “just right” amount, while the latter are usually variables that we seek to maximise, and that they are often related, in the sense that the value outcomes are improved by tuning the enabling variables closer to their “just right” levels. The CM should help to clarify these relationships and to determine the target levels of the enabling properties.

The implications of these two criteria for the CM are significant and profound. It needs to be able to represent the presence of adaptive mechanisms, the factors that will influence their effectiveness, and the linkages between them.

Finally, the last set of Uses Criteria tackles the Holy Grail of how to produce valuable new C2 ideas. It seeks to build on the powerful functionality developed in addressing all of the previous criteria, and to apply it to generate and evaluate new C2 concepts (U6) and to characterise under what conditions they are likely to be more or less effective (U7). Speed will be of the essence here simply because the space of possibilities to be explored is so vast.

These two criteria do not attempt to indicate what particular strategies are likely be useful in this quest, but early indications suggest that understanding and exploiting adaptivity is once again going to be key.

CLOSING DISCUSSION OF THE CM IN RELATION TO THE CRITERIA

The Conceptual Model presented in this report has made substantial progress towards the vision portrayed by the criteria, although there is still much work to be done to fully deliver on that vision. This is to be expected given the scale and complexity of the challenge undertaken.

As illustrated in Figure 10-1.3, the criteria fall naturally into six groups: Scope, Features, and four subgroups of Uses: Learn more about C2, Support C2 Aspects of Studies, Explore New C2 Concepts, and Improve C2 Concepts.

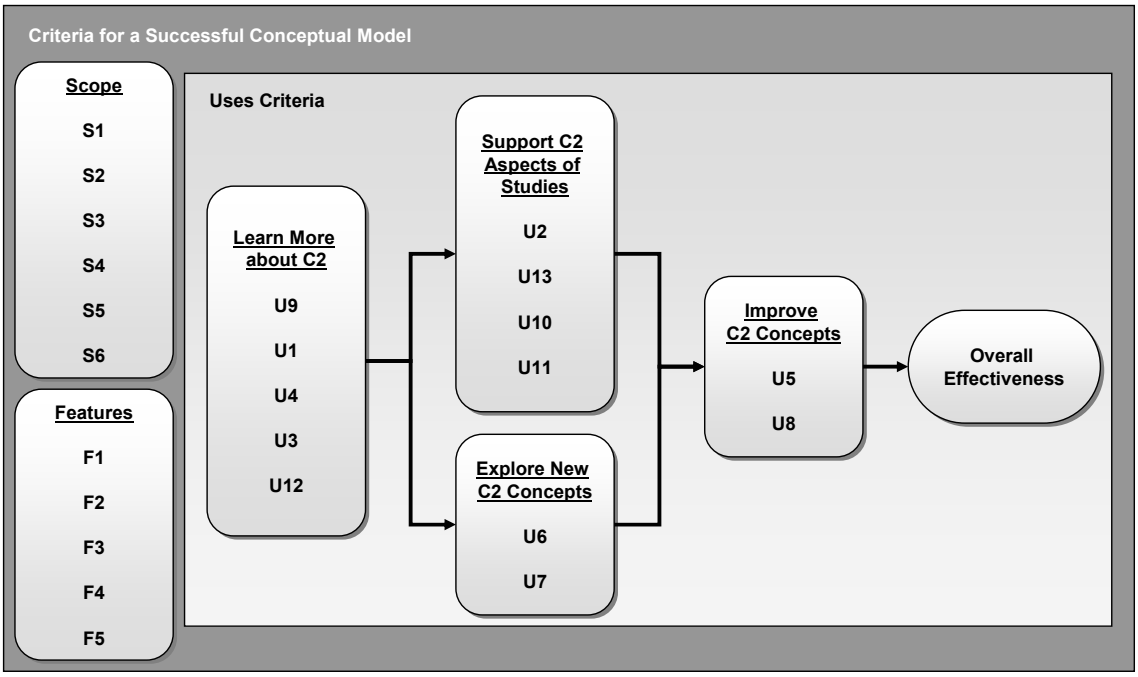

Figure 10-1.3: Schematic Showing the Groupings of the Criteria Adopted by the Group for a Successful Conceptual Model.

The most significant progress made in the Conceptual Model has been against the three left-most criteria boxes in the above diagram: the Scope and Features criteria and the Learn More About C2 subgroup of the Uses Criteria. While there is of course still room for improved compliance with these criteria, the degree of compliance achieved does create a sound basis on which to build a more solid CM and start exercising it for some limited applications in the Support C2 Aspects of Studies subgroup of the Uses Criteria.

One priority area for development that has not been significantly progressed yet is that touched on by the criteria relating to emergent properties and natural "modes" in the Learn More About C2 subgroup, and that is further articulated by the criteria in the Explore New C2 Concepts and Improve C2 Concepts subgroups, an area that springs from the inherent complexity of the context that C2 aims to influence. These criteria require a more comprehensive analysis of the dynamic properties of complex systems and their interactions, their emergent properties, and in particular, how adaptive properties arise and how they can be harnessed to foster increased effectiveness, and to explore the space of possible C2 concepts. This constitutes a considerable program of work and will require extensions to the current CM in the form of higher level variables to capture essential characteristics of adaptive mechanisms and of the relationships they require between capability elements.

Another area earmarked for further development is the elaboration of U9 and U1 in the domain of individual and team behaviours and characteristics (ITCB). SAS-050 has identified over 300 C2-relevant variables and their relationships, of which about one third are related to individual and team characteristics and behaviours.

Addressing the above mentioned criteria U1 and U9, a literature-based search for relevant empirical findings concerning relationships between variables within the ITCB part of the model, as well as between ITCB variables and variables of other parts of the model, was conducted. Chapter 10-5 presents an overview of the relationships between variables captured by the CM. It reveals that so far only a small number of these relationships have been empirically validated. The majority of them represent plausible hypotheses about their principal nature such as, for example, the relationship between individual alertness and stress level depicted in Figure 10-1.4. It is hypothesized to have the shape of an inverted "U" which depends, among others, on individual characteristics such as cognitive flexibility.

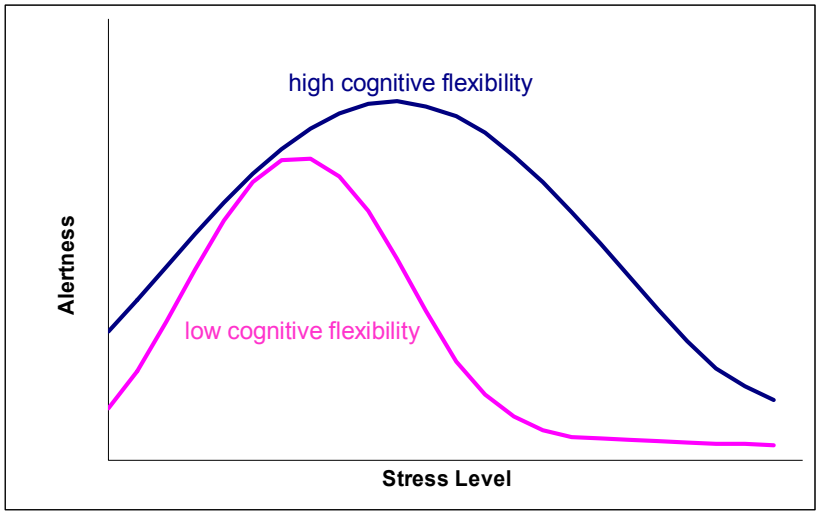

Figure 10-1.4: Alertness as a Function of Stress Level.

As is well known to automobile drivers, alertness (in the sense of paying attention to the traffic environment and being ready for a timely control response) increases up to a maximum level as the stress level (caused by traffic density, speed and speed differentials, erratic behaviour of other drivers, road obstacles, and other factors) grows, and decreases as the stress level keeps increasing further because of cognitive and physical limitations of the driver. However, the location and shape of the functional relationship between alertness and stress level depends, among others, on the cognitive flexibility of the driver, which reflects his understanding of a situation when confronted with new information. For a given stress level, high cognitive flexibility is associated with a higher degree of alertness than low cognitive flexibility, or a certain degree of alertness involves lower stress levels, or can be maintained at higher stress levels for drivers with high cognitive flexibility.

In order to develop a knowledge base for specifying relationships between ITCB variables for instantiations of the CM and the development of workable C2 models, systematic empirical research is indispensable.

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Grisogono, Anne-Marie. "Criteria for a Conceptual Model of C2." Presented at the Peer-to-Peer Workshop, 4-6 October 2005. Virginia Beach, VA USA.

Chapter 10-2 – VALIDATION OF THE MODEL

SUBJECT

In this chapter, we are concerned with the validation of the Conceptual Model. Of course, it is understood that in any scientific undertaking, it is impossible to have a theory, hypothesis, or model (let us call this our "model" for brevity) that is absolutely verified. We thus have to concern ourselves with the area within which the model is to be applied and the restrictions on that area of application, i.e. what are the constraints within which we know that the model works?

To answer this question, we have to think about what the model we have developed is to be used for, and also equally important, what it should not be used for. This raises further questions. Should it look as if it is capable of doing the job (face validity)? Should it contain the correct concepts and constructs (construct validity)? Should it be able to replicate a process in detail (process validity)?

APPROACH

Our Conceptual Model has been constructed with the aim of having the correct constructs and concepts. It consists of a number of variables and hypothesised links between these variables. The aim of validation in this case is thus to test whether the model has a rich enough set of such variables (i.e., has a requisite set of variables) sufficient to cover all the likely applications, and whether the links between the variables are supported by evidence where possible. It should also be easy to use in the domain of application. This leads us to consider criteria such as the following for validation:

- Requisite;
- Internally consistent;
- Authoritative;
- Has construct validity;
- Usability; and
- Unresolved differences between experts in the field have to be signalled.

To consider at least some of these aspects in detail, and with the focus on application of the model, we have taken the set of criteria developed for a Conceptual Model (in Chapter 10-1) and extracted those that are concerned with the usability aspects. This gives us the following expanded list of "useful aspects" of a Conceptual Model:

- Can support testing and refinement of causal and influence links;
- Provides a generic framework of metrics;
- Identifies natural modes of behaviour of variable sets;
- Identifies emergent behaviour;
- Suggests point of influence and pressure;
- Helps in rapid generation of ideas;

- Helps reason about constraints on validity;
- Helps understand how much of a property is enough;
- Helps identify correlations between variables;
- Supports analysis of failure modes;
- Supports studies and analysis;
- Identifies gaps in knowledge; and
- Supports customised views for different audiences.

To test these detailed criteria, we worked through two separate case studies. In Case Study 1, we considered a focussed analysis of a future complex peacekeeping and warfighting scenario with the emphasis on validating the richness of the variable set, the links between variables, and the usefulness of the Conceptual Model in supporting such a scenario-based study. In Case Study 2, we focussed on the broader tenets of Network Centric Operations, and approached the usefulness of the CM from a number of different directions. These included a detailed literature search of relevant materials, analysis of variables and links using agent-based modelling, building a process model describing the tenets of the NCO, a review of relevant human in the loop experimentation, and a historical review of leadership.

CASE STUDY 1

In Case Study 1, we focussed on the following set of criteria from the list above:

- Can support testing and refinement of causal and influence links (U1);
- Provides a generic framework of metrics (U2);
- Identifies natural modes of behaviour of variable sets (U3);
- Identifies emergent behaviour (U4);
- Helps reason about constraints on validity (U7);
- Helps identify correlations between variables (U9);
- Supports studies and analysis (U2, U10, U11, U13); and
- Identifies gaps in knowledge (U12).

Relative to the use criteria articulated in Chapter 10-1, we have thus focussed on the key groups labelled Learn More about C2 and Support C2 Aspects of Studies.

The case study approach was chosen as a relatively independent way of testing the CM because it would represent an example of use according to a pre-determined process with clear goals, and would not, therefore, be wholly dependent on the judgement of the SAS-050 team.

The objectives of this case study were:

- To test the C2 conceptual model against a specific, focussed study problem to find out if it:
  - Is an effective starting point for the specific study;
  - Facilitates requisite treatment (by identifying the full range of critical variables and relationships);

  - Comprised a set of variables rich enough to differentiate adequately between different C2 Approaches;
  - Encourages broad and innovative thinking; and
  - Facilitates shared understanding between the nations.
- To propose improvements to the conceptual model.

The case study was conducted according to the process recommended by the *NATO Code of Best Practice for C2 Assessment*. Given the time and resources available and the principal role of the C2 Reference Model in studies, the case study focussed principally on Problem Formulation, which the COBP emphasises should be done explicitly before a Solution Strategy is formulated. Problem Formulation (sometimes called "questioning the Question") includes:

- Explicit declarations of assumptions and constraints;
- Identification of independent and dependent variables that will be evaluated; and
- Explicit declarations of high level Measures of Merit (or criteria) by which outputs will be judged for significance.

While this was the original aim, the case study actually went much further than this.

The COBP also recommends an iterative approach so that all aspects of the problem are re-visited at least twice during the study. The study was conducted from March to September 2004 (based on the Reference Model version current at that time) and involved a series of four workshop sessions that constructed a strawman problem formulation and sought to work the problem systematically. The third of these workshops used a Synthetic Environment experimentation facility to allow participants to immerse themselves in the chosen scenario before discussing the study problem.

Fuller details of the conduct of Case Study 1 are contained in Chapter 10-3.

What We Learned

Case Study 1 demonstrated that the Reference Model contained the majority of the variables needed to describe the different C2 Approaches considered, but that it needed more development in terms of completing the map of linkages between those variables for which it was to be capable of sustaining rigorous analysis.

The case study demonstrated the power of rigorous systematic analysis and the value of having a well formed Reference Model to sustain it.

The case study indicated that the type of C2 problem for which the Reference Model was being developed might not be reducible to a small number of key variables and relationships, presaging the need for rigorous and systematic methods of use for the Reference Model.

Of the eight criteria for a good Reference Model that Case Study 1 was expected to inform, it was able to say something useful about five:

- *Can support testing and refinement of causal and influence links*: The case study showed how the Reference Model could be used to test study specific conceptual models.

- *Helps reason about constraints on validity*: The case study clearly identified the extent to which study problems in the C2 area can be reduced in complexity without losing key factors.
- *Helps identify correlations between variables*: The case study showed how the Reference Model, when complete enough, could form the basis for study-specific conceptual modelling, thus allowing correlations between variables to be inferred.
- *Supports studies and analysis*: The case study could not use the Reference Model for its intended purpose because of its (then) incompleteness, but the exercise allowed a much more complete Reference Model to be developed.
- *Identifies gaps in knowledge*: The use of the Reference Model in the study was, in the end, more about identifying gaps in itself rather than in the team's comprehension of the case study problem.

Overall, Case Study 1 demonstrated that, even in its immature state, the Conceptual Model went a long way towards providing the kind of support envisaged in the criteria above. However, completeness of the causal network of variables is a critical pre-requisite to exploiting this potential. The case study was of great value in informing the further development of the model; if a similar exercise were carried out now with a more mature model it would be of significant benefit in further validation.

CASE STUDY 2

Literature Review

The aim of the Literature Review was to review the existing literature in order to support and refine the CM. It addressed several questions. Are specific variables and relationships in the CM supported by the literature? Do we need additional variables and relationships? We addressed the following specific aspects of Validation:

- Can support testing and refinement of causal and influence links (U1);
- Provides a generic framework of metrics (U2);
- Helps reason about constraints on validity (U7); and
- Identifies gaps in knowledge (U12).

Most of these are in the foundation group Learn More about C2.

The literature review was carried out in two phases, and efforts were made to ensure that the group carrying this out achieved a comprehensive and objective appraisal of the relevant supporting literature. This was done in a number of ways, including peer review of each other's work, announcement of the review, requests for relevant literature, and peer review of work in progress by those attending the 9th International Command and Control Research and Technology Symposium (ICCRTS) in Copenhagen (14-16 September 2004).

The result of the two phases of work was a detailed review of 29 highly relevant pieces of literature, drawn from conference papers, peer-reviewed papers in relevant journals, technical reports from NATO nations, and books. Full details of each review are in Chapter 10-4. Here we focus on the highlights of the review. Papers are identified by the lead author and by the number by which they are listed in the Case Study 2 Chapter under either Phase 1 or Phase 2, so that the relevant contribution can be accessed easily.

What We Learned

Highlights from Phase 1 of the Literature Review:

- There was support in the literature for shared awareness and team values increasing team performance (Mathieu et al., Phase 1).
- A rich expansion of the concepts in the C2 Approach was possible (Moffat, Phase 1).
- Further possible variables and relationships in the C2 Approach were identified related to personality, training, and experience (Dodd et al., Phase 1).
- There was literature support for the Behaviours part of the CM and emphasising the importance of Agility as a Measure of Merit (UK MoD paper, Phase 1).
- Additional possible variables were identified related to networks in the Value View of the CM, and theoretical analysis supported the link between information, shared awareness, and Measures of C2 Effectiveness, and the link between information, collaboration, and force effectiveness (Perry et al., Phase 1).
- The "Myths" of Network Centric Warfare were explored from a critical perspective (Cantos 1,2,3, Phase 1).
- Knowledge creation, collaboration, learning, and related key variables were identified to enrich and support the CM (Gauvin et al., Phase 1).
- A "Command Concepts" approach to C2 led to some possible changes to the associated CM variables and relationships (Builder et al., Phase 1).
- Metrics were identified related to Network Centric Warfare, which added to those in the CM (McInerney et al., Phase 1).
- There was literature support for the advantages of networking (Gompert et al., Phase 1).

In the second phase of the Literature review, we focussed on Performance and Agility as key aspects of the CM.

Highlights from Phase 2 of the Literature Review:

- The essence of the meaning of Command as human-centred, and of Control as process-centred (McCann and Pigeau, Phase 2).
- The representation of Command in terms of proactive rather than reactive constructs, based on Mental Models and hypotheses (Bryant, Phase 2).
- How belief propagates in Social networks (Behrman, Carley, Phase 2).
- Situation Assessment as a key ingredient (Endsley, Edgar, Phase 2).
- Natural and "Engineered" Complex Adaptive Systems are an insightful way of capturing state change over time and aspects of agility (Grisogono, Phase 2).
- Agility and self-organisation are at the heart of modern flexible production processes (Neubert et al., Phase 2).
- Key factors in headquarters performance from a human-centred perspective (Mathieson et al., Phase 2).
- Critical appraisals (Kaufman, McMaster, Phase 2).

We concluded from the review that significant support had been identified in the literature for some of the relationships in the CM. A rich set of additional variables and relationships had also been identified.

PROCESS MODEL

The aim of developing this NCO process model was to help understand some of the key variables and linkages that the CM should be able to represent. This related particularly to the criterion U1 in the group Learn More about C2.

What We Learned

The model was enhanced to ensure that it was rich enough to reflect this process.

AGENT-BASED MODELLING (ABM)

The aims of these activities were to:

- Identify advantages, limitations, and gaps of the CM to support the development of an agent-based model for testing NCO hypothesis. This relates particularly to the use criteria U1, U6, U12, and U13.
- Assess the capabilities of agent-based models to support the specification of relationships hypothesized in the CM. This relates particularly to the Uses Criteria U4 and U9.

These Uses Criteria relate particularly to the group Learn More about C2.

The agent-based modelling activities are also part of the example instantiation of the CM. The detailed discussion and results are shown in Chapter 10-7.

What We Learned

Bringing forward the results of the example instantiation, here is what we have learned:

- Because most of the variables in ABM are very basic, one cannot directly map ABM variables to the CM variables. However, using aggregation and de-aggregation, the variables and relations within the CM provide a valuable basis for the development of an ABM. Relations in the CM provide a basis for interdependencies between variables from which to select those modelling behaviours of agents.
- ABM models have a high potential for further refinements of the CM. The variables and behavioural rules in ABM provide indicators for CM variables and relations. In the course of ABM experiments, often surprising relations emerge that are not explicitly modelled but arise from the dynamic combination of a large set of simple rules. Further investigations of these emerging relations will have to provide the evidence that such relations are worthy to be part of the CM.

HUMAN IN THE LOOP EXPERIMENTS

As with the process model, the aim of reviewing the Human in the Loop literature was to help understand some of the key variables and linkages that should be able to be represented in the CM. This relates particularly to the criterion U1.

The references of the literature that were reviewed are P. Essens et al., "Military Command Team Effectiveness: Model and instrument for assessment and improvement," M. Spaans, "An assessment of the Dutch Battlefield Management System," and A. Worme, "Human Centric Implications of Network-Centric Operations." All were used as general background in helping to construct the CM.

What We Learned

The briefings reviewed were used as general background in the initial development of the CM.

HISTORICAL CASE STUDY

In principle, historical case studies are an excellent approach to validate hypotheses embedded in models. However, rarely can sufficient data be retrieved for that purpose from historical accounts. One notable exception is the 1980 BDM report compiled by General William De Puy (U.S. Army, Ret.) based on a series of structured interviews to elicit, in conjunction with a series of war games, the knowledge of the German WW2 Generals Balck and von Mellenthien in reviewing plans for defending against Soviet attacks in the Fulda gap. From a first look at this document, the impression was won that it contained a wealth of useful information for validating parts of the CM. Even though C2 is not addressed in any detail in the DePuy report, and with reference to organisational aspects only, in their statements the German Generals referred to a series of human factors and behavioural parameters that they regarded as important for success in battle based on their extensive field experience in World War II, especially in situations when they fought successful battles against a numerically superior enemy.

Therefore, a text analysis was done with the aim of developing a structured basis for the development of a conceptual model that reflects the experience of both generals as a contribution to the validation of the C2 conceptual model (CM). Based on some 30 relevant variables identified in the report, and more than 15 statements in which variables were explicitly related to each other, influence diagrams were developed showing the links between environmental and institutional parameters and human characteristics and individual and team behaviours related to battle performance. A comparison showed that the existing CM covered most of the variables and relationships identified from the DePuy report. In particular, the accounts of the German Generals emphasize the need for flexibility and maintaining the initiative, and understanding higher intent.

What We Learned

- The experience captured in historical accounts offers valuable clues as to the potentially most important individual and team characteristics/variables and their relationships and may be helpful to focus on core variables in a specific C2 context.
- Variables identified from historical case studies can be used to develop hypotheses on relationships, which then can be examined in the light of empirical studies.
- Psychological research supports some of the relationships between variables that were identified from the Balck / von Mellenthin accounts.
- The majority of the identified variables are covered by the CM, however some variables important in a warfighting context were missing and were subsequently added.
- The CM is helpful in structuring historical accounts of military operations to provide a basis for the validation of models.

LACK OF TOOLS

Relative to the Uses Criteria, in particular Support C2 Aspects of Studies and Exploring New C2 Concepts, we found that there were very few tools and combinations of tools available that allowed us to visualise and navigate through the variables. Consequently, we are not sure that we have fully explored all of the variables and the linkages. For example, during the agent-based modelling, it was very difficult to identify the key parts of the CM relating to the problem.

Chapter 10-3 – CASE STUDY 1: NET EFFECT WITH REACH-BACK

INTRODUCTION

This chapter describes how the emerging C2 Conceptual Model was tested for completeness and validity (i.e., fitness for purpose) through a case study exercise. The case study approach was chosen as a relatively independent way of testing the CM because it would represent an example of use, according to a pre-determined process and with clear goals, and would not, therefore, be wholly dependent on the judgement of the SAS-050 team.

The objectives of this case study were:

1) To test the C2 Conceptual Model against a specific, focussed study problem to find out if it:
   a) Is an effective starting point for the specific study;
   b) Facilitates requisite treatment (by identifying the full range of critical variables and relationships);
   c) Comprises a set of variables rich enough to differentiate adequately between different C2 Approaches;
   d) Encourages broad and innovative thinking; and
   e) Facilitates shared understanding between the nations.
2) To propose improvements to conceptual model.

The case study was conducted according to the process recommended by the *NATO Code of Best Practice for C2 Assessment*. Given the time and resources available and the principal role of the C2 Reference Model in studies, the case study focussed principally on Problem Formulation (see Figure 10-3.1), which the COBP emphasises should be done explicitly before a Solution Strategy is formulated. Problem Formulation (sometimes called "questioning the Question") includes:

- Explicit declarations of assumptions and constraints;
- Identification of independent and dependent variables that will be evaluated; and
- Explicit declarations of high level Measures of Merit (or criteria) by which outputs will be judged for significance.

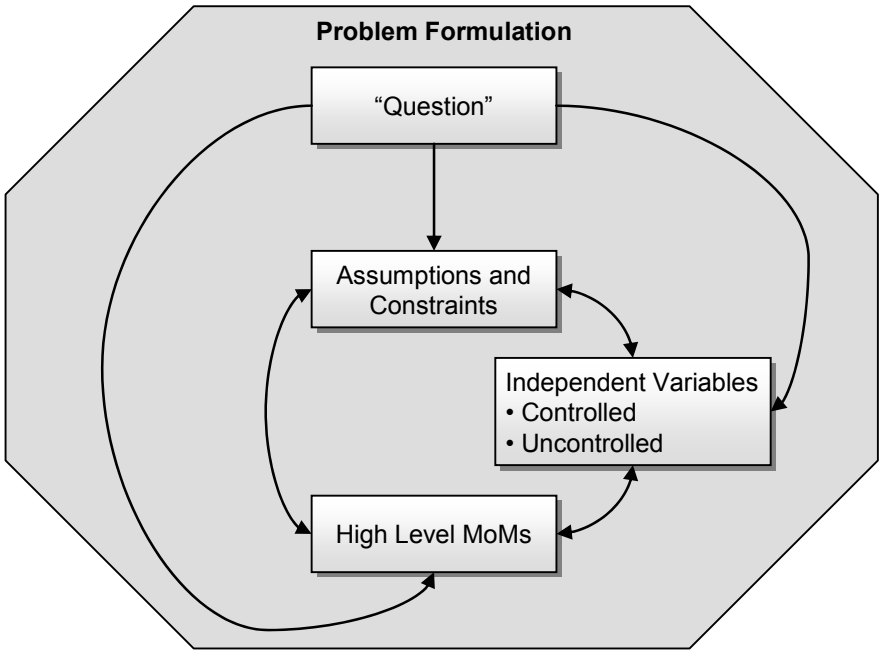

Figure 10-3.1: Key Parts of Problem Formulation as Defined by the NATO Code of Best Practice for C2 Assessment.

In line with COBP guidance on Problem Formulation, the case study briefly considered all aspects of the study process in order to obtain early insight into Solution Strategy issues that might shape the nature of the problem that can feasibly be addressed.

The COBP recommends an iterative approach so that all aspects of the problem are re-visited at least twice during the study. The study was conducted from March to September 2004 (based on the Reference Model version current at that time) and involved a series of four workshop sessions that constructed a strawman problem formulation and sought to work the problem systematically. The third of these workshops used a Synthetic Environment experimentation facility to allow participants to immerse themselves in the chosen scenario before discussing the study problem.

The remainder of this chapter outlines the case study context, the "Question" as presented, the results of the Problem Formulation and the initial Solution Strategy adopted. The next section describes the results of the case study in respect of testing the C2 Reference Model.

CASE STUDY CONTEXT

The case study was set in a fictional scenario involving a dispute between the countries of Tetlovia and Keswonia. The geography and fielded military forces involved are illustrated in Figure 10-3.2. The following actions were declared to have already taken place:

- Tetlovia invaded Keswonia and seized control of the only deep-water port, which was important to international trade.
- The Keswonian Government was in disarray and local Armed Forces were unable to restore territorial sovereignty.

- Lochland to the north closed its border to refugees and a huge humanitarian crisis, with increasing disorder, was forecast.
- UN resolutions were passed demanding Tetlovian withdrawal and authorising military intervention to return control of the Port to Keswonian authorities.
- NATO was asked to provide the military force needed.
- The UN was conducting humanitarian aid operations and requested NATO protection and support.

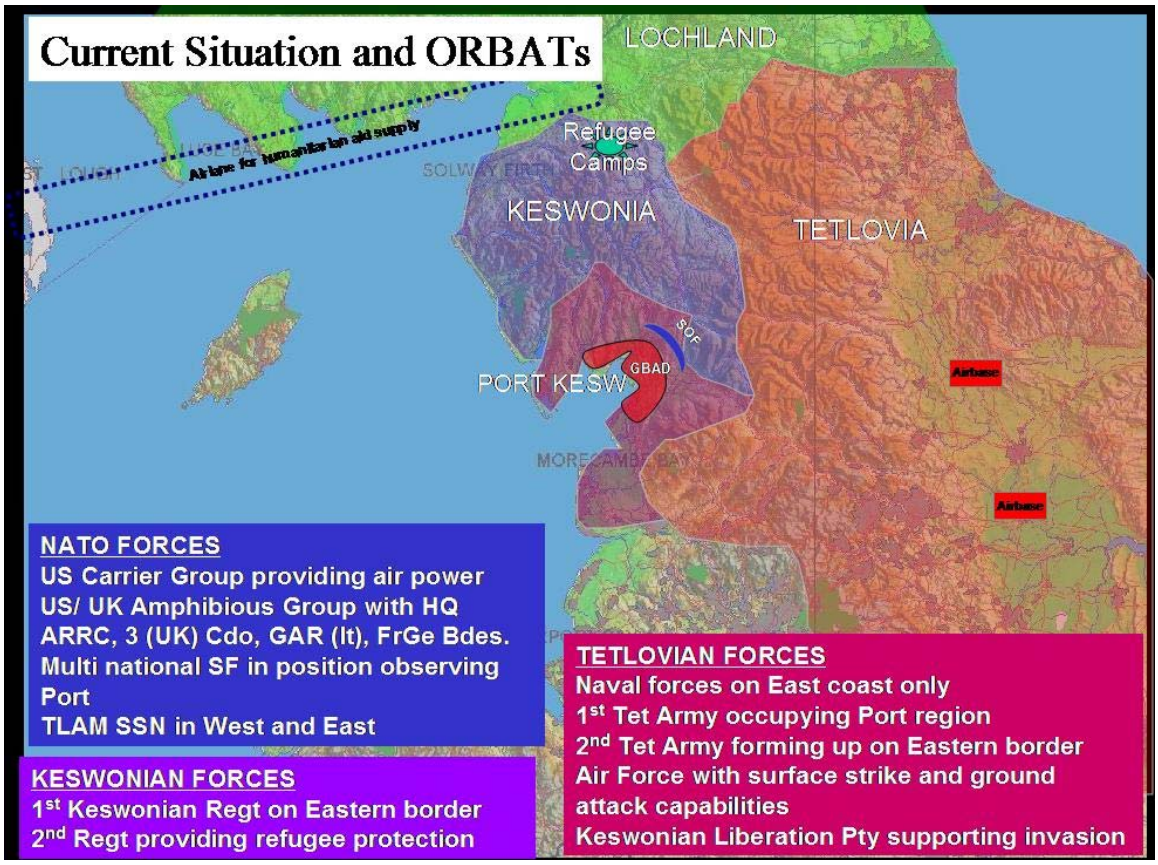

Figure 10-3.2: Illustration of Case Study Scenario Including Geography and Military Forces.

NATO's involvement in this situation has been ordered under the name Operation Restore Order, whose political goals and military mission are:

- Political Goals:
  - Visibly oppose Tetlovian invasion.
  - Restore Port Kesw operations.
  - Resolve humanitarian crisis in northern Keswonia.
  - Stabilise region and restore legitimate government.

- Military Mission:
  - Take control of Port Kesw protect restoration of ops.
  - Provide security and support to humanitarian ops.
  - Prevent further Tetlovian intervention in Keswonia.

The NATO Joint Force Commander (designate) has an initial campaign plan involving three phases:

1) An amphibious landing and move to re-take the Port.
2) A simultaneous movement to provide military security to the humanitarian activities in the north.
3) Following restoration of Port operations, a stabilisation action to maintain security and deter further Tetlovian aggression.

However, the JFC is aware that the situation could become volatile, possibly requiring rapid adaptation of the plan. He is also aware of possibilities to improve the agility and/or efficiency of his force C2 by fielding new supporting capabilities, but feels the need for some scientific and analytic advice, hence commissioning a study.

THE CUSTOMER'S "QUESTION"

Joint Force Commander (designate), who was played by a member of the team with suitable military experience, has asked for a study to address the following question:

- "In forthcoming Operation Restore Order, how should I organise my C2 and what support capabilities should I propose to field?"

PROBLEM FORMULATION: "QUESTIONING THE QUESTION"

Discussions with JFC and his staff clarified and decomposed the question as follows:

- Can JFC reduce the logistics and communications load by using network-enabled HQ staff afloat to support a C2 cell ashore?
- There is an expectation that units involved in humanitarian assistance missions will need rapid, reliable access to regional experts and technical data from homeland sources. How should this be integrated into the C2 process?
- There is a risk that the situation could become volatile with Phase 1 operations overlapping in time and space Phase 2 humanitarian support. What C2 Approach will best enable agile force re-configuration capability? Particularly, how can JFC create an effective agile net-fires capability? (There was also a Civil Military Cooperation aspect to this volatility risk.)
- The JFC has been advised that the use of network-based collaboration technologies will enable agility and improve overall force capability, but he would like an unbiased assessment to guide his planning.
- What are the other benefits and risks of distributing C2 responsibilities between the geographically diverse units of a multi-national force working within potentially different constraints?

The following assumptions and constraints were identified:

- Assumptions:
  - JFC has freedom to modify C2 structure for NATO forces, but can only advise Keswonian force C2. Does not need to modify structure but feels that conventional approach may be cumbersome and is willing to consider other options. Nothing is sacrosanct, but JFC wants to know about constraints.
  - JFC expects to have to be quick on his feet in this situation.
  - UN mandate is clear. NATO C2 is default, with Keswonians independent.
  - Clear arguments are more important to JFC than quantification per se.
  - Some extra C2 equipment could be acquired in time.
  - There are no immediate risks from Tetlovia that prevent LCC going ashore.
- Constraints:
  - Limited effort, very limited time.
  - National ROE are a factor, but do not assume they cannot change. But Legal and national issues are factors.
  - C2 Information Exchange Data Model is across NATO force (but not with Keswonian Forces).

SOLUTION STRATEGY

Initially, the team sought to use a systematic, path-tracing technique, designed to identify variables from the Reference Model considered relevant to describe and differentiate C2 Approaches while exploiting its network of relationships. This initial approach made little progress because the Model, at that time, was not well enough connected to sustain path tracing from characteristics discriminating C2 Approaches to the value variables representing their implications. Consequently, on the next iteration of the case study, a different method was adopted.

The study plan was re-designed to involve developing and critiquing C2 “solutions” to the case study problem, and selecting Reference Model variables that describe the differences between those options and the force behaviour under specific scenario evolutions:

- Immerse in the scenario and discuss which Reference Model variables characterise it;
- Brainstorm potential C2 solutions;
- Critique the solutions, select a credible sub-set, and describe the differences between them in terms of Reference Model variables (identifying gaps in the model);
- Walk through the scenario to assess the likely impact of a few widely dispersed C2 solutions;
- Review the Reference Model variables needed to describe how the situation might evolve differently under each solution; and
- Identify gaps in the Reference Model and suggest improvements.

Based on the case study context, some postulated future vignettes were developed representing possible evolutions of the Operational situation.

- Stage 1: ARRC HQ and Div sail for Keswonia. Remainder to follow at time D-3. Plan is for 3 Cdo and GAR Bdes to recapture Port Kesw with FrGe Bde in reserve. Other divisions come ashore through Port Kesw and re-establish Keswonian borders.
- Stage 2: Plan changes because of threat of 2nd Tetlovian Army attack across eastern border, and riots in refugee camp. Operational priority becomes stabilising the Keswonian northern region by relieving suffering in refugee camps and preventing intervention by 2nd Tetlovian Army. 3 Cdo Bde continues on original task. Others re-deploy.
- Stage 3: Imperative of mission to regain control of Port as soon as possible is strengthened because Aid being provided to refugees via the air bridge to Lochland is proving inadequate.

A number of possible C2 Approaches were created using creative thinking techniques and two of these were selected for deeper treatment: a traditional hierarchy and a functional hierarchy.

Under the traditional hierarchy, the JFC and his staff are co-located in an afloat HQ, with staff organised into traditional "J" cells. Commander ARRC and his G-cell staff co-locate in an HQ ashore, with each Brigade HQ deployed with their units. The JFC's J2 is in charge of force ISTAR and, in each HQ, staff conduct operations using traditional planning and battle management procedures. Traditional information architecture is in place supporting common operational pictures across elements of the military force. Liaison with UN, coalition, and NGO entities involves Liaison Officers.

Under the functional hierarchy, functional elements in the force are teamed together under theatre-level functional commanders. Functional elements, including commanders, are mobile and deploy to wherever the focus of action in their functional areas is strongest. For example, the theatre J9 (civil military co-operation) is deployed to the refugee camps in the north and the Logistics commander deploys to the port (once it is taken). Only a small core staff remains in the afloat HQ while commanders can come and go as required, reaching back to their staff using the information network. Liaison Officers are used to help dispersed elements to synchronise. The J2 function is distributed, layered, networked, and robust, with a mixture of autonomous and human resources. Like other functions, elements are able to self-synchronise or be directed, can take multiple tasking inputs, and are supported by an info management and dissemination architecture that facilitates coordination and deconfliction of tasking and resource allocation. Dispersed elements across the force are empowered, within the limit of law, their national ROE and available resources to act and collaborate with peers to satisfy a declared command intent. This requires knowledge of relevant capabilities, intent and authority.

EVOLUTIONS OF SCENARIO

Each C2 Approach was discussed in the context of the scenario and hypotheses were developed over how the scenario might evolve under each C2 Approach.

STAFF FOCUS

Under the traditional hierarchy, the conventional staff structure will focus on the primary military mission and is less likely to think outside the box, about the emerging refugee crisis for example. Consequently it might be expected that less force will be available for the main effort due to being forced to divert resources to deal with the refugee crisis once it has fully developed. Under the functional hierarchy, the more collaborative

style of C2 empowers freer thinking of the J9 function (including LOs), which will be less constrained by the J3 main effort. This could allow direct negotiations to be started with SHAPE to enable pre-emptive actions to defuse the refugee crisis, for example by paying Lochland to keep the border open and enable the continued acceptance and care of refugees. Such early pre-emptive action might then leave more force available for the main effort.

INTEGRATION OF PRE-OPERATIONAL ACTIVITIES

The traditional hierarchy applies to operational forces deployed with the Joint Force, but a different C2 structure, more like the functional hierarchy, applies to a range of pre-operational activities such as INT and IO across force structure. Applying the traditional hierarchy could result in elements that were previously working closely together now being fragmented across the force C2 structure, needing to re-focus onto serving their command node. This could lead to a loss of coherence in the early days of the operation, leading to discontinuity and possible conflict of actions. The functional C2 structuring enables smoother assimilation of functions such as INT, especially HUMINT, and IO from SF, etc. from pre-op actions into JFC structure, or into supporting roles outside the Joint Force structure.

CO-LOCATION

In the traditional hierarchy, the various C2 functions are more dispersed in terms of footprint with possibly more and smaller groupings requiring greater operative load (e.g., force protection and sustainment). The functional hierarchy could allow more staff to be more co-located and afloat, easing logistic and force protection burdens, facilitating a more robust C2, although also an increased value as a target, due to the geographical concentration. The Reference Model has a well developed treatment of individual and team characteristics and behaviours that plays into the human dimension of co-location.

"SURPRISE" EVENTS

Under the traditional hierarchy, surprise events require ISTAR reporting, checking, new plans, negotiation, authorisation of asset release, and dissemination of new orders. This is likely to mean better management of criticalities and coordination of activities, but slower and less appropriate responses to events. Under the functional hierarchy, a more widely shared appreciation of events and a willingness to allow low level tasking requests via links to distributed J2 and J3 cells allows lower level options generation. This may result in faster, more responsive resourcing and execution, but needs management of knock-on effects and bigger picture appreciation.

The case study took the last of these possible scenario evolutions, surprise events, and developed it further, but detailed a particular sequence of events related to the concept of network-enabled effects generation.

STORY OF NET-EFFECTS EPISODE IN SCENARIO

The effect of the two C2 Approaches on the vignette concerning the Tetlovian incursion on the eastern border was developed by telling the story of the episode from the perspective of the C2 system. Within the vignette, an intelligence failure leads to Keswonian forces being surprised by the Tetlovian incursion, which threatens to over-run their positions.

Figure 10-3.3 illustrates how events unfold under the traditional C2 hierarchy. The Liaison Officer with the 1st Keswonian Regiment contacts JFHQ and reports the position, passing on a request for reinforcement. JFHQ immediately revises its plan and negotiates changes to the mission requirements with the CAOC and ARRC Division HQ. Each of these HQ issue revised tasking down their respective command chains resulting in coordinated air and land recce, manoeuvre, and strike missions to achieve the desired effect of repulsing and further deterring the Tetlovians.

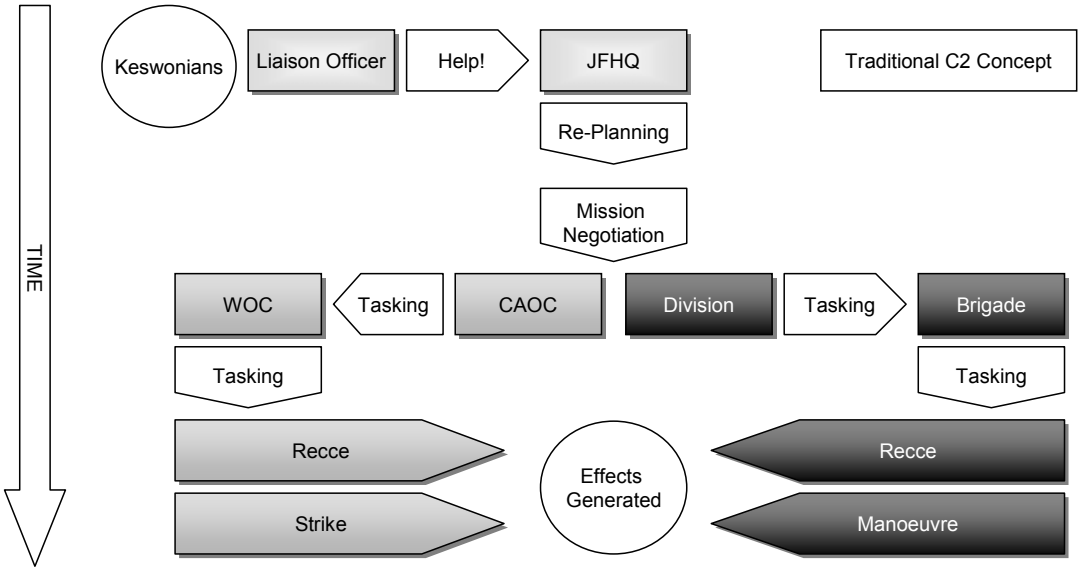

Figure 10-3.3: Illustration of Course of Events in Tetlovian Incursion Vignette under the Traditional C2 Hierarchy Assumption.

Figure 10-3.4 illustrates how the same situation might unfold under the alternative functional C2 hierarchy. The LO reports the situation to JFHQ, but is empowered to directly contact the Brigade HQ, which he knows from information on the network is in a position and has capabilities that could assist the Keswonians. The Brigade recognises that, while it can manoeuvre to stabilise the situation, it cannot do so quickly enough. However, the Brigade is aware of air component capabilities that could provide the rapid effect needed to fix the Tetlovians, thus allowing the Brigade to manoeuvre forces into a position to stop the Tetlovians and force them to retreat.

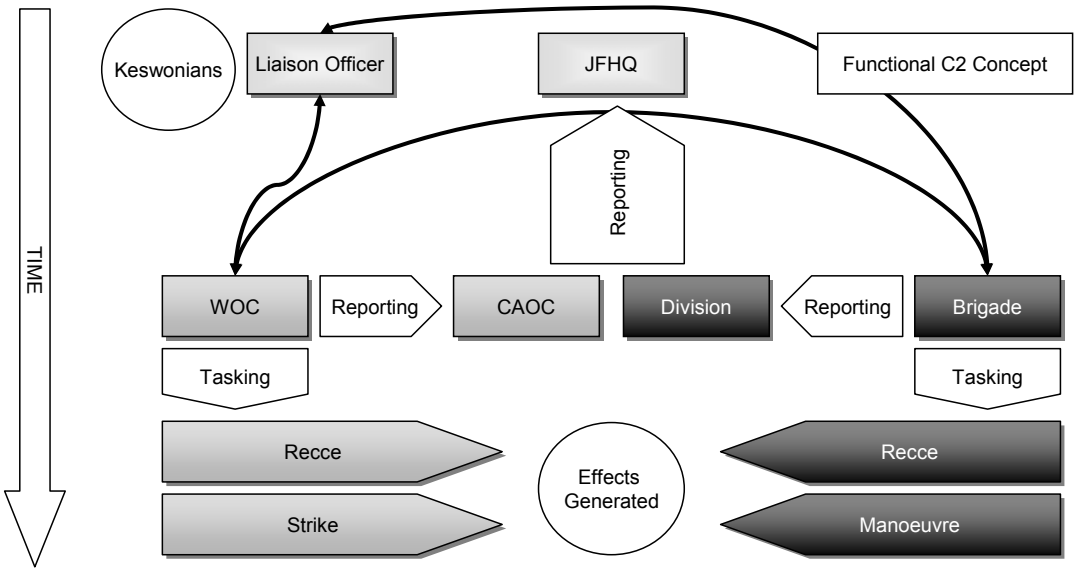

Figure 10-3.4: Illustration of Course of Events in Tetlovian Incursion Vignette under the Functional C2 Hierarchy Assumption.

The Brigade reports up to Division, but is empowered to contact the Wing Operations Centre directly to negotiate a coordinated tasking, The WOC reports to the CAOC, but is empowered to complete negotiations with the Brigade, liaising with the LO attached to the Keswonian regiment, and initiating tasking to recce and strike assets.

The anticipated result of the functional C2 hierarchy is that effects can be generated faster in response to surprise events, although this comes at the risk of disrupting higher level plans, and the higher formation HQ may need to countermand actions initiated lower down.

RELEVANT VARIABLES

Consideration of the case study, including all the evolutions identified under the case study scenario, confirmed the significance of a wide range of the variables already in the Reference Model. This indicated that the study-specific model was not greatly reduced in complexity when compared with the Reference Model as a whole from which it was derived. This was somewhat surprising, but it is a finding confirmed by national work carried out in the U.K. in a similar context.

A number of gaps in the Reference Model were identified in covering the following areas:

- Formal vs. Informal “Organisation”;
- Vulnerability Variables (e.g., signature);
- Individual Experience;
- “Followship” (i.e., the complement to Leadership);
- Decision Rights (e.g., Rules of Engagement); and
- Competence with Autonomy.

Also, a number of areas were identified as needing refinement:

- Enhance Description of Trust;
- Extend Will to apply at multiple levels;
- Refine thinking on Information "Generators" (e.g., sensors);
- Refine thinking on Information "Movers" (e.g., Comms); and
- Move Variables into Physical Domain where appropriate.

VARIABLE LINKAGES

Early attempts to do systematic manipulation of the Reference Model showed that it did not (then) have nearly enough completeness of variable linkage to sustain such rigorous manipulation. In order to explore the extent of this incompleteness and test the correctness of the links between variables in the Reference Model, a study-specific network of variables was created. This study-specific network was then compared with the Reference Model to identify missing links and variables. Figure 10-3.5 illustrates both the study-specific variables and linkages (abstracted from the scenario evolution discussion outlines above and coloured blue in the figure) with the Reference Model equivalent variables and linkages (coloured in black).

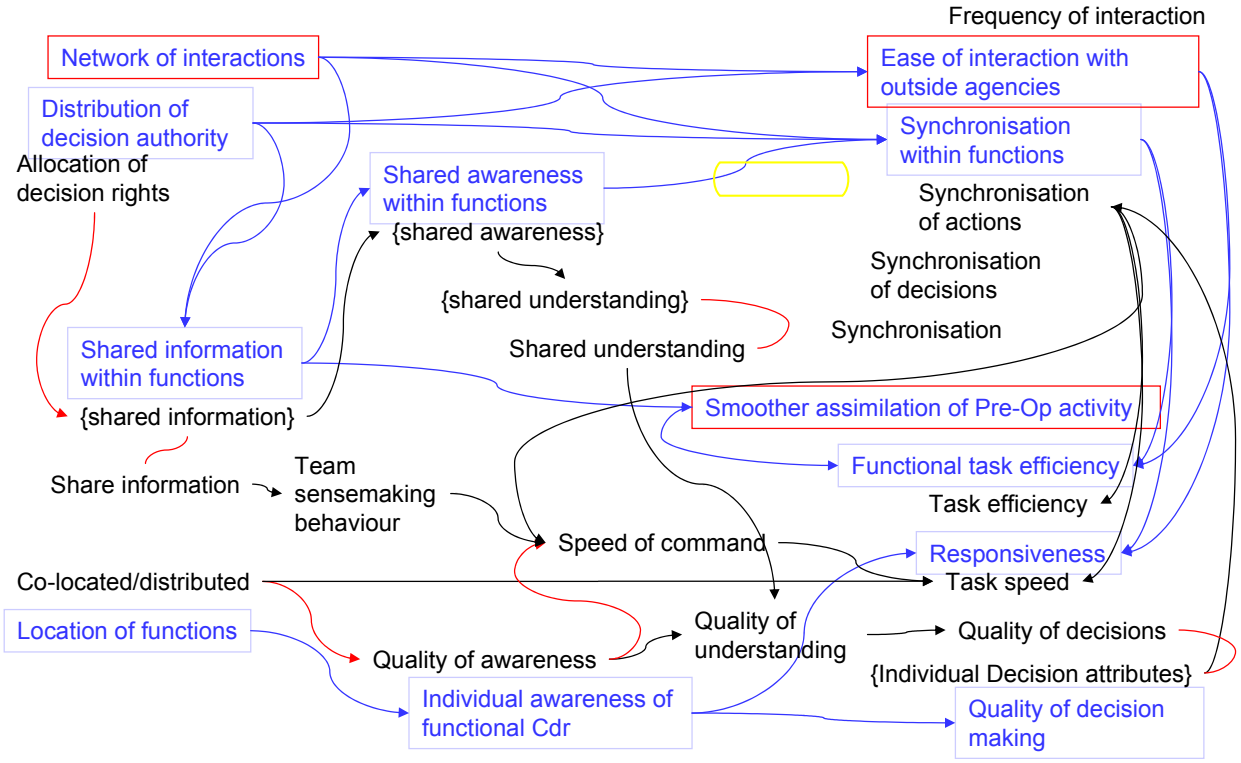

Figure 10-3.5: Example of a Comparison between a Study Specific Network of Variables and Linkages (coloured blue) and the Equivalent Variables and Linkages from the Reference Model (coloured black). Missing variables and links, i.e. those in the case specific model but with no equivalent in the Reference Model, are coloured or outlined in red.

Missing variables and links (i.e., ones in the study-specific model but with no equivalent in the Reference Model) are outlined or coloured in red. This exercise was carried out for more than one of the scenario evolution areas discussed above, indicating many gaps.

RESULTS

Case Study 1 demonstrated that the Reference Model contained the majority of the variables needed to describe the different C2 Approaches considered, but that it needed more development in terms of completing the map of linkages between those variables if it was to be capable of sustaining rigorous analysis.

The case study demonstrated the power of rigorous systematic analysis and the value of having a well formed Reference Model to sustain it.

The case study indicated that the type of C2 problem for which the Reference Model was being developed might not be reducible to a small number of key variables and relationships, presaging the need for rigorous and systematic methods of use for the RM.

Chapter 10-4 – CASE STUDY 2: LITERATURE REVIEW

Listed here is the final set of references to the literature that we looked at in detail. It is partitioned into the literature reviewed in Phase 1 and that reviewed in Phase 2, in order to simplify cross-reference with the discussion in the main body of the report.

The detailed review of each of these contributions considered the articulation of the hypotheses in the document, and then related these to those contained, or potentially contained, in the Conceptual Model. The details of each review are contained on the Web site.

LIST OF LITERATURE FOR DETAILED REVIEW IN PHASE 1

[1] Dearth, D.H. "The Human Factor in Future Conflict: Continuity and Change. CYBERWAR 3.0: Human Factors in Information Operations and Future Conflict." AFCEA International Press (publisher of SIGNAL Magazine). October 2000.

[2] Reid, D.J. and Giffin, LtCol R.E. "A Woven Web of Guesses, Canto Three: Network Centric Warfare and the Virtuous Revolution." Paper presented at 8th ICCRTS.

[3] Mathieu, J.E., Goodwin, G.F., Heffner, T.S., Salas, E. and Cannon-Bowers, J.A. "The Influence of Shared Mental Models on Team Process and Performance." Journal of Applied Psychology. 2000 Vol. 85 No 2. pp. 273-283.

[4] Moffat, J. "Command and Control in the Information Age: Representing its Impact." The Stationery Office, London, UK. 2002. ISBN 011 772984 1.

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Chapter 10-5 – INDIVIDUAL AND TEAM CHARACTERISTICS FOR SUCCESSFUL COMBAT OPERATIONS

A Note on the 1980 BDM-Report on "Generals Balck and von Mellenthin on Tactics: Implications for NATO Military Doctrine," by General William DePuy (U.S. Army)

INTRODUCTION

This note is based on the edited version of the BDM-report* by General William DePuy (U.S. Army, Ret.) summarizing the analysis of the opinions and ideas of retired German Generals Balck and von Mellenthin with respect to tactical problems of NATO vis-à-vis the Soviet Union in the late 1970s and early 1980s. It was rediscovered when searching the first named author's personal archives for pre-Internet materials on human and organisational factors relevant for military Command and Control.

Even though C2 is not addressed in any detail in the BDM report, and with reference to organisational aspects only, in their statements the German Generals referred to a series of human factors and behavioural parameters that they regarded as important to success based on their extensive field experience in World War II, especially in situations when they fought successful battles against a numerically superior enemy. The respective statements in the report are marked by a yellow background.

Below, the relevant variables identified from the report and the implied relationships between them are presented as a contribution to SAS-050.

VARIABLES

The characteristics/variables mentioned by Balck and von Mellenthin in their discussion with the U.S. Generals (Gorman and Otis) and analysts (Dunnigan, Karber, Sprey), and identified by General DePuy as characteristic for the German Generals, fall into four categories related to:

- Higher level commanders (as represented by the Generals Balk and von Mellenthin);
- Lower level commanders (including NCOs);
- Soldiers in general; and
- Organisational and institutional aspects.

HIGHER LEVEL COMMANDERS

The factors listed under this category were addressed by Balck and von Mellenthin when they described each others' characteristics and their mutual interactions as Commander 4th Panzer Army (General Balck) and his Chief of Staff (Major General von Mellenthin) during WW II operations in Russia. They include:

- Authority;
- Mental stability (iron will);

* Technical Report BDM/W-81-077-TR, McLean, VA, December 19, 1980. An edited version of the report is available for downloading at the following Web site: http://www.dodccrp.org/

- Determination (iron will);
- Self-confidence;
- Confidence in subordinates;
- Confidence in institution (German Army);
- Professionalism;
- Experience;
- Performance record;
- Cognitive abilities (brightness);
- Thoughtfulness;
- Creativity;
- Risk propensity (cautiousness);
- Familiarity with peers (live together, think together); and
- Loyalty.

LOWER LEVEL COMMANDERS (INCLUDING NCOs)

The variables in this category refer to characteristics that distinguish field successful troop commanders:

- Trust (deference to superior commander);
- Knowledge of superior commander's concept;
- Understanding concept and operational objectives (commander's intent);
- Instinctive grasp of situation (sixth sense, "Fingerspitzengefühl");
- Willingness to take initiative (strong initiative);
- Flexibility / responsiveness / learning aptitude;
- Cognitive abilities (imagination, apprehensiveness);
- Leadership (ability to convince and motivate subordinates);
- Wartime leadership / peacetime leadership;
- Attention to detail;
- Training;
- Experience;
- Decisiveness;
- Creativity;
- Risk propensity (boldness); and
- Respect for human being.

Based on their personal experience, both generals emphasized that at any level a commander's performance record is a prime factor affecting the battlefield performance of his troops. However, individual characteristics observed in peacetime rarely provide a basis for assessing the competence as a wartime leader.

Balck: "It is just by accident if you can observe that in peacetime…You will experience in any war that there will be a total reversal. Those people who were considered very good people in peacetime often would be lousy in war, and those who were doing very poorly in peacetime can suddenly become excellent."

Another important, albeit rare, property of successful military leaders is captured by what both German generals named "Fingerspitzengefühl" (fingertip feeling), a German term that conveys the idea of an instinctive sixth sense for terrain and tactics. Asked by General DePuy how many German generals had Fingerspitzengefühl, General Balck said "…three or four (out of every one hundred), but they were unrecognized in peacetime."

SOLDIERS IN GENERAL

Regardless of rank, the following characteristics of soldiers were considered as decisive for success in battle by the German Generals:

- Craft knowledge (training and experience);
- Courage;
- Steadfastness / perseverance;
- Familiarity with peers;
- Understanding;
- Trustworthiness;
- Individuality (autonomous thinking, cognitive maturity);
- Cultural attitudes / orientation;
- Cognitive flexibility; and
- Physical flexibility.

In addition to the level of training and experience, and institutional and other factors that affect the behaviour of soldiers, General DePuy concluded that it was the meticulous attention to detail by commanders at all levels, and the manifest courage and steadfastness of German soldiers in the face of difficulties as well as their strong initiative and perseverance that were key to German successes on the battlefield in WWII.

ORGANISATIONAL / INSTITUTIONAL

The organisational/institutional variables refer to parameters that characterize the cultural background and traditions of a military organisation and its operational philosophy, doctrine, and constraints. They include:

- Cultural background;
- Military tradition;
- Command philosophy ("Auftragstaktik");

- Degree C2 centralisation;
- Education/training;
- Training and doctrine;
- Freedom to take initiatives;
- Freedom of action;
- Reputation of organisation; and
- System of rewards / reprimands.

In the context of holding the defence line at the Chir River against the overwhelming numerical superiority of the Russians, General Balck observed that "we lived of a century-long tradition, which is that in a critical situation the subordinate with an understanding of the overall situation can act responsibly. We always placed great emphasis on the independent action of subordinates, even in peacetime training."

Both German Generals considered the individuality of the German fighting man – his freedom to take initiative and the system that engendered these policies and attitudes – to be the key to superlative German performance.

In the context of success and failure associated with individualistic responses to situations, opportunities, and initiatives, General Balk pointed out that German high commanders were fostering the individual's initiative: "They left him (the soldier) room for initiative, and did not reprimand him unless he did something very wrong. Of course, there were exceptions, and there was sometimes trouble, but generally independent action along the line of the general concept was praised, and accepted as something good."

RELATIONSHIPS BETWEEN VARIABLES

The relationships between variables retrieved from the analysis of the DePuy report are depicted in Figures 10-5.1 through 10-5.3. In conjunction with text interpretations made by the authors of this paper, the identified relationships are captured in the following quotes by the German Generals in the report (the respective pages in the report are listed in parentheses):

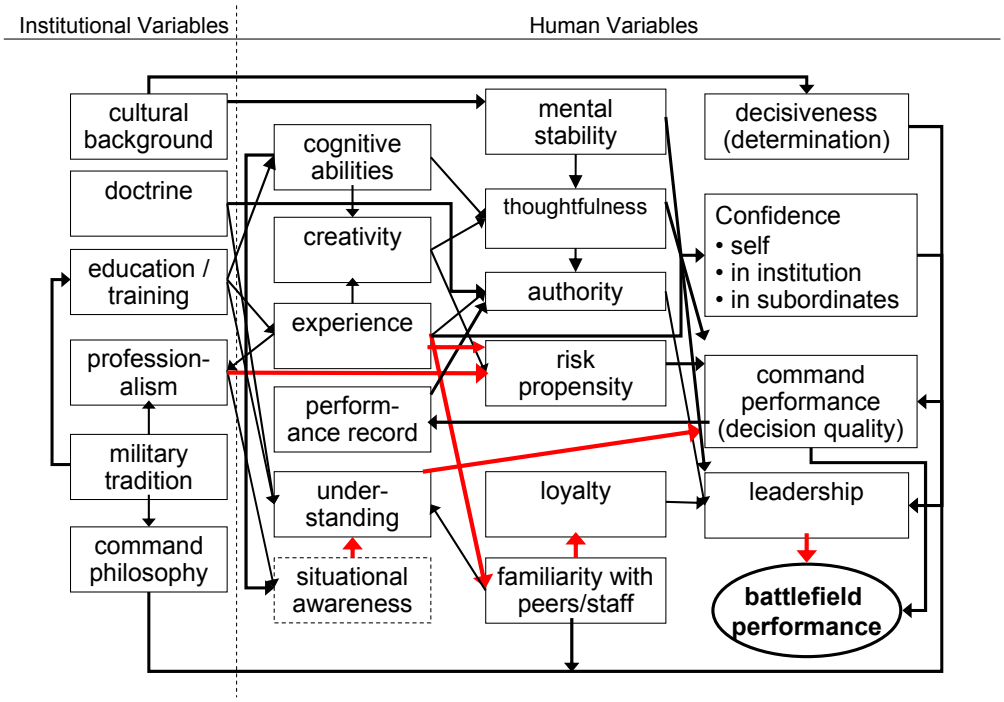

Figure 10-5.1: Relationships between Human and Institutional Variables (Higher Level Commanders).

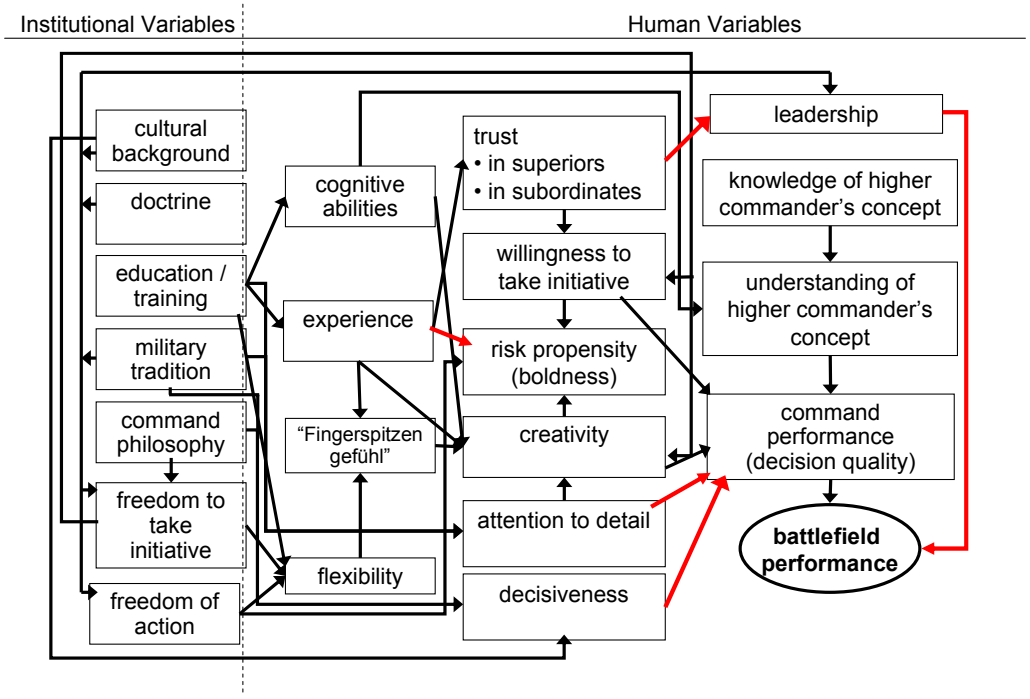

Figure 10-5.2: Relationships between Human and Institutional Variables (Lower Level Commanders).

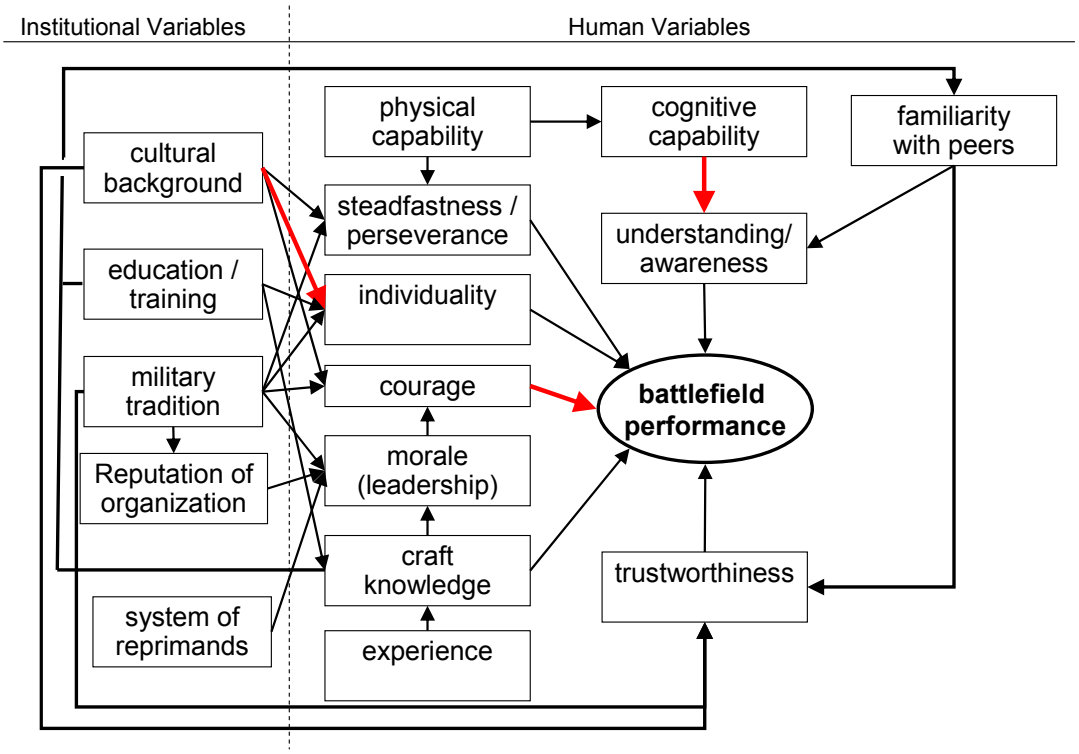

Figure 10-5.3: Relationships between Human and Institutional Variables (Soldiers in General).

- Authority growing out of an incomparable set of experiences in war and a record of battlefield performance (p. 9);
- No army can separate itself from the principles on which it has acted from the very outset (p. 11);
- They (Russians) are rigid and bound to certain patterns, and they are thus more vulnerable than we are (p. 13);
- Auftragstaktik, the theory and practice and training, in order to amplify the advantages that flow from the full exploitation of the battlefield initiative (p. 15);
- Success of Auftragstaktik rests, at least in part, on knowledge of higher commander's concept and operations and objectives (p. 15);
- Understanding is achieved either through careful explanation or campaigning together long enough that the "modus operandi" is second nature to all …it is also by-product of doctrine and training (p. 15);
- Leaders at any level grow with their experience (p. 19);
- The better they know each other, the shorter and less detailed the orders can be (p. 19);
- Reasons for success on the battlefield include (commanders') attention to detail, their manifest courage and steadfastness in face of the difficulties, and their strong initiative and perseverance (p. 19);

- During each phase of the battle, factors such as doctrine, terrain, and force relationships were considered in connection with the probable battle outcomes (p. 21);
- Success depends on quality of leadership and the size of the units being led; avoid big units (pp. 41-42);
- "Pure" (homogeneous) companies and battalions facilitate training, maintenance, and leadership (p. 42);
- Integrity of the organisation must be maintained because it is the basis for training and feeding and Command and Control of the unit (p. 42);
- Small forces skilfully led can win battles against large forces if the small force is synchronised and the large force is disorganised (p. 46);
- Essence of battle is to synchronise own forces and disorganise the enemy's (p. 46); and
- Creation of opportunities depends on the enemy's susceptibility to disorganisation when confronted with new and unexpected situations (p. 46).

CONCLUSIONS

Based on the analysis of the historical account of the field experience of the German Generals Balck and von Mellenthin in World War 2, the following conclusions may be drawn:

- The evaluation of the Balck / von Mellenthin accounts supports the hypothesis that the documentation of or lessons learned from historical military operations can be helpful in validating conceptual models;
- The experience captured in historical accounts offers valuable clues as to the potentially most important individual and team characteristics/variables and their relationships and may be helpful to focus on core variables in a specific C2 context;
- Variables identified from historical case studies can be used to develop hypotheses on relationships, which then can be examined in the light of empirical studies;
- Psychological research supports some of the relationships between variables that were identified from the Balck / von Mellenthin account;
- The majority of the identified variables are covered by the CM, however some variables important in a warfighting context are missing;
- The CM is helpful in structuring historical accounts of military operations to provide a basis for the validation of models; and
- The accounts emphasize the need for flexibility and maintaining the initiative, and understanding higher intent.

Chapter 10-6 – AF2T2EA: AN ILLUSTRATIVE EXAMPLE

SUBJECT

This chapter presents the results of an illustrative example of the AF2T2EA "Kill Chain."

APPROACH

Using the cognitive pyramid approach as shown in Figure 10-6.1, the Conceptual Model variables were binned into five areas. They were: Environment, Information, Awareness, Understanding, and Action (or decision).

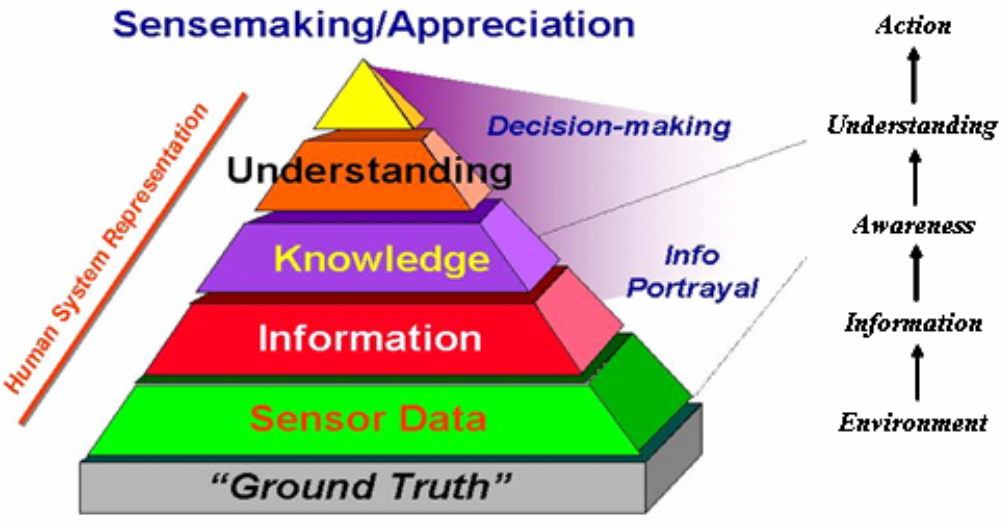

Figure 10-6.1: Cognitive Pyramid.

The execution of today's Air Force's "Kill Chain" is a lengthy process that is subdivided into seven "events", namely: (1) Anticipate, (2) Find, (3) Fix, (4) Track, (5) Target, (6) Engage, and (7) Assess.

The desired attributes to accomplish this process can be summarised as:

- Focussed, persistent C2ISR for all target categories, to achieve desired effects.
- C2 of ISR assets to persistently track target entities to predict the adversary's courses of action in the battlespace.
- Full-spectrum, networked ISR focussed by anticipation in order to re-detect potential targets.
- C2 of ISR to cross-cue assets to precisely geo-locate targets.
- Networked, multi-sensor inputs to characterise a target's operational, physical, functional capabilities, and tactical employment patterns.
- Share information across entire operational network (i.e., collaborate).
- C2 of ISR assets to persistently track target entities to lead to other target entities.

- Dynamic C2ISR network to enable target engagement at time and place of choosing.
- NRT automated C2 of forces to provide consistent ROE and with human-in-the-loop.
- Automated, machine-to-machine dialogue passing precise decision quality data/information across network to coalition assets.
- NRT and dynamic C2 of ISR assets and collection planning and tasking to execute battle damage assessment of operational effects.
- Deliver information in NRT across network of sensors, decisionmakers, and strikers to shorten AF2T2EA cycle.

An illustrative example to apply the Conceptual Model (May 2005 version) was to take a subset of capabilities for each of the seven areas and then apply the Conceptual Model's variables to each of the sub-events.

The selected capabilities were:

1) **Anticipate:**
   - Ability to model, predict and display possible effects and threats.
   - Anticipate adversary's actions in order to streamline and shorten AF2T2EA cycle.
   - Ability to model and predict CBRNE and TIM threats and events.
   - Predict how (Red, Blue, Gray) actions will cascade into direct/indirect effects in support EBO.
   - Require correct, current, consistent and shared information.

2) **Find:**
   - Fully merge and integrate sensor/information to support battlespace SA.
   - Accurate/real-time battlespace SA, enabling decisionmakers to correctly react to changes.
   - Rapidly and accurately update situational understanding as a result of changes in SA awareness.

3) **Fix:**
   - Accurate and timely positive combat identification of surface, air, and space objects.

4) **Track:**
   - Integration/display and availability of operations information in a common operational picture.
   - Improve, automate, and streamline monitoring of friendly surface, air and space force location.

5) **Target:**
   - Improve commander's COA selection and dissemination process.

6) **Engage:**
   - Better optimized use of the battlespace environment.
   - Conduct real-time effects-based mission execution.

- Real-time collaboration among all C2 entities.
- Capability to achieve self-synchronization of forces.

7) **Assess:**

- Real-time Red, Blue Gray force status assessment.
- Rapid assessment and selection of targets to maximize desired effects.
- Ability to accurately assess surface/air/space impacts of physical environmental conditions.
- Improve COA evaluation and requirements process.

This illustrative example was subdivided into two parts:

- Part 1: For each of the events (AF2T2EA), the Conceptual Model's variables were mapped into environment, information, awareness, understanding, and decision (or action).
- Part 2: The Conceptual Model's variables were mapped into each of the capabilities listed under the AF2T2EA process. For each of the capabilities listed above, the Conceptual Model variables were evaluated as to having high, medium or low correlation to the stated AF2T2EA capabilities. Table 10-6.1 below provides a summary of the top 5 variables for each of the seven events within the AF2T2EA "Kill Chain" process.

Table 10-6.1: Top Five Variables for Value View of AF2T2EA Process

Event within AF2T2EA "Kill Chain" Process	**Conceptual Model Variables**
Anticipate	1) Understanding about Environment, Intentions.
	2) Uncertainty.
	3) Information about Forces, Environment, Intentions, Uncertainty.
	4) Awareness about Forces, Environment, Intentions, Mission.
	5) Correctness of Information, Individual Information, Shared Information.
Find	1) Sensor Persistence, Coverage.
	2) Correctness of Information, Individual Information, Shared Information.
	3) Timeliness of Information, Individual Information, Shared Information.
	4) Awareness about Forces, Environment, Intentions, Mission.
	5) Speed of Command, Decisions, Planning, Task.
Fix	1) Correctness of Information, Shared Information.
	2) Precision of Information, Individual Information, Shared Information.
	3) Timeliness of Information, Individual Information, Shared Information.
	4) Accuracy of Individual Awareness, Individual Understanding, Collective Understanding.
	5) Level of Confidence.

Event within AF2T2EA "Kill Chain" Process	Conceptual Model Variables
Track	1) Correctness of Individual information, Shared Information, Individual Awareness Collective Awareness, Partial Awareness, Individual Understanding, Partial Understanding, Collective Understanding.
	2) Accuracy of Shared Information, Individual Awareness, Collective Awareness, Partial Awareness, Intersection Awareness, Individual Understanding, Partial Understanding, Collective Understanding, Intersection Understanding.
	3) Understanding about Forces, Environment, Mission, Intentions.
	4) Sensor Persistence, Coverage.
	5) Timeliness of Information, Individual Information, Shared Information, Individual Awareness, Collective Awareness, Individual Understanding, Collective Understanding.
Target	1) Accuracy of Collective Awareness, Intersection Awareness.
	2) Currency of Information, Individual Information, Shared Information.
	3) Effectors: Lethal, Non-lethal.
	4) Situation: Political, Social.
	5) Awareness about Forces, Environment, Intentions, Mission.
Engage	1) Awareness about Capabilities, Forces, Environment, Intentions, Mission.
	2) Speed of: Command, Decision.
	3) Task: Competence, Efficiency, Knowledge, Speed.
	4) Mission Effectiveness.
	5) Effectors: Lethal, Non-lethal.
Assess	1) Understanding about Capabilities, Forces, Environment, Mission, Intentions.
	2) Awareness about Capabilities, Forces, Environment, Intentions, Mission.
	3) Correctness of Information, Individual Information, Shared Information, Individual Awareness, Collective Awareness, Partial Awareness, Intersection Awareness, Individual Understanding, Collective Understanding, Partial Understanding, Intersection Understanding.
	4) Task: Competence, Efficiency, Knowledge, Speed.
	5) Mission Effectiveness.

WHAT WE LEARNED

- There was an excellent mapping of the variables to the seven events of the AF2T2EA "Kill Chain" process. In May 2005, the variable listing comprised 337 variables. An outcome of this mapping was to see if variables were missing. This was not the case.
- The correlation of Conceptual Model variables to each of the seven events of the AF2T2EA "Kill Chain" process was strikingly appropriate and consistent. Table 10-6.1 above summarizes the findings.

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Chapter 10-7 – EXAMPLE APPLICATIONS: AGENT-BASED MODELLING, EXAMPLE INSTANTIATION WITH PAX

SUBJECT

This chapter presents the results of an example instantiation of the Conceptual Model using the German agent-based model PAX.

APPROACH

Based on the variables and relations in the CM, a scenario was developed for the German ABM PAX for testing the NCW hypothesis that "Shared Situation Awareness/ Understanding enables Synergistic Actions/ Self Synchronization." As illustrated by Figure 10-7.1, the objectives of this activity were to assess:

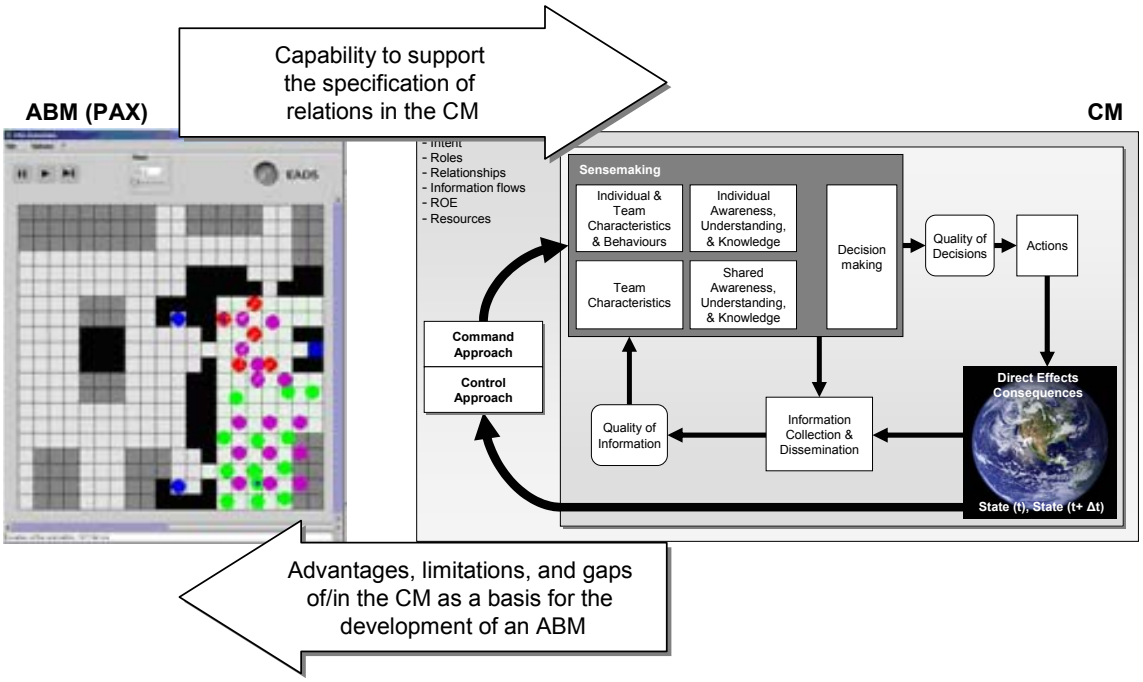

Figure 10-7.1: Objectives of CM Instantiation in Form of an ABM.

- The benefits of the CM for its instantiation in terms of an ABM; and
- The potential of ABMs for refinements of the CM.

The scenario featured a situation where Blue forces were tasked to provide security for Green voters in a soccer stadium during an election campaign event in Afghanistan that Red troublemakers might attempt to break up. In particular, the Blue security was to quell any attempts by troublemakers to disrupt the election campaign.

Individual Awareness and Understanding underlying the decisions of agents was modelled in terms of a map describing a local part of the whole situation (see Figure 6-4a). Shared Awareness and Understanding meant sharing of these local maps between agents of the same party (see Figures 6-4b-d). Based on the situation, a certain combination of behaviours of the security forces was defined to be synergistic. Different information sharing processes were implemented to measure how the occurrence of the synergistic behaviour changes.

THE BENEFITS OF THE CM FOR ITS INSTANTIATION IN TERMS OF AN ABM

The CM provides an extensive list of variables relevant for C2 analysis, especially in the area of the individual and team characteristics and behaviours, from which to select those for modelling attributes and behaviours of agents. Characteristics and state variables present a set of attributes to describe the state, which may change over time.

Similarly, the CM provides a set of dependencies from which those to be instantiated in an ABM may be selected. These might be direct dependencies such as, for example, “alertness depends directly on the state of physical health.”

The CM supports the developer of a model by assisting him to determine which variables need to be considered in modelling the variables of interest. The CM contains references to and definitions in the scientific literature where background and possible instantiations of these variables are described.

The CM also helps to find references to relationships between variables that have been empirically tested and thus may be directly instantiated in the form of rules for interactions between agents.

It should be pointed out, however, that variables in terms of which the NCW tenets are defined (Situational Awareness/Understanding and Synergistic Actions) represent composite variables representing vectors specifying the attributes, or basic variables, by which these (composite) variables are described. Thus, they may not be immediately instantiated. However, the CM provides a list of variables that may influence awareness and understanding that supports the developer in instantiating relevant variables.

THE POTENTIAL OF ABM FOR REFINEMENTS OF THE CM

Agent-based models are mostly based on a large set of very simple rules that are plausible and easy to understand. They describe the response of individual actors in specific situations. The interaction of actors leads to a dynamic combination of these simple rules leading to unpredictable or often surprising behaviour of the (modelled) system comprising the actors. Thus, relationships may emerge that are not modelled explicitly in the ABM but generated through the interaction of agents, or rather the interaction of their simple behavioural rules.

The relationships emerging in the course of ABM experiments may help to specify relationships between variables postulated, or not covered at all, by the CM.

Data Farming, a method to support experimentation with ABM, determines the degree of dependency between variables. Data Farming is a kind of sensitivity analysis for the relationships between variables. It helps to identify the variables that have a significant impact on a specific variable of interest and to establish the relationships that are important in a specific context. Using ABM experiments, it is possible to assess the degree of influence of one variable on another in a given context.

WHAT WE LEARNED

- Because most of the variables in ABM are very basic, a direct matching to the CM variables often fails. However, using aggregation and de-aggregation, the variables and relations within the CM provide a valuable basis for the development of an ABM. Relations in the CM provide a basis for interdependencies between variables from which to select those modelling behaviours of agents.
- ABM models have a high potential for further refinements of the CM. The variables and behavioural rules in ABM provide indicators for CM variables and relations. In the course of ABM experiments, often surprising relations emerge that are not explicitly modelled but arise from the dynamic combination of a large set of simple rules. Further investigations of these emerging relations will have to provide the evidence that such relations are worthy to be part of the CM.

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Chapter 10-8 – AGENT-BASED MODELLING: EXAMPLE INSTANTIATION WITH NETLOGO

SUBJECT

The objective of this effort is to create agent-based models to compare the distribution and flow of information in a hierarchical Command and Control organisation to that of a fully networked Edge Organisation. These experiments were conducted to exercise and strengthen the SAS-050 Conceptual Model.

APPROACH

It is important to understand how the efficiency and effectiveness of an organisation's performance are affected by the structure of its communications network. Capabilities such as information sharing and collaboration depend upon on network connections. This modelling effort investigated the set of network structures illustrated in Figure 10-8.1.

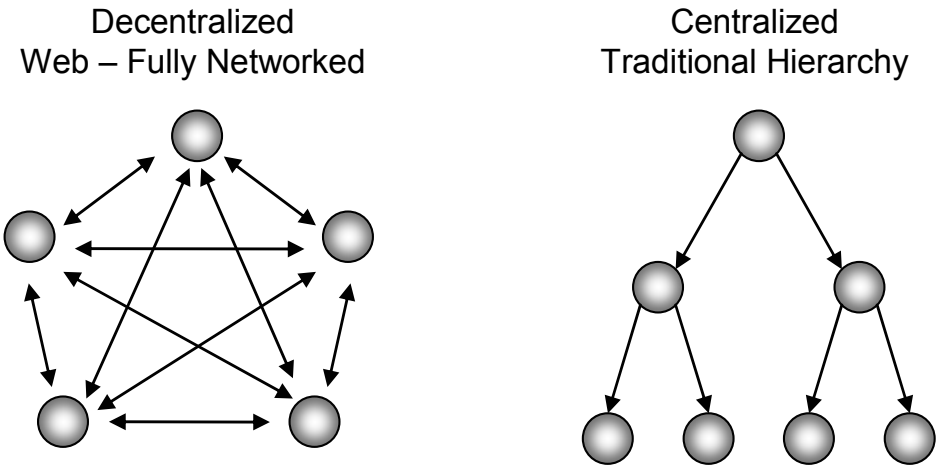

Figure 10-8.1: Four Network Topologies, Power to the Edge (p. 182).

Conducted as part of Case Study 1, the goal was to explore aspects of Network Centric Operations to support the development of the group's Conceptual Model of Command and Control.

These networks were examined in two different scenarios using different modelling tools. The first experiment focussed on the effect of a degraded communications network on an armed force under attack. The study was conducted using Map-Aware Non-uniform Automata (MANA). By data farming relevant communication parameters such as range, capacity, latency, accuracy, and reliability across a variety of network configurations, we were able to determine which communication factors are most important for a force to successfully share information. The study explored several operationally relevant scenarios ranging from the very simple setting to the complex. Primary focus will be placed on message range and accuracy, and how each affects the unit's ability to fight and win decisively. The aim of this analysis is to gain insight into the first order effects of networking on force effectiveness.

The second experiment, developed using NetLogo, models agents receiving information related to a future attack. The agents gather information related to four question areas. Collectively, the agents need to gather information facts to solve each of these questions. An organisation will have completed its task once it answers all four questions. Each organisation consists of agents and four Web sites. Agents need to share and post information in order to achieve their goal of building awareness in each knowledge area. Communication, namely the receiving, sharing, and posting of facts, is constrained by the network structure.

WHAT WE LEARNED

Agent-based modelling fills an important analytical gap in experimentation. Such models allow for rapid, repeatable concept exploration, which is an effective means of examining the impact of network technologies on a force. The use of computer simulations provides a basis for analysing and optimising the abilities of military forces in NCO. In studying the use of sensor systems, shared information, and collaboration, it was possible to determine the effects of information network structures on military situations. These experiments helped validate variables and connections illustrated in the CM.

By data farming relevant communication parameters such as range, capacity, latency, accuracy, reliability, and redundancy across a variety of network configurations, we can determine which communication factors are most important for a force to successfully share information. The aim of this analysis is to gain insight on the first order effects of networking on force effectiveness.

By conducting experiments using multiple modelling tools, we were able to investigate a broader set of variables. This detailed exploration of the variables and relationships defined by the SAS-050 group aided in identifying advantages and limitations of their conceptual model. Agent-based modelling is just one method of exercising and strengthening the C2 model.

REFERENCES

[1] Horne, Johnson, Martin. “Network Centric Operations Agent Based Modelling Group Team 2: Application of MANA and Data Farming.” Copenhagen, Denmark. 23 September 2005.

[2] Martin, Danielle. “An Application of Agent Based Modelling to Explore Effects on Organisational Performance.” Presented at the Peer-to-Peer Workshop, Virginia Beach, VA USA. 4-6 October 2005.

[3] Wilensky, U. NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modelling. Northwestern University, Evanston, IL. 1999.

Chapter 11 – TOOLS: REFERENCE MODEL RELATIONAL DATABASE & UML TOOL

INTRODUCTION

Pushing boundaries, the SAS-050 group sought after well developed software tools that would allow the group to express the Conceptual Model in ways that are useful for both validation and supporting studies. In order to capture the model and facilitate C2 analysis, a visualisation tool was needed. During the development of the model's key variables and the relationships, SAS-050 encountered some difficulties identifying a tool to capture multi-layered relationships. The need for new tools arose in order to explore different approaches and avoid shortcomings of previously used tools. With the lack of a readily available suite of tools that complied with the requirements set forth by the group, a proposal was made to express the model in both UML and MYSQL software. This effort made good use of a combination of available tools to achieve the group's mission, but it is clear that better developed tools would be useful to the community in the future.

REQUIREMENTS FOR TOOLS

In order to develop a concise model of C2 concepts, the group established a set of criteria to select a tool. These criteria are identified below:

- Provide multiple lenses; i.e. give different view to different people so that people with different perspectives see the same thing.
- Have the ability to bring other models to bear and to make sure they map.
- Be able to handle structure, process, and organisation as variables.
- Be able to handle multiple instantiations (and allow the user to "fix/make stable" particular variables).
- Allow for qualitative analysis, exploration, and browsing.
- Incorporate metadata.
- Be flexible enough to allow users to manipulate structure as a result of incorporating metadata.
- Allow users to specify particular kinds of nodes and links, and tool should help ensure consistency of definitions, usage, etc.
- Be capable of tracking changes within the model.

These criteria span both CM development and future use. The need for these tool support requirements can be seen in Figure 11-1.

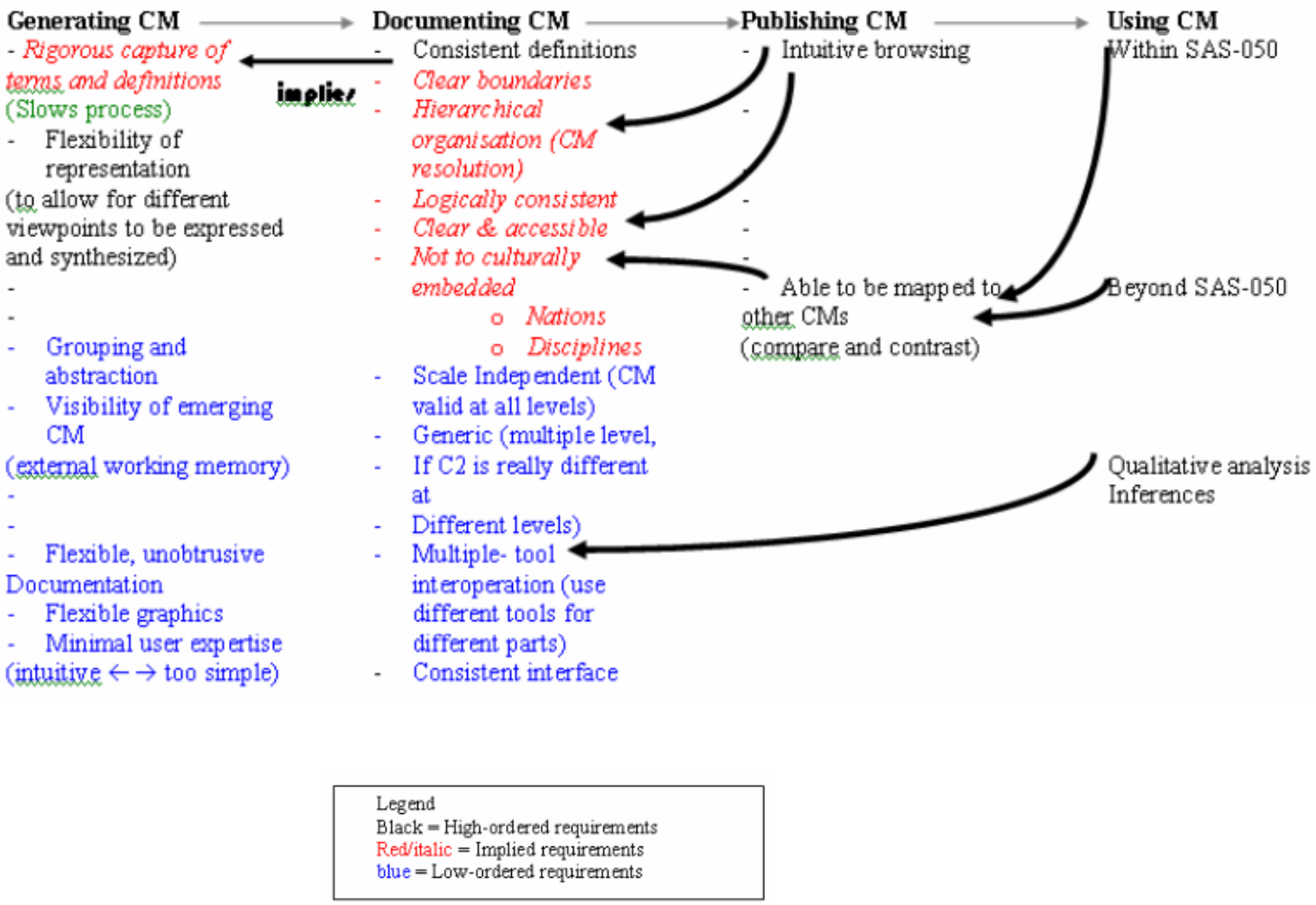

Figure 11-1: Requirements for Tool Support (including Facilitation).

HISTORY OF TOOLS EXAMINED

A wide range of tools were considered for use by the group. A subcommittee reviewed the suggested tools and critiqued the capabilities of each. The tools considered were:

- Octopus
- Decision Explorer
- UML
- Mind Manager
- Analytica
- PowerPoint
- Visio
- DPL
- Netica
- Influence analysis / system dynamics tools
- Influence diagram tools
- Casual Mapping tools
- Social networking tools (Blanche)
- MYSQL Relational Database/Visual Links

Initially the group began to capture their thoughts in PowerPoint documents. As the model increased in complexity, it was necessary to use a more advanced tool to combine multiple C2 concepts. After investigating the variety of tools listed above, the group agreed to capture their work in Analytica. Intended as a visual tool for creating, analyzing, and communicating decision models, Analytica depicted influence networks operating through the different levels of scale. While this tool provided a means to navigate the model, it was difficult for the user to understand the model in its entirety. This software package became overwhelmed by the amount data and it was necessary to identify an alternative tool with effective user interfaces. This additional functionality became a priority, since the CM should be able to support multiple views and tools. In the end, the combination of UML and MYSQL software satisfied the majority of tool requirements deemed necessary by the group.

DISCUSSION OF TOOLS USED

PowerPoint

- Strengths
  - Worldwide acceptance.
  - Ease of use.

- Weaknesses
  - Lacking a means of organisation.
  - Too generic.

Analytica/HTML

- Strengths
  - Easy navigation.
  - It can be exported in XML format (XMI).
  - Free viewer version of software to facilitate multinational collaboration (interoperability).
  - Configuration control.
- Weaknesses
  - Designed to be a visual tool for decision models rather than reference material.
  - Unstable due to Conceptual Model size.
  - Difficult to visualize multilayered relationships.

RELATIONAL DATABASE/MYSQL

The model is currently represented in MYSQL, an open source relational database management system.[1] The relational database was created using a standardized query language (SQL), which is fast and flexible. It allows for data to be stored in multiple tables rather than putting all of the data in one area. These tables are linked by defined relations making it possible to combine data from several tables upon request.

The team chose to utilize a database structure to capture their work for a variety of reasons:

- The database provides a means of configuration control. The group was able to view the material captured in the database and make suggestions for change. The proposed changes were then updated by a single user in order to maintain configuration control.
- The Reference Model must be available to a broader audience. The database can be posted to the group Web site where visitors can navigate through the model.
- In order for the Reference Model to prove useful for the C2 community, it must be accessible for use by other software applications such as statistical analysis packages, Visual tools, and modelling and simulation.

The database consists of a set of tables that depict the variables along with their definitions and relationships. A search function can assist the viewer in navigating the Reference Model. The data can also be imported into analysis packages such as Visual Links.

- Strengths
  - Easy navigation both in HTML and within tools.

[1] http://www.mysql.com/why-mysql/, http://www.mysql.com/doc/F/e/Features.html

- Software source code can be automatically generated (Attn: this requires appropriate design methods).
- It can be exported in XML format (XMI).
- It is a tool independent standard.
- Password protected for configuration control.

- Weaknesses
  - Math analysis/modelling not readily available (unlike in Analytica).
  - Finding the best way to model a system according to OOAD principles is more of an art than of a science.
  - Efficient modelling of complex systems and processes requires proper training: Package & class diagram + object diagram.

UML (INESC/INOV CONTRIBUTION)

UML is a language for the visualization, specification, construction and documentation of a system and its artifacts. UML is not a methodology. It provides a language and requires the user to find the best way to employ it.

It is not a software development process. It can be used for system analysis, for example. It is a standard and thus it is not dependent on specific tools. And it can be applied to many application domains.

We can have different, complementary views of the same system, which we call perspectives or projections. The UML concepts can be divided into elements, relations between elements, and diagrams.

Examples of structural elements are classes, objects, components, nodes, interfaces, etc. Behaviour elements can be states and state transitions. Grouping elements are packages, which can incorporate other model elements. Finally, notation elements can be placed as comments in the model.

There are several kinds of relations such as association, realization/instantiation, dependency, generalization, and state transition, aggregation, and composition, etc. Relations can have attributes like role and multiplicity. Diagrams can be of many kinds in order to capture different aspects of a system, be they functional, static, or dynamic.

In the case of the SAS-050 conceptual model, we believe that it can be best represented using packages, classes, and objects.

- Strengths
  - Easy navigation both in HTML and within tools.
  - Software source code can be automatically. Generated (Attn: this requires appropriate design methods).
  - It can be exported in XML format (XMI).
  - It is a tool independent standard.

- Weaknesses
  - Math analysis/modelling not readily available (unlike in Analytica).
  - Finding the best way to model a system according to OOAD principles is more of an art than of a science.
  - Efficient modelling of complex systems and processes requires proper training: Package & class diagram + object diagram.

CURRENT STATUS/FUNCTIONALITY

Currently the model is represented in UML and MYSQL. These software packages allow users to access the CM and utilize its contents to assist in the instantiation of C2 assessment modelling. Each tool facilitates the importing and exporting of CM data from or into particular tools that may have specialised views or analysis functions desired by different user groups. The broader community can access the CM through a password-protected link posted to the SAS-050 Web site (www.dodccrp.org) once released in early 2006.

RECOMMENDATIONS

The group recommends utilizing the model through a suite of tools. Multiple tools have added value as they allow the user to visualize the data in a variety of forms. The UML model proves useful for model navigation, while the MYSQL database provides a table format that can be imported into other software packages, which may be more tailored to a specific project. The CM is relevant to different user groups and can be customised for particular purposes. Utilizing the CM in this manner will increase both decisionmakers and analyst's comprehension of C2-related subjects.

Chapter 12 – THE PEER REVIEW PROCESS

The Peer Review process consisted of three events: a joint working meeting with SAS-053 in February 2005 at the Air Force Agency for Modelling and Simulation (AFAMS) in Orlando, FL, the Information Age Metrics Working Group (IAMWG) meeting in March 2005 at Evidence Based Research in Vienna, VA, and the Peer Review Workshop, hosted by NATO ACT, held in Virginia Beach, VA on October 4-6, 2005. Each of these events provided an opportunity for formal and informal dialogue regarding the model. The joint session with SAS-053 provided team members with feedback on the completeness and consistency of the identified variables and relationships between and among the variables. At the IAMWG meeting, an interim version of the model and its variables were shown to the group. In Virginia Beach, SAS-050 members gave detailed presentations of the model to a community of experts from NATO, PfP, and other interested nations for the purpose of eliciting constructive criticism and feedback to assist the Working Group in refining the model before presenting their results to the RTO. More specifically, the SAS-050 Working Group members explained the scope and magnitude of the task undertaken, to show what has been accomplished, and to demonstrate how the model could be applied.

JOINT SESSION WITH SAS-053

SAS-050 and SAS-053 held joint working sessions in Orlando. The primary objective was to familiarize each group with the other's work and plans, and to identify potential areas for synergy. SAS-050 members presented their work to SAS-053 to obtain feedback and to enable SAS-053 to work with SAS-050 to expand upon the human behaviour aspects then incorporated in SAS-050's Conceptual Model. The two teams discussed SAS-053's plan for a NATO Virtual Institute for Research on Human Behaviour Representation. SAS-050 will conclude before the SAS-053 capabilities are available. However, a follow-on group could try to take leverage the work of both groups. The following table displays SAS-053 members that participated in the joint session.

Table 12-1: List of Peer Reviewers at the Joint Session with SAS-053

Name	Organization
Dr. Sheila Banks	*Calculated Insight*
Ms. Elizabeth Bowman	*ARL*
Dr. Uwe Dompke	*NATO C3A*
Mr. Walter Dyck	*DRDC-Toronto*
Hawkins	*US ONR*
Ms. Anne Helsdinger	*TNO HF*
Mr. Allen Murashige	*HQ USAF/XIW*
Sheppard	*Dstl, UK*
Shumaker	*IST*
Dr. Martin Stytz	*IDA*
Ms. Janet Sutton	*ARL*

IAMWG REVIEW

The U.S. OSD sponsored an Information Age Metrics Working Group (IAMWG) in March 2005, in advance of the NATO peer review workshop in Virginia Beach. The group reviewed the model in its then current form. The following table displays those that participated in the IAMWG review.

Table 12-2: List of Peer Reviewers at the IAMWG Meeting

Name	Organization
Dr. David Alberts	*OASD/NII*
Mr. Todd Champberlain	*NORAD-USNORTHCOM*
Dr. Robert Clemence	*EBR, Inc.*
Mr. David J. Duncan	*EBR, Inc.*
Ms. Amber Fagan	*EBR, Inc.*
RAdm. Evelyn Fields (ret.)	*EBR, Inc.*
Dr. Richard Hayes	*EBR, Inc.*
Mr. Kirsch Jones	*Lockheed Martin*
Dr. Irving Lachow	*NDU*
Dr. Daniel Maxwell	*EBR, Inc.*
Mr. John Poirier	*SAIC*
Mr. Eugene Visco	*Visco Consulting*
Ms. Corinne Wallshein	*AFSAA*
Ms. Heather Warren	*EBR, Inc*
Ms. Mitzi Wertheim	*CAN*
Mr. Larry Wiener	

The IAMWG members provided a critique of the model structure, which the SAS-050 group later used to refine the product. During the IAMWG meeting, the suggestion of breaking down the model into smaller components or domains was put forward and resulted in this new criteria being added into the model. The overall achievement of the meeting was the identification of key variables and the discussion of important relationships that were needed to complete the model.

Figure 12-1 shows the three layers of the model with the middle layer (composite variables) as the main focus of the IAMWG meeting.

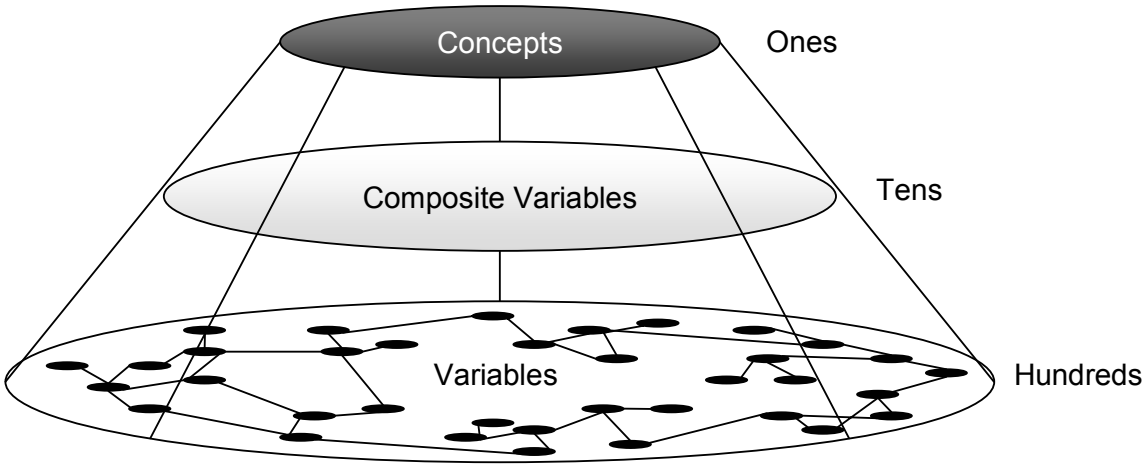

Figure 12-1: Conceptual Model Layers Presented at the IAMWG Meeting.

PEER REVIEW WORKSHOP

Workshop Attendees and Representation

Fifty-four people participated in the Peer Review Workshop. The participants consisted of:

- Government personnel including United States Office of the Assistant Secretary of Defence (OASD/NII), NATO Allied Command Transformation, the German Department of Defence, and United States Joint Forces Command;
- Private sector participants from industries such Boeing, SAIC, and QinetiQ;
- International representatives from countries such as the United Kingdom, Germany, Canada, and the Netherlands;
- Participants from the academic institutions such as the Naval Post Graduate School and Columbia University; and
- SAS-050 Group members.

Figure 12-2: Participants of the Peer Review Workshop.

The SAS-050 Team members who participated in the workshop are listed in Table 12-3.

Table 12-3: List of the SAS-050 Members that Participated in the Peer Review Workshop

Name	Nation	Organization
Dr. David Alberts	US	OSD NII, Chair SAS-050
Mr. Graham Cookman	UK	AMS
Dr. Lorraine Dodd	UK	QinetiQ
Ms. Petra Eggenhofer	GE	ITIS University of the Federal Armed Forces, Germany
Dr. Anne-Marie Grisogono	Australia	DSTO
Dr. Richard Hayes	US	EBR
Dr. Gary Horne	US	Marine Corps Warfighting Lab
Dr. Reiner Huber	GE	IT IS Universitiat der Bundeswehr
Ms. Danielle Martin	US	EBR
Mr. Graham Mathieson	UK	DSTL
Dr. James Moffat	UK	DSTL
Maj. Paulo Nunes	PO	Academia Militar
Dr. Paul Phister	US	AFRL
Mr. Valdur Pille	CA	DRDC-Valcartier
CPT Jens Roemer	GE	IT IS Universitiat der Bundeswehr
Mr. Mark Sinclair	US	EBR
M.Sc. Mink Spaans	NL	TNO Defence, Safety & Security
Ms. Kristi Sugarman	US	EBR
LTC (Ret) Klaus Titze	GE	IT IS Universitiat der Bundeswehr

Peer Reviewers from 6 nations participated and are listed in Table 12-4.

Table 12-4: List of Peer Reviewers that Participated in the Peer Review Workshop

Name	Nation	Organization
Mr. Anthony Alston	UK	QinetiQ
Mr. Don Anderson	US	JFCOM J9 (Contractor)
Mr. Bernard Arata	FR	SACT
Mr. Timothy Bacon	US	USJFCOM J9
Mr. Paul Bloch	US	Boeing
Mr. Gary Bradley	US	Dataline
Mr. Ian Carter	UK	ACT
Mr Victor Corona	US	Columbia Univ
Mr. Louis de Chantal	FR	NATO ACT
Mr. Shane Deichman	US	USJFCOM J9
Mr. Bruce Dickman	US	TRADOC/S3
Mr. David Grant	US	NATO ACT
Mr. Jeffrey Hansberger		ARL
WgCdr Torben Harris	UK	RAF
Dr. Paul Hiniker	US	DISA
Dr. Susan Hocevar	US	NPGS
Mr. Fred Koch	US	USJFCOM J9 Contractor
Mr. Tor Langsæter	Norway	
Dr. Clifford Lieberman	US	USJFCOM/GD-AIS
Mr. Martin Lidy	US	IDA
Mr. Steven Litwiller	US	NATO ACT
LTC Steele MacFarlane	US	USJFCOM J9
Mr. Billy Murphy	US	BCBL Leavenworth
Dr. James Myers	US	NG-MS
LTC J. Neureuther	GE	Bundeswehr Transformation Center @ USJFCOM-J9
LtCol Mike Newman,	UK	SO1 CDE Comd
COL James O'Neal	US	USJFCOM J9
Mr. George Pickburn	UK	Defence Science & Technology Laboratory
Mr. John Poirier	US	SAIC
CAPT Denis Raguin	FR	ACT, NNEC ICT
Mr. Tom Roskowski	US	Lockheed Martin
LtCol Heinz Schweitzer	GE	GE DoD
Dr. Ed Smith	US	Boeing
Dr. Richard Taylor	Australia	DSTO
Mr. Charles Turnitsa	US	VMASC
CDR Arnaud VanDame	FR	NATO ACT
Dr. Colin Wright	UK	NATO ACT

WORKSHOP AGENDA

During the course of the three day event, presentations covered topics such as Criteria for a Conceptual Model, Structure of the Reference Model, Approach to C2 and Decisionmaking, Value View, Information Domain, Individual and Team Characteristics and Relationships, Validation, Tools, Adaptability and Emergent Properties, Example Applications, Agent-Based Modelling, Guidelines for Use, and Future Work Needed.

AGENDA FOR THE PEER REVIEW WORKSHOP

Tuesday	0730	Registration
	0830	Welcome & Opening Remarks – Allied Command Transformation (ACT)
	0845	**Keynote Address** – CAPT Denis Raguin, ACT, NNEC ICT
	0915	**ACT & the RTO** – Dr. Colin Wright, ACT
	1000	Break
	1030	**Overview** – Dr. David S. Alberts, US OSD/NII, Chair SAS-050
	1200	Lunch
	1330	Feedback & Discussion
	1415	**Criteria for a Conceptual Model of C2 –** Dr. Anne-Marie Grisogono
	1445	**Structure of the Model (Intermediate Level)** – Dr. Richard Hayes, Dr Reiner Huber
	1545	Break
	1615	**C2 Approach –** Dr. Richard Hayes, Dr. James Moffat
	1745	End of Session
	1800	Reception
Wednesday	0800	Facilitated Discussion/Feedback
	0830	**Composite Variables Value View** – Mr. Valdur Pille, Mr. Mink Spaans **Structure of the Model – Information Domain** – Dr. Paul Phister, Dr. Lorraine Dodd
	1000	Break
	1030	**Individual & Team Characteristics & Behaviours** – Ms. Petra Eggenhofer, Dr. Reiner Huber, Mr. Graham Mathieson, CPT Jens Roemer, LTC (Ret) Klaus Titze
	1200	Lunch
	1330	Facilitated Discussion/Feedback
	1400	**Validation of the Conceptual Model** – Dr. James Moffat, Mr. Graham Mathieson
	1500	Break
	1530	**Tools – Relational Database** – Ms. Danielle Martin **Tools – UML Version** – Maj Paulo Nunes
	1700	End of Session

Thursday	0800	Facilitated Discussion/Feedback
	0830	**Example Applications**
		AF2T2EA – An Illustrative Example (US Air Force) – Dr. Paul Phister, Mr. Mark Sinclair
		Collaborative Applications of Agent Based Modelling & Data Farming – Overview – Dr. Gary Horne, Dr. Lorraine Dodd
		An Application of Agent Based Modelling to Explore Effects on Organisational Performance – Ms. Danielle Martin
		Agent-Based Models and the Conceptual Model – Mutual Benefits – CPT Jens Roemer
	1000	Break
	1030	**Application and Guidelines for Use** – Dr. Richard Hayes, Dr. Anne-Marie Grisogono, Dr. Reiner Huber, Mr. Mark Sinclair
	1100	Facilitated Discussion/Feedback
	1200	Lunch
	1330	**Future Work**
		Overview
		Code of Best Practice for C2 Assessment Redux – Dr. James Moffat
		Cognitive and Social Experimentation – Ms. Petra Eggenhofer
		Break
		Assessment of Emerging Concepts of Operation – Dr. David Alberts
		Focus on Dynamic Emergent Properties – Dr. Anne-Marie Grisogono
	1630	**Feedback & Wrap-up**
	1700	End of Workshop

THE PEER REVIEW WORKSHOP

The peer review process generated by the workshop was essential in order to obtain constructive feedback on the strengths and weaknesses of the model itself and the groups' ability to present it in a clear and coherent fashion. Each sub-group of the SAS-050 Working Group presented their portion of the model and then opened the floor to comments and feedback from the peer reviewers. The agenda shows the order of presentations, and identifies the sub-groups that worked together throughout the creation of the model. Upon completion of the workshop, the feedback was assembled, analysed, and accepted or rejected by the SAS-050 Working Group. Changes were made to the model to reflect the accepted comments of the peer reviewers.

SUMMARY OF FEEDBACK FROM PEER REVIEWERS

The SAS-050 Working Group received comments on each portion of the model that was presented during the 3-day workshop. The comments were divided into the following categories that generally corresponded to the sub-working groups:

- Criteria;
- Structure;
- C2 Approach;
- Value View;
- Information Domain;
- Tools;
- Validation;
- Individual and Team; and
- Miscellaneous.

Many comments were received, both positive and negative, with regard to the model and its application. One comment that arose multiple times was the need to review the group's definition of the Conceptual Model, its main objective, and the arena in which it will be used (i.e., military or civilian). A number of the reviewers felt the model was only applicable for use within the military while a smaller number of people felt that the model, with a few adjustments, could be used for civilian-led operations as well.

Another frequent comment regarding the Conceptual Model as a whole was whether it was a "Conceptual Model" or a "Reference Model." A number of comments noted that there needed to be greater clarification of the terms Conceptual Model and Reference Model, and that there should be a clear distinction drawn by the group with respect to this model. One suggestion was to seek clarification during the validation process and then determine the type of model that the group had put together.

An often-repeated concern of the majority of the peer reviewers involved the description of the intermediate level variables and their structure. To many, it appeared to be an artificial construct inserted to aid in the explanation of the model when, in fact, it only confused most who examined it. After review of these comments, the SAS-050 group decided to take out the intermediate level and focus on the top-level view and the variables within each domain. This also prompted the SAS-050 Working Group to focus on the top-level view and reassess the model's structure. The overview diagram of the model seemed to confuse many of the peer reviewers who suggested a new top-level view (diagram) might be drawn to reflect the domains and the important variables within them.

While all of the comments were useful, some of the general comments suggested posting material to a Web site so that outsiders could use the group's findings in their respective fields and alluded to the challenges faced by the group due to working with a number of countries that may have unique goals. Many felt that, at first glance, the model was appealing; yet, it needed additional work to explore the variables and their relationships in more depth. Lastly, the general consensus of the peer reviewers was that the work was very important, had made a major contribution to the ability to study C2, and needed to continue on after the end of SAS-050 in order to allow for further development and proof of the model through instantiation in a specific case study.

SYNTHESIS OF FINDINGS AND LESSONS LEARNED

The peer reviewers identified some key issues that needed to be addressed by the group. It was apparent that the top-level diagram caused some concern and confusion regarding the model layers. As a result of the peer review process, significant work was done by the individual SAS-050 Working Group members and by the Working Group collectively in Berlin in order to rethink how to better represent and summarize the model.

ACTION ITEMS

The SAS-050 members met the day after the conference to discuss the feedback they received. The group identified areas for improvement and divided up work for the final report. Dialogue and collaboration followed in order to further develop and refine the Conceptual Model. Efforts were taken to develop a final briefing for the NATO SAS Panel. Additional work was done to solidify a topic for a follow-on group.

Chapter 13 – THE WAY AHEAD

OBSERVATIONS

The Working Group concluded, and reported to the SAS Panel in November 2005, that the C2 Conceptual Reference Model it produced represents an enormous amount of progress in the state of the art, specifically, the:

- Specification of the criteria for a successful or useful conceptual model;
- Identification of the fundamental dimensions across which meaningfully different C2 Approaches vary;
- Providing a framework and a set of variables that constitute a more detailed and robust understanding of the role of individual and team characteristics and behaviours within the C2 domain;
- Demonstration of the value of including diverse perspectives when undertaking C2-related research; and
- Provision of a Reference Model that can be applied by researchers within NATO and NATO countries to a variety of C2 issues.

However, SAS-050 cautioned that the Reference Model of the CM was not fully mature, noting that the Working Group simply did not have enough time and resources to complete such a large and complex task. Moreover, the group noted that the C2 Conceptual Reference Model was generic (as it should be) and thus was not specific enough to adequately represent any particular specific C2 Approach, but needed to be tailored (in an instantiation) before it was applied.

The Working Group also found that its diverse composition and the processes it employed were valuable and should be built on in future SAS efforts. The team was built around a core of individuals representing several nations who have worked together on a series of previous SAS/NATO efforts (RSG-19, SAS-026, and SAS-039), and who have developed a set of work processes that have proven effective over time. That core group was augmented in three important ways for SAS-050: (a) younger members from several nations who brought new knowledge and methods to the group; (b) members from the research communities of non-NATO nations (Australia and Sweden) with novel perspectives; and (c) greater representation from the social sciences, which enabled work on factors not dealt with in detail during prior efforts. The experience of SAS-050, which followed the principles outlined in the *NATO Code of Best Practice for C2 Assessment,* is richly suggestive of next steps and how to make them productive.

RECOMMENDED NEXT STEPS

While SAS-050 was underway, NATO made an important decision about the specific class of C2 Approaches that it plans to follow: it formally adopted NATO Network Enabled Capability (NNEC). Currently, NATO has begun moving toward developing that capability.

With this initiative and the fact that the current CM was immature in mind, the SAS-050 Working Group decided at its last formal meeting to recommend that an Exploratory Group be chartered by the SAS Panel to examine the possibility of creating a new working group that would:

- Generate a more focussed and mature Conceptual Model that explicitly focuses on NNEC;
- Develop a maturity model by which NATO, NATO nations, and other nations interested in having the capability to work with NATO could plan and measure their progress;
- Examine illustrative cases as a way of both improving and assessing the quality of the NNEC Conceptual Model. These illustrative cases would assume NATO operating under different circumstances important to the nations, including, but not limited to:
  - Operating out of area,
  - Operating with non-NATO coalition partners, including disadvantaged partners,
  - Dealing with asymmetric threats,
  - Working with the UN or other international organisations, and
  - Examining the challenges necessary for individual nations seeking to develop C2 Approaches consistent with NNEC;
- Encourage participation from a greater number of NATO nations, Partnership for Peace nations, and other nations able to contribute to or benefit from the effort;
- Conduct technical exchanges with international, non-governmental, and private entities with an interest in seeing NNEC function successfully;
- Seek to understand, to a greater degree, how complexity and agility can be represented meaningfully during research on C2 Approaches; and
- Use this experience to improve the current Conceptual Reference Model.

The members of SAS-050 believe that moving ahead along these lines would benefit SAS, NATO, member nations, and indeed the global communities interested in transformation and C2 in several important ways. A Conceptual Model of NNEC would allow NATO-wide and individual nations to analyze NNEC (network-centric) issues in a coordinated manner that would foster the development of a common analytical framework, both increasing the efficiency of such efforts and also making it much easier to use analyses done by one nation or for one purpose to inform others. The proposed work would also improve the research community's capacity to explore C2 Approaches under conditions of complexity. The development of an NNEC maturity model, one of the most important products of the recommended effort, would be valuable in its own right to NATO, particularly Allied Command for Transformation, and for member nations. In addition, the processes of developing, refining, and validating a NNEC Conceptual Model would increase understanding of the topic within NATO and NATO nations. Finally, this effort would support continued refinement and maturation of the larger Conceptual Model of alternative C2 Approaches.

In addition, the chairman and members of the SAS-050 recognized that their efforts could benefit other SAS and NATO activities and indicated their willingness to work with others (either as individuals or in small teams) such as those already working on human factors in military organisations, experimentation on issues of importance to NATO, and information operations.

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Annex C – TERMS OF REFERENCE, SAS-050: EXPLORING NEW COMMAND AND CONTROL CONCEPTS AND CAPABILITIES

1. ORIGIN

The ability to represent and explore command and control (C2) and new network-centric command concepts was identified by SAS-026 as a high priority area for future research. This long term study seeks to explore collaborative planning, self-synchronization, individual cognition, and individual and organizational behaviour in order to support a conceptual model that will capture our current C2 knowledge, and support further exploratory analysis.

2. MILITARY BENEFITS

By exploring new network-centric command concepts, SAS-050 will provide the military with tools suitable for examining future C2 concepts, further Measures of Merit (MoMs), and an expert panel of peer reviewers available for similar studies.

3. GOALS AND OBJECTIVES

The goal of SAS-050 is to develop a conceptual model of C2 and demonstrate its utility in capturing our knowledge regarding C2; and supporting exploratory analysis. This model will strive to incorporate variables related to individual cognition and individual and organizational behaviour necessary to represent and explore C2. The model will be designed to represent and explore new network-centric command concepts including collaborative planning and self-synchronization.

SAS-050 has the following objectives with respect to exploring C2 and new network-centric concepts and capabilities:

- Develop a conceptual model of key variables and their relationships.
- Use tools to explore relationships between variables.
- Apply the model and tools to a related issue.
- Disseminate exploratory capability for further analysis.
- Conduct peer review with experienced analysts and researchers.

4. SCOPE

The research shall begin with the identification of key variables and the relationships among them. A survey will be conducted to identify the MoMs and the related instruments available. Workshops will be held to identify existing tools that explore relationships among key variables. Existing tools will be adapted, and new tools developed to explore the relationships among variables identified in Task 1. The current conceptual model and applicable tools will be applied to a set of issues related to the nature and effectiveness of new approaches to command and control. These products will be disseminated to allow others to assess its utility. A formal peer review will then be established with experienced analysts and researchers for all relevant areas of expertise.

5. PRODUCTS

The following products will be produced by SAS-050:

- Conceptual model of C2;
- Identification of a set of tools suitable for examining future C2 concepts;
- Analysis of one or more of the fundamental hypotheses;
- Compilation of suitable MoMs;
- List of experts that could serve on peer review panels for similar studies;
- Briefing to the SAS Panel; and
- Education materials for the community.

6. DURATION

This study will be undertaken over a period of two and one half years. Meetings / workshops will be held three to four times a year, with the first meeting to occur in winter of 2002-3 if possible. Additional work will take place in between meetings using the WWW and a Web site created by the study chair. Where feasible and desirable, SAS-050 meetings will leverage relevant symposia and workshops (e.g., the International C2 Research and Technology Symposium). A detailed schedule is provided in the accompanying POW.

7. RESOURCES

Membership is open to NATO nations, PfP partners, and selected and invited experts from other countries, and organisations. The following nations have expressed an interest in participating: CA, FR, NL, NO, UK, GE, and US. NC3A has also expressed an interest in participating. Other countries with significant expertise include AU and SE. The US is prepared to chair SAS-050, and to provide additional resources to support SAS-050 activities. Membership shall remain open for the duration of SAS-050.

8. SECURITY

Although SAS-050 may hold selected meetings at a classification level up to and including NATO Secret, it is intended that the bulk of the group's work will be unclassified, cleared for public release, and for unlimited distribution.

Annex D – PLAN OF WORK: EXPLORING NEW COMMAND AND CONTROL CONCEPTS AND CAPABILITIES

1. OVERVIEW

The purpose of the Program of Work (POW) is to provide a conceptual model of C2 and demonstrate its utility in (1) capturing our knowledge re: C2, and (2) supporting exploratory analysis. This model will strive to incorporate variables related to individual cognition and individual and organisational behaviour necessary to represent and explore C2, as well as the facility to represent and explore new network-centric command concepts including collaborative planning and self-synchronization.

SAS-050 will undertake the following five tasks in an iterative fashion.

- Task 1: Develop a Conceptual Model
- Task 2: Identify, Adapt, and Encourage the Development of Exploratory Tools
- Task 3: Perform an Exploratory Analysis
- Task 4: Disseminate Conceptual Model, Findings, and Lessons Learned
- Task 5: Provide for Peer Review
- Task 6: Produce Study Products

These will be conducted through the series of the eight events depicted in Section 3 of this document "SAS-050 Schedule." Additional work will be performed in between meetings via the WWW.

2. TASK DESCRIPTIONS (WITH TASKS AND PRODUCTS)

It is intended that the emphasis of our efforts would be on the evolution of new ideas related to loosely coupled command systems and distributed command approaches.

Task 1. Develop a Conceptual Model

First, identify key variables and the relationships among them. Second, identify related MoMs and their relationships (qualitative, causal, correlational, co-variable), including (but not limited to):

- Quality of information
- Information dissemination and sharing
- Perceptions of information
- Shared Situational Awareness
- Human characteristics and performance
- Organisational structures and processes
- Command and control approaches
- Task / Mission Performance

As part of this task, a survey will be conducted to identify appropriate MoMs that have been defined, are in use, and the related instruments available.

Task 2. Identify, Adapt, and Encourage the Development of Exploratory Tools

Find, adapt, and encourage the development of a set of tools to explore the relationships identified in Task 1. This includes both tools that have the ability to manipulate multiple variables to generate a "response surface" as well as those tools that can support the development of metamodels to make sense of the complex relationships involved and distil outputs.

Task 3. Perform an Exploratory Analysis

Demonstrate the utility of the conceptual model and the set of exploratory tools by applying them to a set of issues related to the nature and effectiveness of new approaches to command and control. Issues to be explored may include:

- Relationships between information quality, its dissemination, and situation awareness.
- Relationships among improved situation awareness, collaborative processes, and improved synchronization as a function of various command approaches.
- Relationships between interoperability/co-operability and awareness, shared awareness, and synchronisation.

Task 4. Disseminate Conceptual Model, Findings, and Lessons Learned

Efforts will be undertaken to disseminate the conceptual model developed in Task 1, information about the exploratory tools identified in Task 2, and the results of the exploratory analysis performed in Task 3. This will facilitate peer review and set the stage for a to-be proposed SAS RSY at an appropriate time.

Task 5. Provide for Peer Review

Provisions will be made to subject the work of this RTG SAS-050 to peer review. This will involve reaching out beyond member nations to find the best possible reviewers in the international community to serve as peer reviewers. The to-be proposed RSY will also serve as a venue for peer review.

Task 6. Produce Study Products

The following products will be produced:

- Conceptual model of C2
- Identification of a set of tools suitable for examining future C2 concepts
- Analysis of one or more of the fundamental hypotheses
- Compilation of suitable MoMs
- Identification of experts that could serve on peer review panels for similar studies
- Briefing to NATO panel
- Educational material for the community

3. MILESTONES/SCHEDULE

Eight meetings are planned over 2 ½ years. Additional work will be accomplished in between meetings using the WWW and a website to be established by the RTG SAS-050 chair.

Meeting 1: June 2003

Organization, Planning, and Preliminary Formulation of the Conceptual Model (3 days)

The purpose of this kick-off meeting is to review the TOR, develop a detailed project plan, identifying dates, hosts, and objectives of SAS-050 meeting to begin work on the conceptual model of C2 that will guide the analysis and be matured over the course of the analysis, and to formulate one or more C2 issues (tentatively specified in the POW) to be explored.

Meeting 2: (3 days)

Conceptual Model Workshop

This workshop will, while concentrating on the development of a conceptual model of C2 (identify key variables and their hypothesized relationships, suitable MoMs and their interrelationships, and bounds on these variables), complete a first iteration of the C2 assessment process specified by the *NATO COBP for C2 Assessment*.

Meeting 3: (4 days)

Tools Workshop

This workshop will bring together developers and users of various tools that can be used to represent and explore human and organizational performance. The ability of these tools to form part of a solution strategy for C2 assessment will be explored.

Meeting 4: (3 days)

Case Studies Session 1

This meeting will be organized around presentations of a case study exploring one of the issues identified. Lessons learned from this case study will form the basis for identifying modifications needed to the Conceptual Model and to the set of tools available for their exploration.

Meeting 5: (3 days)

Case Studies Session 2

This meeting will be organized around presentations of the same, or a second case study exploring one of the issues identified. Lessons learned from these case studies will form the basis for identifying modifications needed to the Conceptual Model and to the set of tools available for their exploration.

Meeting 6: (3 days)

Integration

This meeting will serve to review and integrate the lessons learned from the case studies and feedback from the community.

Meeting 7: (3 days)

Conceptual Model and Requirements for Exploratory Tools

The original formulation of the conceptual model for C2 will be revisited and modified as appropriate. The characteristics and capabilities that are necessary for the full exploration of C2 issues related to future command concepts and related human and organizational issues will be identified.

Meeting 8: (3 days)

Final Products

Produce remaining study products.

Annex E – C2 VARIABLE DEFINITIONS

Variable Name	Variable Description
Achievement Orientation: Culture	A cultural dimension, characterized by the degree to which values such as assertiveness, the acquisition of money and material goods, and competition prevail in a society [derived from the original concept "Masculinity"].
Achievement Orientation: Personal Values	An individual attitude, characterized by the degree to which an individual values assertiveness, the acquisition of money and material goods, and competition [derived from the original concept "Masculinity"].
Action Accuracy	Extent to which actions executed are directed to the intended purpose.
Action Appropriateness	Extent to which actions executed are the appropriate ones to achieve the intended purpose.
Action Completeness	Extent to which actions executed encompass the full scope of the plan or order.
Action Consistency	Extent to which actions executed are consistent with actions in an earlier timeframe.
Action Correctness	Extent to which actions executed without error.
Action Efficiency	Extent to which actions executed are efficient in the use of resources.
Action Precision	Extent to which actions executed are precisely related to the intended purpose.
Action Synchronization	Purposeful arrangement of actions in time, space and purpose. JCS Dictionary of Military and Associated Terms
Action Timeliness	Extent to which actions are executed at the time required by the plan or order (in the case of self-synchronising forces the plan could be an ad hoc arrangement between peers).
Adaptive Behaviour	Any process whereby behaviour or subjective experience alters to fit in with a changed environment or circumstances or in response to social pressure (Colman, A.M. (2003). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Adaptiveness	The ability to change work processes and the ability to change the organization. (Power to the Edge, 2003)
Agreeableness	Personality trait characterized by being pleasant, characterized by kindness, generosity, warmth, unselfishness and trust (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Alertness	State characterized by the preparedness to recognize and to react to stimuli. "Continuous Alertness": Selective recognition of and reaction to continuously or frequently occurring stimuli. "Vigilance": Recognition of and reaction to irregularly and infrequently occurring events.
Allocation of Decision Rights	The distribution of choices related to a particular topic under a set of circumstances or conditions disseminated to the international community, a society, an enterprise, or an organization.
Ambiguity of Situation	Extent to which information does not lend itself to interpretation.
Ambiguity Tolerance	The degree to which one is able to tolerate lack of clarity in a situation or in a stimulus.

Variable Name	Variable Description
Anxiety	The affective state characterized by apprehension, dread, distress, uneasiness (Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books.
Authentication	A security measure designed to protect a communications system against acceptance of a fraudulent transmission or simulation by establishing the validity of a transmission, message, or originator. JCS Dictionary of Military and Associated Terms
Awareness Accuracy	Appropriateness of precision of awareness for a particular use NCO CF
Awareness Completeness	Extent to which awareness necessary form understanding is obtained. NCO CF Awareness completeness includes awareness about capabilities, environment, forces, intentions, and mission.
Awareness Consistency	Extent to which awareness is consistent with relevant awareness at an earlier time period NCO CF
Awareness Correctness	Extent to which awareness is consistent with ground truth NCO CF
Awareness Currency	Time lag of awareness NCO CF
Awareness Precision	Level of granularity of awareness NCO CF
Awareness Relevance	Extent to which awareness obtained is related to task at hand NCO CF
Awareness Timeliness	Extent to which currency of awareness is suitable to its use NCO CF
Awareness Uncertainty	Subjective assessment of awareness uncertainty NCO CF
Blood Sugar Level	Level of blood glucose. High blood sugar leads to hyperglycaemia, low blood sugar leads to hypoglycaemia. cancerweb.ncl.ac.uk
C2 Doctrine	Fundamental principles by which the military forces or elements thereof guide their actions in the command and control arena in support of national objectives. Based on US JCS Pub 1 definition of doctrine
Cognitive Capacity	The amount of information the human brain can hold and process within a given time (Oxford Dictionary of Economics. Original reference: H. A. Simon, Models of bounded rationality, Volume 2, Cambridge, Massachusetts (MIT Press, 1982)).
Cognitive Complexity	The degree to which a person is able to differentiate cognitive elements, and the degree to which these elements can be integrated or related to each other (e.g., Fransella & Bannister, 1977; Schroder et al., 1967; Wyer, 1964; citation (p. 782) from Van Hiel, A. & Mervielde, I. (2003). The Measurement of Cognitive Complexity and Its Relationship With Political Extremism. Political Psychology, 24 (4), 781-801.
Cognitive Flexibility	An individual's willingness and ability to change in their understanding of a situation when confronted with new or contradictory information.
Cohesion	The degree to which team members are attracted to each other and motivated to stay in the team.
Collaboration Capacity	Team members' ability to working together towards a common purpose.

Variable Name	Variable Description
Collaboration Completeness	Includes collaboration about capabilities, environment, forces, intentions, and mission.
Collaboration Mechanism	System that enables collaboration.
Collaboration Participants	The ability of team members to work together towards a common purpose.
Co-Located / Distributed	Distributed: Placed or positioned so as to be properly apportioned over or throughout an area. Co-located: placed together; especially: to place (two or more units) close together so as to share common facilities. (Websters)
Command Speed	Time lag between an occasion for action and the implementation of action or a decision not to respond. Headquarters Effectiveness Assessment Tool User's Manual. McLean, VA: Defense Systems, Inc., 1984. Note: Speed of Decision is a synonym for this variable.
Commanders Decision Style	A commander's habitual approach to affecting a choice and then acting on that choice. They way in which operational objectives are implemented in a systematic and efficient way (Connor, P.E. & Becker, B.W. (2003). Personal Value Systems and Decision-Making Styles of Public Managers. Public Personnel Management, 32 (1), 155-180).
Commanders Leadership Behaviour	Authoritative vs. cooperative, task orientated vs. relationship orientated, transactional vs. transformational.
Commanders Myers-Briggs Style	The commander's ability to communicate data and interacts with others. The Myers-Briggs Typology: Attitudes: "Extraversion vs. Introversion"; Perception: "Sensing Perception vs. Intuitive Perception"; Judgment: "Thinking Judgment vs. Feeling Judgment"; Orientation to the outer world: "Judging vs. Perceiving". Sensing Perception refers to the tendency to rely on perceptions observable by way of the senses. Intuitive perception refers to the tendency to perceive possibilities, meanings, and relationships by way of insight. Thinking judgment: Persons who are primarily oriented toward thinking may develop characteristics associated with principles of justice and fairness, criticality, and an orientation to time that is concerned with connections from the past through the present and toward the future. Feeling judgment: Persons who are primarily oriented toward thinking may develop characteristics associated with principles of justice and fairness, criticality, and an orientation to time that is concerned with connections from the past through the present and toward the future. Perceptive attitude: In the perceptive attitude, a person is attuned to incoming information. Judging attitude: In the judging attitude, a person is concerned with making decisions, seeking closure, planning operations, or organizing activities. (Myers, I.B. & McCaulley, M.H. (1992). Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator. Palo Alto: Consulting Psychologists Press).
Commanders Risk Propensity	A commander's natural inclination or preference for being exposed to possible harm or loss. (Websters)
Commitment/Loyalty	The degree to which an individual identifies with their organization or group and its goals and wishes to maintain membership with the organization/group.

Variable Name	Variable Description
Communication System Characteristics	Communication System Characteristics: The distinguishing traits, reach, reliability, robustness, richness of a communication system. Webster's Ninth Collegiate Dictionary and Understanding Information Age Warfare
Communications Interoperability	The condition achieved among communications-electronic systems or items of communications-electronic equipment when information or services can be exchanged directly and satisfactorily between them and/or their users. US JCS Pub 1 Dictionary of Military and Associated Terms
Complexity of Situation	The degree to which the relevant information is complicated (involves many factors), and involves intricate linkages; and is therefore difficult to understand.
Complicated-ness	A system with a large number of degrees of freedom. (Moffat)
Confidentiality	Information or material that requires protection from unauthorized disclosure which could reasonably be expected to cause damage to the national security. JCS Dictionary of Military and Associated Terms
Conformity	"Conformity" as a human attribute: Tendency to allow ones opinions, attitudes, actions and perceptions to be affected by prevailing opinions, attitudes, actions and perceptions. ""Behavioural conformity"" is the tendency to attempt to act in ways consistent with the majority; ""attitudinal conformity"" is the tendency to change an attitude or belief in response to pressure from others, which may but need not result in behavioural change; ""conformity as a personality trait is the tendency for an underlying characteristic of an individuals personality to change under the influence of behavioural or attitudinal conformity"" (Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books). ""Conformity"" in general: ""Correspondence in form, manner, or character. An index of conformity ranging from none (0) to perfect (1.0)"" Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam Webster, Inc.: 1986.
Conscientiousness	Personality trait characterized by organization, thoroughness, reliability, practicality; absence of carelessness, negligence, unreliability.
Consistency of Command Intent	A concise expression of the purpose of the operation and the desired end state that serves as the initial impetus for the planning process. It may also include the commander's assessment of the adversary commander's intent and an assessment of where and how much risk is acceptable during the operation. (JP 5-00.1)
Constraint Enforcement	To force by imposed stricture, restriction, or limitation Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam Webster, Inc.: 1986.
Constraint Setting	Establishing constraints. The state of being checked, restricted, or compelled to avoid or perform some action. Merriam-Webster, Inc.: 1986.
Continuity of Interactions	An uninterrupted succession or flow mutual or reciprocal actions or influences. Webster's Dictionary and the American Heritage Dictionary
Cooperability	The ability to engage in co-operative behaviour in a team, e.g. by information sharing and mutual support.

Variable Name	Variable Description
Cooperative Behaviour	The practice of people or greater entities working in common with commonly agreed-upon goals and possibly methods, instead of working separately in competition. URL: http://en.wikipedia.org/wiki/Cooperation [10.03.2005]
Criticality	The significance and importance of decisions. NCO CF Version 2.0
Data Interoperability	A level of interoperability in which data from one system can be used directly as data in another system, without translation or transformation.
Databases	Collection of information organized in a structured fashion.
Decision Accuracy	Appropriateness of precision of decision (plan, directives) for a particular use. NCO CF
Decision Completeness	Extent to which relevant decisions encompass the necessary: depth: range of actions and contingencies included, breadth: range of force elements included, time: range of time horizons included. NCO CF
Decision Congruence	Extent to which decisions taken at different times or different locations are consistent with one another.
Decision Consistency	Extent to which decisions are internally consistent with prior understanding and decisions. NCO CF
Decision Correctness	Extent to which a decision is consistent with ground truth. NCO CF
Decision Currency	Time taken to make a decision (start time – external signal). NCO CF
Decision Participants	The number of individuals or perspectives taking part in a decision.
Decision Precision	Level of granularity of decisions. NCO CF
Decision Relevance	Extent to which a decision is significant to the task at hand. NCO CF
Decision Speed	The time required to make a decision after the need for a decision is recognized.
Decision Style	A habitual (albeit learned) approach to effecting a choice and then acting on that choice. “Analytical decision style”: Logical, abstract thinking, performance is achieved by analysis, planning, forecasting. “Behavioural decision style”: Supporting behaviour and empathy, performance comes from focusing on people and their needs. “Conceptual decision style”: Broad, creative thinking, performance is achieved by exploring new options, forming new strategies, being creative, and taking risks. “Directive decision style”: Focused thinking and production of rapid results, implementation of operational objectives in a systematic and efficient way (Connor, P.E. & Becker, B.W. (2003). Personal Value Systems and Decision-Making Styles of Public Managers. Public Personnel Management, 32 (1), 155-180).
Decision Timeliness	Extent to which currency of decision making is suitable to its use. NCO CF
Decision Type	Extent to which a decision is based on rules, algorithms or human judgment.
Decision Uncertainty	Process of generating command intent. NATO COBP for C2 Assessment.
Development of Intent	Process of generating command intent. NATO COBP for C2 Assessment.
Direct Sensing	Direct sensing takes place when humans experience an object or event in the physical domain with one of their senses (such as seeing, hearing, or smelling), and the sensing registers directly in the cognitive domain. Understanding Information Age Warfare.
Discovery	Intellectual undertakings to support learning new concepts and developing new hypotheses. Code of Best Practice for Experimentation.

Variable Name	Variable Description
Distances	The space between adjacent men, animals, vehicles, or units in a formation measured from front to rear. The space between known reference points or a ground observer and a target, measured in meters (artillery), in yards (naval gunfire), or in units specified by the observer. (JCS Pub 1)
Dynamics Across Purpose (Command)	Extent to which the fundamental dimensions of command approach change across purpose.
Dynamics Across Purpose (Control)	Extent to which the fundamental dimensions of control approach change across purpose.
Dynamics Across Time (Command)	Extent to which the fundamental dimensions of command approach change across time.
Dynamics Across Time (Control)	Extent to which the fundamental dimensions of control approach change across time.
Economic Situation	Status with regards to the production and allocation of goods and services and their impact on the material well-being of human beings. William Outhwaite and Tom Bottomore, eds. The Blackwell Dictionary of Twentieth-Century Thought. Cambridge, MA: Blackwell, 1993.
Education	Capacity to learn, A program of instruction of a specified kind or level. The American Heritage Dictionary of the English Language, Fourth Edition. 2004
Emotional Stability	A personality trait representing the opposite of the trait "neuroticism" (which is itself characterized by nervousness, tenseness, moodiness, tempermentality).
Enemy Forces	Personnel, material and supporting capabilities of the adversary.
Equivocality of Situation	Extent to which information can be interpreted in different ways.
Experience of Personnel	Active participation in events or activities, leading to the accumulation of knowledge or skill of individuals whose aim is to accomplish the mission.
Extent of Shared Information	Proportion of understanding in common across force entities, within and across communities of interest (Communities of Interest). Proportion of force entities which share information item
Extra-Role Behaviour	Behaviour characterized by activities that are essential for organizational effectiveness but are discretionary in nature (e.g., acting courteously, helping others (Moorman, Niehoff & Organ, 1993; Organ, 1988); citation from Becker, T.E. & Kernan, M.C. (2003). Matching Commitment to Supervisors and Organizations to In-Role and Extra-Role Performance. Human Performance, 16 (4), 327-348).
Extraversion	An individual's style to interact with the environment, characterized by awareness and reliance on the environment for stimulation and guidance, an action-oriented, sometimes impulsive way of meeting life, frankness, ease of communication and sociability. The opposite is introversion: characterized by enjoyment of solitude and privacy, as well as interest in the clarity of concepts and ideas, reliance on enduring concepts more than on transitory external events, and a thoughtful, contemplative detachment (Myers, I.B. & McCaulley, M.H. (1992). Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator. Palo Alto: Consulting Psychologists Press).

Variable Name	Variable Description
Field Independence	A cognitive style characterized by the propensity to differentiate perceptual and other experiences from their contexts; the extent to which one's perceptions are independent from cues in the environment (the "field"). The opposite is "field dependence".
Financial Resources	Pecuniary means; funds; money, or any property that can be converted into supplies; available means or capabilities of any kind.
Flexibility	The ability to employ multiple ways to succeed and the capacity to move seamlessly between them. (Power to the Edge, 2003)
Force Effectiveness	The extent to which military missions are accomplished. NATO COBP for C2 Assessment
Force Will	The disposition or inclination of a force or an element of a force to action Webster"s Third International Dictionary, Unabridged. Springfield, MA: Merriam-Webster, Inc.: 1986.
Frequency of Interactions	Rate of interactions over time. Note: Time scale depends on level of modelling e.g. tactical seconds/minutes/hours... Enterprise...months/years.
Friendly Forces	Personnel, material and supporting capabilities of the friendly entities.
Fusion	The ability of systems (manual, automated, autonomous) to support the integration of data/information to support intelligence inference. Levels are defined in Antony's Principles of Data Fusion Automation. In intelligence usage, the process of examining all sources of intelligence and information to derive a complete assessment of activity. DoD Dictionary of Military and Associated Terms
General Intelligence	The ability to learn or understand or to deal with new or trying situations; the ability to apply knowledge to manipulate one's environment or to think abstractly.
Goal Consistency	Consistency among purposes for which resources are expended in order to achieve a desired objective or end-state. Derived from Merriam Webster
Group Pressure	The degree to which team members exercise force on each other to act in a unique way.
Hardness	Team members' familiarity with each other and knowledge of other team members' styles and capabilities, based on their repeated or continued interaction in the team (e.g. J. Holzworth, Meta-Analysis of Team Performance Accuracy and Shared Situational Awareness in SCUDHunt Experiments, C4ISR Decision Support Center/ ThoughtLink Inc., Cantata Court, Vienna, VA, 2002; W. Perry, J. Boob & D. Signori, Exploring Information Superiority, RAND 2004).
History	A chronological record of significant events, often including an explanation of their causes Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam-Webster, Inc.: 1986.
Homogeneity	A homogeneous team shows consistency in a specified attributes, e.g. attitudes, values and beliefs, among the team members (e.g. Handy, 1989).
Human Semantic Interoperability	Consistency of meaning across individuals.

Variable Name	Variable Description
Impulsivity	An individual's tendency to respond spontaneously without deliberation, especially in situations of uncertainty. The opposite of impulsivity is "reflectivity": An individual's tendency to consider and deliberate over alternative solutions to a problem. (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Indirect Sensing	To become aware of; perceive by involving intermediate or intervening parts or pathways The American Heritage Dictionary of the English Language, Fourth Edition
Individual Task Efficiency	The degree to which an individual exhibits a high ratio of output to input in performing a task. American Heritage Dictionary. 2000
Individual Task Quality	How well an individual performs a task. (American Heritage Dictionary 2000)
Individualism: Culture	A cultural dimension, characterized by the degree to which it is common in a society to perceive oneself independent from others and their attitudes and opinions. This meaning can reflect either a positive connotation, in that one who displays it stands above/outside social and peer pressure, or a negative connotation, in the sense of being uncooperative and uncaring. (Reber, A.S., The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books, 1995). The opposite is \"collectivism\".
Individualism: Personal Values	An individual attitude, characterized by the degree to which an individual perceives himself/herself independent from others and their attitudes and opinions. This meaning can reflect either a positive connotation, in that one who displays it stands above/outside social and peer pressure, or a negative connotation, in the sense of being uncooperative and uncaring. (Reber, A.S., The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books, 1995). The opposite is "collectivism".
Information Accuracy	Degree to which information quality matches what is needed.
Information Completeness	Extent to which information relevant to ground truth is collected.
Information Consistency	Extent to which information is consistent with prior information and consistent across sources.
Information Correctness	Extent to which information is consistent with ground truth.
Information Currency	Difference between the current point in time and the time the information was made available.
Information Distribution	The way information flows and is disseminated in the "real world" because of informal relationships, linkages and sources.
Information Networks	Various points on the information spectrum from data to knowledge that are linked in a complex, interconnected group or system. Understanding Information Age Warfare and the American Heritage Dictionary.
Information Pedigree	Extent to which you know where information came from.
Information Precision	Level of measurement detail of information item.

Variable Name	Variable Description
Information Relevance	Extent to which information quality is relevant to the task at hand.
Information Richness	Measures that address the quality of the information content used by actors. (Understanding Information Age Warfare)
Information Service Characteristics	Describes a range of processing services support than might be provided to the force for continuance of operations. Each alternative builds on the previous.
Information Sharability	The extent to which an element of information is in a form or format understandable by all nodes in a network.
Information Source Characteristics	The traits of tools used to develop facts, data, or instructions in any form or medium. All information sources are reporters. They have the following characteristics: False alarm rate; coverage; persistence; spectrum (sensitivity); phenomenonology DOD Dictionary of Military and Associated Terms
Information Timeliness	Extent to which currency of information is suitable to its use.
Information Transfer Approach	Movement and distribution of information.
Information Uncertainty	A fundamental attribute of war. Uncertainty pervades the battlefield in the form of unknowns about the enemy, the surroundings, and our own forces. (Power to the Edge)
Innovation	The ability to do new things and the ability to do old things in new ways. (Power to the Edge, 2003)
Integrity	The quality or condition of being whole or undivided; completeness. The American Heritage Dictionary of the English Language, Fourth Edition
Intent Motivation	The forces responsible for the initiation, persistence, direction, and vigour of goal-directed behaviour to reach an objective. (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Interaction Quality	Usefulness of actively sharing information, and developing awareness, understanding and/or making decisions (developing plans) in a collaborative fashion. (NCO CF Version 2.0 and the American Heritage Dictionary)
Interdependence	Degree to which team members have to rely on each other.
Intra Group Conflict	Disagreement among team members. \“task conflict\”: different viewpoints, ideas and opinions, and/or disagreements about task content; \“relationship conflict\”: interpersonal incompatibilities, including tension, animosity, annoyance. relationship conflicts are affectly loaden.

Variable Name	Variable Description
Leadership Behaviour	The extent to which a leader inspires subordinates to transcend their own self-interests and has a profound and extraordinary effect on followers. Authoritative: The extent to which a leader makes decisions without consulting with his/her subordinates. Democratic: The extent to which a leader consults with his/her subordinates to reach a shared decision. The extent to which a leader emphasizes interpersonal relations, taking a personal interest in the needs of subordinates and accepting individual differences among members. The extent to which the underlying value basis is characterized by the assumption that a leader should emphasize technical or task aspects of the job in order to achieve goals. The extent to which a leader guides and motivates his/her subordinates in the direction of established goals by clarifying role and task requirements.
Leadership Culture	Authoritative: The extent to which the underlying value basis is characterized by the assumption that a leader should make decisions without consulting with his/her subordinates. Democratic: The extent to which the underlying value basis is characterized by the assumption that a leader should consult with his/her subordinates to reach a shared decision. The extent to which the underlying value basis is characterized by the assumption that a leader should emphasize interpersonal relations, take a personal interest in the needs of subordinates and accept individual differences among members. The extent to which the underlying value basis is characterized by the assumption that a leader should emphasize technical or task aspects of the job in order to achieve goals. The extent to which the underlying value basis is characterized by the assumption that a leader should guide and motivate his/her subordinates in the direction of established goals by clarifying role and task requirements. The extent to which the underlying value basis is characterized by the assumption that a leader should inspire subordinates to transcend their own self-interests.
Lethal Effectors	Resources which are designed and employed to inflict casualties on an opponent.
Levelling	The tendency to smooth over the unusual, irregular or novel aspects of a situation or an event such that details are glossed over and what ends up in memory is a homogeneous, less incongruous version than what was objectively presented. The reverse tendency is “sharpening”: the tendency to (over)emphasize and accentuate details rather than to smooth over unusual, irregular or novel aspects of a situation or an event (Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books).
Likelihood of Success	Probability of mission accomplishment.
Locus of Control	The perceived source of control over one’s behaviour; “internal Locus of Control”: the belief to have control over one’s own destinies; “external Locus of Control”: the belief that control over one’s destinies resides outside oneself, e.g. chance, luck, fate, or the actions of powerful others (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).

Variable Name	Variable Description
Measures of C2 Effectiveness	Measures of impact of the state of the command and control. Example: force planning.
Memory Performance	In empirical research, "memory performance" is most often operationalized as the quality (correctness and extent) of recall of cognitive contents previously encoded. "Memory" in general is defined as "the psychological function of preserving information, involving the processes of encoding, storage, and retrieval". Memory can be differentiated into "long-term memory for information stored for more than a few seconds, short-term memory for temporary storage of information for briefer periods, and sensory memory (including the iconic store) for very brief storage of visual and possibly other sensory information" (Colman, A.M. (2003), A Dictionary of Psychology. Oxford: Oxford University Press.
Mental Models Confidence	The degree of subjective confidence that the mental model in use is appropriate to situation and task.
Mental Models Relevance	The extent to which mental model in use is appropriate to the actual situation and task at hand.
Mental Models Richness	The breadth and depth of the range of models that can be brought to bear on the situation.
Mission Effectiveness	Mission Effectiveness is the degree to which a force accomplishes its assigned military mission. Examples of specific components are described in Maxwell, 1998.
Mobility	Extent to which a sensor is able to move from place to place while retaining its ability to fulfil its primary mission.
Mood	Any relatively short-lived, low-intensity emotional state (Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books).
Motivation	A driving force or forces responsible for the initiation, persistence, direction, and vigour of goal-directed behaviour. It includes biological drives (e.g. hunger, thirst, sex, self-preservation) and social forms of motivation, e.g. need for achievement, need for affiliation. (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Motor Skill	A skill required for proper usage of skeletal muscles. Besides muscles, these depend upon the proper functioning of the brain, skeleton, joints, and nervous system. Most motor skills are learned in early childhood. Disabilities can affect motor skills.

Variable Name	Variable Description
Myers-Briggs Style	The manner in which one learns and communicates data and interacts with others. The Myers-Briggs Typology: Attitudes: "Extraversion vs. Introversion"; Perception: "Sensing Perception vs. Intuitive Perception"; Judgment: "Thinking Judgment vs. Feeling Judgment"; Orientation to the outer world: "Judging vs. Perceiving". Sensing Perception refers to the tendency to rely on perceptions observable by way of the senses. Intuitive perception refers to the tendency to perceive possibilities, meanings, and relationships by way of insight. Thinking judgment: Persons who are primarily oriented toward thinking may develop characteristics associated with principles of justice and fairness, criticality, and an orientation to time that is concerned with connections from the past through the present and toward the future. Feeling judgment: Persons who are primarily oriented toward thinking may develop characteristics associated with principles of justice and fairness, criticality, and an orientation to time that is concerned with connections from the past through the present and toward the future. Perceptive attitude: In the perceptive attitude, a person is attuned to incoming information. Judging attitude: In the judging attitude, a person is concerned with making decisions, seeking closure, planning operations, or organizing activities. (Myers, I.B. & McCaulley, M.H. (1992). Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator. Palo Alto: Consulting Psychologists Press).
Needs	A general course of action or behavioural tendency (Colman, Oxford Dictionary of Psychology, 2003).
Network Assurance	The degree of confidence in the ability of force entities to have good connectivity. This includes the security, privacy, and integrity of the network and its contents. (From NCO Conceptual Framework v. 1.0)
Network Availability	The percentage of time all authorized users have access to the network. This is necessary if current information is to be shared and if the user community is to develop trust and confidence in using the information in the system. Understanding Information Age Warfare
Network Reach	The number and variety of people, work stations, or organizations that can share information. (Understanding Information Age Warfare)
Network Redundancy	Multiple ways to get at the same information or to get from point A to point B in a network. This helps in the availability of the system, where if part of the network goes down, then we do not have to stop the information flow because there are other means of accessing or getting to a certain part of the network.
Network Reliability	An attribute of any network that consistently produces the same results, preferably meeting or exceeding its specifications. (The Free Online Dictionary of Computing, Denis Howe)
Network Richness	The quality and breadth of the information found in the network. (Understanding Information Age Warfare)
Network Sustainability	The ability to maintain the necessary level and duration of operational activity to achieve military objectives (JP 1-02). In a network context, sustainability is a function of the ability to manage, maintain, and restore the network and network components.

Variable Name	Variable Description
Neutral Forces	In combat and combat support operations, an identity applied to a track whose characteristics, behaviour, origin, or nationality indicate that it is neither supporting nor opposing friendly forces. (JCS Pub 1)
Non-Lethal Effectors	Resources designed and employed for self protection and to control ambiguous situations with inflicting casualties.
Non-Repudiation	The inability to avoid responsibility for inserting data, information, or knowledge into the information domain. One of the elements of information assurance.
Norm Strength	Degree to which teams are expected to comply to a norm.
Number of Personnel	Quantity of personnel available to accomplish the mission.
Nurturing: Culture	A cultural dimension, characterized by the degree to which relationships are valued, and sensitivity and concern for the welfare of others is shown in a society [derived from the original concept "Femininity"].
Nurturing: Personal Values	An individual attitude, characterized by the degree to which an individual values relationships, and shows sensitivity and concern for the welfare of others [derived from the original concept "Femininity"].
Open / Closed	Refers to the willingness and ability of an individual to change their understanding of a situation when confronted with new or contradictory information.
Open Sources	Information available from the public domain.
Openness to Experience	A personality trait characterized by imagination, curiosity, and creativity; the opposite of shallowness and imperceptiveness (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Other Physical Abilities	Physical abilities including body coordination, balance and stamina. "body coordination": the ability to coordinate the simultaneous actions of different parts of the body. "balance": the ability to maintain equilibrium despite forces pulling off balance. "stamina": the ability to continue maximum effort requiring prolonged effort over time.
Patterns of Interaction Enabled	Establishing standards or protocols that facilitate the appropriate level and quality of communication, information exchange and collaboration required for success.
Patterns of Interaction Not Allowed	To disallow certain types of communication, information exchange and collaboration.
Perceived Likelihood of Success	An awareness of the probability if a mission will be accomplished.
Perceptual Filters	Bias in an individual's capacity to identify or focus on relevant information
Persistence	The action or fact of existing for a long time or continuously Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam-Webster, Inc.: 1986.
Personnel Resources	Those individuals available in either a military or civilian capacity to accomplish the assigned mission.
Physical Flexibility	Extent flexibility: the ability to move the trunk and back muscles as far as possible. "dynamic flexibility": the ability to make rapid, repeated flexing movements.

Variable Name	Variable Description
Physical Strength	"Dynamic strength": the ability to exert muscular force repeatedly or continuously over time. "trunk strength": the ability to exert muscular strength using the trunk (particularly abdominal muscles). "static strength": the ability to exert force against external objects. "explosive strength": the ability to expend a maximum of energy in one or a series of explosive acts.
Plan Accuracy	Degree that the plan matches the Commander's intent.
Plan Completeness	Degree that the plan does not have missing components.
Plan Consistency	Degree of logical coherence of the plan, including elements that cut across functions or echelons.
Plan Correctness	Degree the plan is error free.
Plan Currency	The time lag of issuance of the plan.
Plan Feasibility	Degree to which the plan is practicable.
Plan Precision	Level of granularity of elements of the plan.
Plan Relevance	Degree that the plan is pertinent to the Commander's Intent.
Plan Timeliness	Extent to which the plan currency is suitable for use. A suitable length of time used to develop a plan after recognition of the need for a plan.
Plan Uncertainty	Extent to which is it not able to know or predict ground truth based on the plan.
Planning Speed	Time required to develop a plan after recognition of the need for a plan.
Policy Effectiveness	The degree of success in influencing and determining decisions, actions, and other matters as related to societal and policy outcomes. NATO COBP for C2 Assessment and the American Heritage Dictionary of the English Language, Fourth Edition
Political Situation	The element of the battlespace environment that has to do with the distribution of authority and power between competing individuals or groups outside the military arena. (Websters)
Position-Based Power	Position-based power refers to an individual's (legal) power based on their holding a position of authority.
Power Distance: Culture	A cultural dimension, characterized by the degree to which it is accepted in a society that power is distributed unequally.
Power Distance: Personal Values	An individual attitude, characterized by the degree to which an individual accepts that power is distributed unequally.
Predictability Type	The characteristic being likely to be foreseen and/or countered effectively. Power to the Edge. 2003.
Privacy	A system in which no one except authorized users has access and each user's access is appropriate for their roles and responsibilities. When that cannot be avoided (e.g., long haul communications are required), the system itself must be designed to keep out unauthorized users and to detect, with a high degree of confidence, efforts to penetrate the system.

Variable Name	Variable Description
Problem Solving Style	An individual's problem solving style may be either divergent or convergent. Convergent thinking: bringing together or synthesizing of information and knowledge focused on a solution to a problem; characterized by synthesis of information and analytical, deductive thinking; logical, consciously controlled, reality-oriented. Divergent thinking: diverging of ideas to encompass a variety of relevant aspects, fluent production of a variety of novel ideas relevant to the problem (Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books).
Quality of Command Intent	Usefulness of aims or purposes. American Heritage Dictionary. 2000.
Quality of Communication of Command Intent	The ability and extent able to communicate aims or purposes.
Quality of Communications Equipment	The subjective assessment of the quality of available tangible forces, material and other assets.
Quality of Computing Equipment	The subjective assessment of the quality of computing hardware and associated equipment.
Quality of Consumable Equipment	The subjective assessment of the quality of expendable assets (ammunition, food, fuel, etc.) available to the force.
Quality of Facilities	The subjective assessment of the quality of real property entities consisting of one or more of the following: a building, a structure, a utility system, pavement, and underlying land.
Quality of Interactions	Usefulness of actively sharing information, and developing awareness, understanding and/or making decisions (developing plans) in a collaborative fashion. (NCO CF Version 2.0 and the American Heritage Dictionary)
Quality of Non-Consumable Equipment	The subjective assessment of the quality of non-expendable assets (tanks, trucks, tents, etc.) available to a force.
Quality of Personnel	The subjective assessment of the quality of those individuals available in either a military or civilian capacity to accomplish the assigned mission.
Quality of Sets of Unit Equipment	The subjective assessment of the quality of tangible elements of a mission capability package available to a unit.
Quality of Visualization	The ability to capture the full richness of the insights, particularly risk and uncertainty (e.g., depicts the distribution rather than just the statistical) that are derived in assessments. (NATO COBP)
Quantity of Communications Equipment	The number of available tangible forces, materiel and other assets.
Quantity of Computing Equipment	The number of computing hardware and associated equipment.

Variable Name	Variable Description
Quantity of Consumable Equipment	The number of expendable assets (ammunition, food, fuel, etc.) available to the force.
Quantity of Facilities	The number of real property entities consisting of one or more of the following: a building, a structure, a utility system, pavement, and underlying land.
Quantity of Non-Consumable Equipment	The number of non-expendable assets (tanks, trucks, tents, etc.) available to a force.
Quantity of Sets of Unit Equipment	The number of tangible elements of a mission capability package available to a unit.
Relation to Environment	An individual's style of interacting with their social environment, the ends of the continuum being "Desire to control the environment" and "Willingness to adapt to the environment".
Repression	The disposition to react to threatening stimuli or ideas by blocking and denial. The opposite is Sensitization: The Disposition to react by approaching, facilitating, and increasing vigilance, i.e. by confronting the threatening stimuli directly).
Resilience	The ability to recover from or adjust to misfortune, damage, or a destabilizing perturbation in the environment. (Power to the Edge, 2003, p. 128)
Resolution	A measurement of the smallest detail that can be distinguished by a sensor system under specific conditions.
Response Speed	"Response speed is measured by a response initiation time and a movement time. Initiation time refers to the speed with which a participant reacts to a cue and may be akin to simple RT [reaction time]; another processing speed measure. Movement time is the speed with which a person completes a response following response initiation, [...] resulting in a combined decision and movement time response." Luciano, M., Wright, M.J., Geffen, G.M., Geffen, L.B., Smith, G.A., Martin, N.G. (2004). Multivariate genetic analysis of cognitive abilities in an adolescent twin sample. Australian Journal of Psychology, 56 (2), 79-88.
Responsiveness	The ability to react to a change in the environment in a timely manner. (Power to the Edge, 2003, p. 128)
Restriction of Decision Rights	The restriction of choices related to a particular topic under a set of circumstances or conditions.
Restriction on Information Distribution	To restrict the way information flows and is disseminated in the "real world".
Risk Propensity	An individual's natural inclination or preference for being exposed to possible harm or loss. (Websters Dictionary)
Risk Taking	The degree to which an individual willingly undertakes actions that involve a significant degree of risk; the action of undertaking actions that involve a significant degree of risk. Reber, A.S. (1995). The Penguin Dictionary of Psychology. 2nd ed. London: Penguin Books.

Variable Name	Variable Description
Robustness	The ability to maintain effectiveness across a range of tasks, situations, and conditions. (Power to the Edge, 2003, p. 128)
Role Clarity	The unambiguous knowledge of what tasks/functions one (and the other team members) has (have) been assigned and is (are) expected to accomplish/fulfil.
Role of Emotion	The role emotion is assigned in the context of social interaction, ranging from "neutral interactions" versus "emotional interactions". "Neutral interactions" refers to the assumption that it is not appropriate to express emotions in social interactions; "emotional interactions" refers to the assumption that it is appropriate to express emotions in social interactions.
Selectivity	The quality or state of being judicious and restrictive of choice. Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam Webster, Inc.: 1986.
Self-Efficacy	The sense of one's abilities to deal with particular sets of conditions or with a particular task.
Self-Esteem	An individual's evaluation of himself/herself (ranges from "favourable" to "unfavourable").
Self-Monitoring	The behaviour of self-observation and control of one's expressive behaviour and self-presentation.
Sensor Coverage (Medium)	Origin of the sensor platform supporting indirect sensing e.g. land, UAV, satellite
Sensor Coverage (Spatial)	Sequence or range of values (e.g., frequency, optical, infrared) to which sensor exhibits in order to observe, analyze and report targets of interest.
Sensor Coverage (Spectrum)	Sequence or range of values (e.g., frequency, optical, infrared) to which sensor exhibits in order to observe, analyze and report targets of interest.
Sensor Persistence	Persistence is a compound attribute that addresses both the percentage of time an area is covered along different dimensions of the spectrum.
Shared Awareness Accuracy	Appropriateness of precision of shared awareness for a particular use.
Shared Awareness Completeness	Extent to which awareness necessary forms a complete shared understanding. NCO CF
Shared Awareness Consistency	Extent to which shared awareness is consistent within and across Col.
Shared Awareness Correctness	Extent to which shared awareness is consistent with ground truth.
Shared Awareness Currency	Time lag of shared awareness.
Shared Awareness Precision	Level of granularity of shared awareness.
Shared Awareness Relevance	Proportion of shared awareness that is related to the task at hand.
Shared Awareness Timeliness	Extent to which currency of shared awareness is suitable to its use.
Shared Awareness Uncertainty	Subjective assessment of confidence in shared awareness.

Variable Name	Variable Description
Shared Information Accuracy	Appropriateness of precision of shared information for a particular use.
Shared Information Completeness	Extent to which relevant shared information is obtained.
Shared Information Consistency	Extent to which shared information is consistent within and across communities of Interest (CoI).
Shared Information Correctness	Extent to which shared information is consistent with ground truth.
Shared Information Currency	Time lag of shared information.
Shared Information Precision	Level of granularity of shared information.
Shared Information Relevance	Proportion of shared information that is related to task at hand.
Shared Information Timeliness	Extent to which currency of shared information is suitable to its use.
Shared Information Uncertainty	Subjective assessment of confidence in shared information.
Shared Understanding Accuracy	Appropriateness of precision of shared understanding for a particular use.
Shared Understanding Completeness	Extent to which relevant shared understanding is obtained.
Shared Understanding Consistency	Extent to which shared understanding is consistent within and across Col.
Shared Understanding Correctness	Extent to which shared understanding is consistent with ground truth.
Shared Understanding Currency	Time lag of shared understanding.
Shared Understanding Precision	Level of granularity of shared understanding.
Shared Understanding Relevance	Proportion of shared understanding that is related to the task at hand.
Shared Understanding Timeliness	Extent to which currency of shared understanding is suitable to its use.
Shared Understanding Uncertainty	Subjective assessment of confidence in shared understanding.

Variable Name	Variable Description
Situational Familiarity	The characteristic of having encountered or seen, or having knowledge of a situation.
Sleep Deprivation	The condition of being deprived of sleep either under experimental or unusual real life conditions (as distinguished from being unable to sleep). cancerweb.ncl.ac.uk
Social Situation	The element of the battlespace environment that has to do with human society and its modes of organization outside the military arena. Deals with the distribution of wealth among the members of society. The American Heritage Dictionary of the English Language, Fourth Edition.
Source of Status	Cultural dimension, ranging from "Status through achievement" to "Status through traditional roles ranks"; deals with how people are judged, either by their deeds and accomplishments (status through achievement) or by predetermined status based on rank, age, etc. (status through traditional roles/ranks).
State of Mental Health	The state of well-being in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community (WHO, 2001).
State of Physical Health	The ability to cope with everyday activities, state of fitness and well-being, absence of illness. Characterised by homeostasis, i.e. a state of balance, with inputs and outputs of energy and matter in equilibrium (allowing for growth). Health also implies good prospects for continued survival.
Stress Level	Psychological and physical strain or tension generated by physical, emotional, social, economic, or occupational circumstances, events or experiences that are difficult to manage or endure (Colman, A.M. (2001). A Dictionary of Psychology. Oxford, NY: Oxford University Press).
Synchronization	The meaningful arrangement of things or effects in time and space. Understanding Information Age Warfare.
System Semantic Interoperability	Consistency of meaning across systems. Webster's Third International Dictionary, Unabridged. Springfield, MA: Merriam-Webster, Inc.: 1986.
Task Competence	The degree to which the knowledge required to execute a specified task is held.
Task Currency/ Latency	Time lag of information.
Task Efficiency	The degree to which the performance of a task exhibits a high ratio of output to input. American Heritage Dictionary. 2000
Task Speed	The time an individual spends performing a task. American Heritage Dictionary. 2000.
Task Understanding	The degree to which what is required to execute a specified task is understood.
Team Scale	The number of individuals being part of a team.

Variable Name	Variable Description
Team Shape	Basic category of organisational structure based on proportions of people in different subunits (functional types; Mintzberg H. (1979) The Structuring of Organisations, Prentice Hall) and on work specialization (the degree to which tasks in the team are subdivided into separate jobs), span of control (the number of subordinates a manager directs (can efficiently and effectively direct), centralization (the degree to which decision making is concentrated at a single point in the team), formalization (the degree to which jobs within the organization are standardized), and communication network complexity (proportion of accessible interpersonal communication links of the overall number of possible links between two individuals of a team).
Temporal Focus	Time into the future of an understanding or plan.
Temporal Orientation: Culture	A cultural dimension; Long-term orientation is characterized by the degree to which a society fosters virtues oriented towards future rewards. Short-term orientation is characterized by the degree to which a society fosters virtues related to the past and present (developed from Hofstede 2001, Culture's consequences. Comparing Values, Behaviors, Institutions and Organizations Across Nations, Thousand Oaks).
Temporal Orientation: Personal Values	An individual attitude; Long-term orientation is characterized by the degree to which an individual fosters virtues oriented towards future rewards. Short-term orientation is characterized by the degree to which an individual fosters virtues related to the past and present (developed from Hofstede 2001, Culture's consequences. Comparing Values, Behaviors, Institutions and Organizations Across Nations, Thousand Oaks).
Trafficability	Capability of terrain to bear traffic. It refers to the extent to which the terrain will permit continued movement of any or all types of traffic. (JCS Pub 1)
Training	Training is the process by which job-related skills and knowledge are taught. Building skill level. Mintzberg 79, p. 95
Trust	The extent to which an individual has decided to rely on others (subordinate, superior, peers) and to make himself/herself vulnerable to the consequences of their actions.
Trust Propensity	The extent to which an individual is basically willing to rely on others (subordinate, superior, peers) and to be vulnerable to the consequences of their actions.
Type I Error (False Alarm Rate)	The declaration of a positive identification when no target exists.
Type II Error	The declaration that no target exists when there is a target present.
Uncertainty Avoidance: Culture	A cultural dimension, characterized by the degree to which uncertain and ambiguous situations cause feelings of threat and the tendency to avoid them.
Uncertainty Avoidance: Personal Values	An individual attitude, characterized by the degree to which an individual feels threatened by uncertain and ambiguous situations and tries to avoid them.
Uncertainty of Situation	Not having sufficient information to describe a current state or to forecast future states, preferred outcomes, or the actions needed to achieve them. (Zach 1999)

Variable Name	Variable Description
Understanding Accuracy	Appropriateness of precision of Understanding for a particular use NCO CF
Understanding Completeness	Extent to which Understanding necessary from understanding is obtained NCO CF. A completeness of understanding includes understanding of capabilities, environment, forces, intentions, and mission.
Understanding Consistency	Extent to which Understanding is consistent with relevant awareness at an earlier time period NCO CF
Understanding Correctness	Extent to which understanding is consistent with ground truth NCO CF
Understanding Currency	Time lag of Understanding NCO CF
Understanding Precision	Level of granularity of Understanding NCO CF
Understanding Relevance	Extent to which Understanding obtained is related to task at hand NCO CF
Understanding Timeliness	Extent to which currency of Understanding is suitable to its use NCO CF
Understanding Uncertainty	Subjective assessment of Understanding uncertainty NCO CF
Weather (Atmospheric)	The state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness.
Weather (Space)	Activity on the surface of the sun, such as solar flares, that cause high levels of radiation in space. This radiation can come as plasma (particles) or electromagnetic radiation (light). NOAA Definition.
Willingness to Interact	The disposed or inclined willingness to act on others. The American Heritage Dictionary of the English Language, Fourth Edition

Annex F – HIERARCHY

C2 Approach		
	Command Approach	
		Allocation of Decision Rights
		Patterns of Interaction Enabled
		Information Distribution
		Dynamics Across Purpose (command)
		Dynamics Across Time (command)
	Control Approach	
		Restriction of Decision Rights
		Patterns of Interaction Not Allowed
		Restriction on Information Distribution
		C2 Doctrine
		Dynamics Across Purpose (control)
		Dynamics Across Time (control)
		Constraint Enforcement
		Selectivity
	Leadership	
		Consistency of Command Intent
		Leadership Behaviour
		Leadership Culture
		Quality of Command Intent
		Quality of Communication of Command Intent
		Intent Motivation
	Command Style	
		Commander's Leadership Behaviour
		Commander's Decision Style
		Commander's Myers-Briggs Style
	Control Style	
		Commander's Risk Propensity
		Open/Closed Commander
Quality of Actions*		
	Likelihood of Success	
	Action Synchronization	
	Action Accuracy	
	Action Completeness	
	Action Consistency	
	Action Correctness	
	Action Precision	

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***Group agrees these variables apply to a team but do not agree they apply to individuals

		Action Timeliness
		Action Appropriateness
		Action Efficiency
Decision Making**		
		Command Speed
		Constraint Setting
		Criticality
		Decision Congruence
		Decision Participants
		Decision Speed
		Decision Type
		Development of Intent
		Perceived Likelihood of Success
		Perceptual Filters
		Planning Speed
		Synchronization
Quality of Decisions		
		Decision Accuracy
		Decision Completeness
		Decision Consistency
		Decision Correctness
		Decision Currency
		Decision Precision
		Decision Relevance
		Decision Timeliness
		Decision Uncertainty
Entity Characteristics and Behaviors		
	Behaviour	
		Adaptive Behaviour
		Conformity
		Cooperative Behaviour
		Extra-Role Behaviour
		Memory Performance
		Risk Taking
		Self-Monitoring
		Response Speed
	Individual Cognitive Abilities	
		Cognitive Capacity
		Cognitive Complexity
		Cognitive Flexibility

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	General Intelligence
Personality and Values**	
	Agreeableness
	Ambiguity Tolerance
	Conscientiousness
	Decision Style
	Emotional Stability
	Extraversion
	Field Independence
	Impulsivity
	Levelling
	Locus of Control
	Achievement Orientation: Personal Values
	Temporal Orientation: Personal Values
	Myers-Briggs Style
	Needs
	Nurturing: Personal Values
	Openness to Experience
	Problem Solving Style
	Relation to Environment
	Repression
	Risk Propensity
	Role of Emotion
	Self-Efficacy
	Self-Esteem
	Trust Propensity
	Power Distance: Personal Values
	Individualism: Personal Values
	Uncertainty Avoidance: Personal Values
	Willingness to Interact
Physical Abilities	
	Motor Skill
	Other Physical Abilities
	Physical Flexibility
	Physical Strength
State**	
	Alertness
	Anxiety
	Blood Sugar Level
	Commitment/Loyalty
	Mood
	Motivation

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	Position-Based Power
	Sleep Deprivation
	State of Mental Health
	State of Physical Health
	Stress Level
	Trust
Sensemaking	
Mental Models	
	Mental Models Confidence
	Mental Models Relevance
	Mental Models Richness
Quality of Awareness	
	Awareness Accuracy
	Awareness Completeness
	Awareness Consistency
	Awareness Correctness
	Awareness Currency
	Awareness Precision
	Awareness Relevance
	Awareness Timeliness
	Awareness Uncertainty
Quality of Shared Awareness	
	Shared Awareness Accuracy
	Shared Awareness Completeness
	Shared Awareness Consistency
	Shared Awareness Correctness
	Shared Awareness Currency
	Shared Awareness Precision
	Shared Awareness Relevance
	Shared Awareness Timeliness
	Shared Awareness Uncertainty
Quality of Plan	
	Plan Accuracy
	Plan Completeness
	Plan Consistency
	Plan Correctness
	Plan Currency
	Plan Feasibility
	Plan Precision
	Plan Relevance
	Plan Timeliness
	Plan Uncertainty

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Quality of Understanding
Understanding Accuracy
Understanding Completeness
Understanding Consistency
Understanding Correctness
Understanding Currency
Understanding Precision
Understanding Relevance
Understanding Timeliness
Understanding Uncertainty
Quality of Shared Understanding
Shared Understanding Accuracy
Shared Understanding Completeness
Shared Understanding Consistency
Shared Understanding Correctness
Shared Understanding Currency
Shared Understanding Precision
Shared Understanding Relevance
Shared Understanding Timeliness
Shared Understanding Uncertainty
Task Performance**
Individual Task Efficiency
Individual Task Quality
Task Competence
Task Efficiency
Task Speed
Task Understanding
Culture***
Achievement Orientation: Culture
Individualism: Culture
Norm Strength
Power Distance: Culture
Source of Status
Uncertainty Avoidance: Culture
Temporal Orientation: Culture
Nurturing: Culture
Team Characteristics
Cohesion
Group Pressure
Intra Group Conflict
Persistence

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		Role Clarity
		Cooperability
		Goal Consistency
		Hardness
		Homogeneity
		Interdependence
		Team Scale
		Team Shape
Information		
	Collaboration	
		Collaboration Mechanism
		Collaboration Capacity
		Collaboration Participants
		Collaboration Completeness
		Continuity of Interactions
		Frequency of Interactions
		Interaction Quality
	Network	
		Communication System Characteristics
		Information Richness
		Information Transfer Approach
		Network Reach
		Network Richness
		Quality of Visualization
		Information Assurance
		Authentication
		Confidentiality
		Non-Repudiation
		Network Assurance
		Network Availability
		Network Reliability
		Network Redundancy
		Network Sustainability
		Information Pedigree
		Privacy
		Integrity
	Information Sources	
		Direct Sensing
		Indirect Sensing
		Databases
		Information Source Characteristics
		Open Sources

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		Task Currency/Latency
		Sensors
		Mobility
		Resolution
		Sensor Coverage (Spatial)
		Sensor Coverage (Medium)
		Sensor Coverage (Spectrum)
		Sensor Persistence
	Interoperability	
		Communications Interoperability
		Data Interoperability
		Human Semantic Interoperability
		Quality of Interactions
		System Semantic Interoperability
	Performance of Information Equipment	
		Quality of Communications Equipment
		Quality of Computing Equipment
		Quantity of Communications Equipment
		Quantity of Computing Equipment
Quality of Information		
	Information Quality*	
		Information Accuracy
		Information Completeness
		Information Consistency
		Information Correctness
		Information Currency
		Information Precision
		Information Relevance
		Information Timeliness
		Information Uncertainty
		Information Service Characteristics
		Information Sharability
		Information Source Characteristics
	Shared Information Quality*	
		Shared Information Accuracy
		Shared Information Completeness
		Shared Information Consistency
		Shared Information Correctness
		Shared Information Currency
		Shared Information Extent
		Shared Information Precision
		Shared Information Relevance

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			Shared Information Timeliness
			Shared Information Uncertainty
		Situational Characteristics*	
			Ambiguity of Situation
			Complexity of Situation
			Equivocality of Situation
			Uncertainty of Situation
			Situational Familiarity
			Temporal Focus
High Level Measures of Merit			
	Measures of C2 Effectiveness		
	Force Effectiveness		
	Mission Effectiveness		
	Policy Effectiveness		
	Measures of Agility		
		Adaptiveness	
		Flexibility	
		Innovation	
		Resilience	
		Responsiveness	
		Robustness	
State (t)			
	Force		
		Force Will	
		Error Rate	
			Type I Error (False Alarm Rate)
			Type II Error
		Material Resources	
			Quality of Consumable Equipment
			Quality of Facilities
			Quality of Non-Consumable Equipment
			Quality of Sets of Unit Equipment
			Quantity of Consumable Equipment
			Quantity of Facilities
			Quantity of Non-Consumable Equipment
			Quantity of Sets of Unit Equipment
		Non-Material Resources	
			Financial Resources
			Personnel
			Education

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		Experience of Personnel
		Number of Personnel
		Personnel Resources
		Quality of Personnel
		Training
	Information Resources	
	Information Networks	
	Information Value Added Services	
		Discovery
		Fusion
	Types of Effectors	
	Lethal Effectors	
	Non-Lethal Effectors	
Situation (t)		
	Operational Situation	
	Complicated-ness	
	Co-Located/Distributed	
	Economic Situation	
	Enemy Forces	
	Friendly Forces	
	History	
	Neutral Forces	
	Political Situation	
	Social Situation	
	Predictability Type	
	Physical Situation	
	Terrain	
		Distances
		Trafficability
	Weather	
		Weather (Atmospheric)
		Weather (Space)

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Annex G – RELATIONSHIPS

Is Influenced By (Input)	Variable	Influences (Output)
Individualism: Culture	Achievement Orientation: Culture	
	Achievement Orientation: Culture	Achievement Orientation: Personal Values
	Achievement Orientation: Culture	Individualism: Culture
	Achievement Orientation: Culture	Leadership Culture
	Achievement Orientation: Culture	Source of Status
Achievement Orientation: Culture	Achievement Orientation: Personal Values	
Individualism: Culture	Achievement Orientation: Personal Values	
Individualism: Personal Values	Achievement Orientation: Personal Values	
Locus of Control	Achievement Orientation: Personal Values	
Source of Status	Achievement Orientation: Personal Values	
	Achievement Orientation: Personal Values	Cohesion
	Achievement Orientation: Personal Values	Commanders Leadership Behaviour
	Achievement Orientation: Personal Values	Commitment/Loyalty
	Achievement Orientation: Personal Values	Conformity
	Achievement Orientation: Personal Values	Cooperability
	Achievement Orientation: Personal Values	Cooperative Behaviour
	Achievement Orientation: Personal Values	Group Pressure
	Achievement Orientation: Personal Values	Leadership Behaviour
	Achievement Orientation: Personal Values	Motivation
	Achievement Orientation: Personal Values	Needs
	Achievement Orientation: Personal Values	Openness to Experience

Is Influenced By (Input)	Variable	Influences (Output)
	Achievement Orientation: Personal Values	Risk Propensity
	Achievement Orientation: Personal Values	Stress Level
Decision Accuracy	Action Accuracy	
Motivation	Action Accuracy	
Plan Accuracy	Action Accuracy	
	Action Accuracy	Action Efficiency
	Action Accuracy	Likelihood of Success
Commitment/Loyalty	Action Appropriateness	
Consistency of Command Intent	Action Appropriateness	
Decision Correctness	Action Appropriateness	
Decision Relevance	Action Appropriateness	
Decision Style	Action Appropriateness	
Plan Feasibility	Action Appropriateness	
Plan Relevance	Action Appropriateness	
Quality of Command Intent	Action Appropriateness	
Risk Taking	Action Appropriateness	
Role Clarity	Action Appropriateness	
	Action Appropriateness	Likelihood of Success
	Action Appropriateness	Mission Effectiveness
Decision Completeness	Action Completeness	
Decision Participants	Action Completeness	
Information Distribution	Action Completeness	
Motivation	Action Completeness	
Number of Personnel	Action Completeness	
Plan Completeness	Action Completeness	
Quantity of Sets of Unit Equipment	Action Completeness	
Role Clarity	Action Completeness	
	Action Completeness	Likelihood of Success
	Action Completeness	Mission Effectiveness
Cohesion	Action Consistency	
Decision Congruence	Action Consistency	
Decision Consistency	Action Consistency	
Intra Group Conflict	Action Consistency	
Plan Completeness	Action Consistency	
Plan Consistency	Action Consistency	
Plan Uncertainty	Action Consistency	
	Action Consistency	Likelihood of Success
Consistency of Command Intent	Action Correctness	
Information Distribution	Action Correctness	

Is Influenced By (Input)	Variable	Influences (Output)
Motivation	Action Correctness	
Plan Correctness	Action Correctness	
Plan Feasibility	Action Correctness	
Quality of Communication of Command Intent	Action Correctness	
Task Competence	Action Correctness	
	Action Correctness	Likelihood of Success
	Action Correctness	Mission Effectiveness
Action Accuracy	Action Efficiency	
Action Precision	Action Efficiency	
Cohesion	Action Efficiency	
Cooperability	Action Efficiency	
Decision Congruence	Action Efficiency	
Decision Consistency	Action Efficiency	
Decision Speed	Action Efficiency	
Distances	Action Efficiency	
Motivation	Action Efficiency	
Plan Uncertainty	Action Efficiency	
Response Speed	Action Efficiency	
Task Competence	Action Efficiency	
Team Shape	Action Efficiency	
	Action Efficiency	Likelihood of Success
Decision Precision	Action Precision	
Perceived Likelihood of Success	Action Precision	
Plan Precision	Action Precision	
	Action Precision	Action Efficiency
	Action Precision	Likelihood of Success
Allocation of Decision Rights	Action Synchronization	
Cohesion	Action Synchronization	
Constraint Enforcement	Action Synchronization	
Cooperability	Action Synchronization	
Decision Congruence	Action Synchronization	
Decision Correctness	Action Synchronization	
Information Distribution	Action Synchronization	
Role Clarity	Action Synchronization	
Synchronization	Action Synchronization	
	Action Synchronization	Command Speed
	Action Synchronization	Force Effectiveness
	Action Synchronization	Mission Effectiveness
	Action Synchronization	Task Efficiency
	Action Synchronization	Task Speed
Commanders Risk Propensity	Action Timeliness	

Is Influenced By (Input)	Variable	Influences (Output)
Decision Currency	Action Timeliness	
Decision Timeliness	Action Timeliness	
Distances	Action Timeliness	
Plan Currency	Action Timeliness	
Plan Timeliness	Action Timeliness	
Planning Speed	Action Timeliness	
Quality of Communication of Command Intent	Action Timeliness	
	Action Timeliness	Likelihood of Success
	Action Timeliness	Mission Effectiveness
Cognitive Complexity	Adaptive Behaviour	
Cognitive Flexibility	Adaptive Behaviour	
Commitment/Loyalty	Adaptive Behaviour	
Conscientiousness	Adaptive Behaviour	
Impulsivity	Adaptive Behaviour	
Individualism: Personal Values	Adaptive Behaviour	
Interdependence	Adaptive Behaviour	
Locus of Control	Adaptive Behaviour	
Motivation	Adaptive Behaviour	
Needs	Adaptive Behaviour	
Position-Based Power	Adaptive Behaviour	
Relation to Environment	Adaptive Behaviour	
Self-Monitoring	Adaptive Behaviour	
Training	Adaptive Behaviour	
	Adaptive Behaviour	Adaptiveness
	Adaptive Behaviour	Cooperability
	Adaptive Behaviour	Flexibility
	Adaptive Behaviour	Innovation
	Adaptive Behaviour	Resilience
	Adaptive Behaviour	Responsiveness
	Adaptive Behaviour	Robustness
Adaptive Behaviour	Adaptiveness	
Emotional Stability	Agreeableness	
Extraversion	Agreeableness	
Individualism: Personal Values	Agreeableness	
Needs	Agreeableness	
Nurturing: Personal Values	Agreeableness	
Trust	Agreeableness	
Trust Propensity	Agreeableness	
	Agreeableness	Commanders Decision Style
	Agreeableness	Cooperability
	Agreeableness	Cooperative Behaviour
	Agreeableness	Decision Style

Is Influenced By (Input)	Variable	Influences (Output)
	Agreeableness	Extra-Role behaviour
	Agreeableness	Intra Group Conflict
	Agreeableness	State of Mental Health
	Agreeableness	Trust Propensity
	Agreeableness	Willingness to Interact
Anxiety	Alertness	
Blood Sugar Level	Alertness	
Commanders Risk Propensity	Alertness	
Motivation	Alertness	
Openness to Experience	Alertness	
Risk Propensity	Alertness	
Sleep Deprivation	Alertness	
Stress Level	Alertness	
	Alertness	Awareness Completeness
	Alertness	Awareness Correctness
	Alertness	Awareness Currency
	Alertness	Awareness Precision
	Alertness	Awareness Relevance
	Alertness	Awareness Uncertainty
	Alertness	Cognitive Capacity
	Alertness	Cognitive Flexibility
	Alertness	Response Speed
Criticality	Allocation of Decision Rights	
	Allocation of Decision Rights	Action Synchronization
	Allocation of Decision Rights	C2 Doctrine
	Allocation of Decision Rights	Co-Located / Distributed
	Allocation of Decision Rights	Consistency of Command Intent
	Allocation of Decision Rights	Individual Task Quality
	Allocation of Decision Rights	Interdependence
	Allocation of Decision Rights	Leadership Culture
	Allocation of Decision Rights	Locus of Control
	Allocation of Decision Rights	Patterns of Interaction Enabled
	Allocation of Decision Rights	Position-Based Power
	Allocation of Decision Rights	Power Distance: Culture
	Allocation of Decision Rights	Role Clarity
	Allocation of Decision Rights	Team Shape
Complicated-ness	Ambiguity of Situation	
Fusion	Ambiguity of Situation	
	Ambiguity of Situation	Collaboration Completeness
	Ambiguity of Situation	Information Consistency
	Ambiguity of Situation	Information Correctness
	Ambiguity of Situation	Information Precision
Cognitive Complexity	Ambiguity Tolerance	

Is Influenced By (Input)	Variable	Influences (Output)
General Intelligence	Ambiguity Tolerance	
Mental Models Confidence	Ambiguity Tolerance	
Mental Models Relevance	Ambiguity Tolerance	
Mental Models Richness	Ambiguity Tolerance	
Openness to Experience	Ambiguity Tolerance	
Understanding Consistency	Ambiguity Tolerance	
Understanding Uncertainty	Ambiguity Tolerance	
	Ambiguity Tolerance	Awareness Completeness
	Ambiguity Tolerance	Awareness Consistency
	Ambiguity Tolerance	Awareness Correctness
	Ambiguity Tolerance	Awareness Precision
	Ambiguity Tolerance	Awareness Uncertainty
	Ambiguity Tolerance	Cognitive Complexity
	Ambiguity Tolerance	Cognitive Flexibility
	Ambiguity Tolerance	Commanders Decision Style
	Ambiguity Tolerance	Commanders Risk Propensity
	Ambiguity Tolerance	Cooperability
	Ambiguity Tolerance	Decision Style
	Ambiguity Tolerance	Emotional Stability
	Ambiguity Tolerance	Impulsivity
	Ambiguity Tolerance	Intra Group Conflict
	Ambiguity Tolerance	Levelling
	Ambiguity Tolerance	Memory Performance
	Ambiguity Tolerance	Mental Models Richness
	Ambiguity Tolerance	Openness to Experience
	Ambiguity Tolerance	Power Distance: Personal Values
	Ambiguity Tolerance	Repression
	Ambiguity Tolerance	Risk Propensity
	Ambiguity Tolerance	State of Mental Health
	Ambiguity Tolerance	Stress Level
	Ambiguity Tolerance	Understanding Completeness
	Ambiguity Tolerance	Understanding Consistency
	Ambiguity Tolerance	Understanding Correctness
	Ambiguity Tolerance	Understanding Precision
Commanders Risk Propensity	Anxiety	
Emotional Stability	Anxiety	
Extraversion	Anxiety	
Intent Motivation	Anxiety	
Motivation	Anxiety	
Repression	Anxiety	
Risk Propensity	Anxiety	
Self-Efficacy	Anxiety	

Is Influenced By (Input)	Variable	Influences (Output)
Self-Esteem	Anxiety	
Trust	Anxiety	
	Anxiety	Alertness
	Anxiety	Awareness Accuracy
	Anxiety	Awareness Completeness
	Anxiety	Awareness Correctness
	Anxiety	Awareness Precision
	Anxiety	Cognitive Complexity
	Anxiety	Cognitive Flexibility
	Anxiety	Mood
	Anxiety	Response Speed
	Anxiety	Risk Taking
	Anxiety	Self-Efficacy
	Anxiety	Stress Level
Quality of Communications Equipment	Authentication	
Quality of Computing Equipment	Authentication	
Quantity of Communications Equipment	Authentication	
Quantity of Computing Equipment	Authentication	
	Authentication	Confidentiality
	Authentication	Integrity
	Authentication	Non-Repudiation
	Authentication	Privacy
Anxiety	Awareness Accuracy	
Awareness Precision	Awareness Accuracy	
Experience of Personnel	Awareness Accuracy	
Impulsivity	Awareness Accuracy	
Information Accuracy	Awareness Accuracy	
Locus of Control	Awareness Accuracy	
Memory Performance	Awareness Accuracy	
Mental Models Richness	Awareness Accuracy	
Shared Information Accuracy	Awareness Accuracy	
Stress Level	Awareness Accuracy	
Training	Awareness Accuracy	
	Awareness Accuracy	Shared Awareness Accuracy
	Awareness Accuracy	Understanding Accuracy
Alertness	Awareness Completeness	
Ambiguity Tolerance	Awareness Completeness	
Anxiety	Awareness Completeness	

Is Influenced By (Input)	Variable	Influences (Output)
Cognitive Capacity	Awareness Completeness	
Cognitive Complexity	Awareness Completeness	
Collaboration Completeness	Awareness Completeness	
Commanders Myers-Briggs Style	Awareness Completeness	
Complexity of Situation	Awareness Completeness	
Information Completeness	Awareness Completeness	
Levelling	Awareness Completeness	
Locus of Control	Awareness Completeness	
Memory Performance	Awareness Completeness	
Mental Models Richness	Awareness Completeness	
Motivation	Awareness Completeness	
Myers-Briggs Style	Awareness Completeness	
Openness to Experience	Awareness Completeness	
Repression	Awareness Completeness	
Shared Information Completeness	Awareness Completeness	
Sleep Deprivation	Awareness Completeness	
Stress Level	Awareness Completeness	
	Awareness Completeness	Awareness Correctness
	Awareness Completeness	Shared Awareness Completeness
	Awareness Completeness	Understanding Completeness
Ambiguity Tolerance	Awareness Consistency	
Awareness Relevance	Awareness Consistency	
Information Consistency	Awareness Consistency	
Mental Models Relevance	Awareness Consistency	
Mental Models Richness	Awareness Consistency	
Shared Information Consistency	Awareness Consistency	
	Awareness Consistency	Awareness Uncertainty
	Awareness Consistency	Shared Awareness Consistency
	Awareness Consistency	Understanding Consistency
	Awareness Consistency	Understanding Correctness
	Awareness Consistency	Understanding Uncertainty
Alertness	Awareness Correctness	
Ambiguity Tolerance	Awareness Correctness	
Anxiety	Awareness Correctness	
Awareness Completeness	Awareness Correctness	
Awareness Precision	Awareness Correctness	
Cognitive Complexity	Awareness Correctness	
Cognitive Flexibility	Awareness Correctness	
Commanders Myers-Briggs Style	Awareness Correctness	

Is Influenced By (Input)	Variable	Influences (Output)
Field Independence	Awareness Correctness	
General Intelligence	Awareness Correctness	
Information Correctness	Awareness Correctness	
Levelling	Awareness Correctness	
Mental Models Relevance	Awareness Correctness	
Mental Models Richness	Awareness Correctness	
Mood	Awareness Correctness	
Motivation	Awareness Correctness	
Myers-Briggs Style	Awareness Correctness	
Openness to Experience	Awareness Correctness	
Repression	Awareness Correctness	
Shared Information Correctness	Awareness Correctness	
Sleep Deprivation	Awareness Correctness	
Stress Level	Awareness Correctness	
	Awareness Correctness	Awareness Uncertainty
	Awareness Correctness	Shared Awareness Correctness
	Awareness Correctness	Understanding Correctness
Alertness	Awareness Currency	
Cognitive Flexibility	Awareness Currency	
Information Currency	Awareness Currency	
Mental Models Relevance	Awareness Currency	
Motivation	Awareness Currency	
Shared Information Currency	Awareness Currency	
Sleep Deprivation	Awareness Currency	
	Awareness Currency	Awareness Timeliness
	Awareness Currency	Shared Awareness Currency
	Awareness Currency	Understanding Currency
Alertness	Awareness Precision	
Ambiguity Tolerance	Awareness Precision	
Anxiety	Awareness Precision	
Cognitive Complexity	Awareness Precision	
Cognitive Flexibility	Awareness Precision	
Commanders Myers-Briggs Style	Awareness Precision	
Field Independence	Awareness Precision	
Information Precision	Awareness Precision	
Levelling	Awareness Precision	
Memory Performance	Awareness Precision	
Mental Models Richness	Awareness Precision	
Mood	Awareness Precision	
Motivation	Awareness Precision	
Myers-Briggs Style	Awareness Precision	
Openness to Experience	Awareness Precision	

Is Influenced By (Input)	Variable	Influences (Output)
Repression	Awareness Precision	
Shared Information Precision	Awareness Precision	
Sleep Deprivation	Awareness Precision	
Stress Level	Awareness Precision	
	Awareness Precision	Awareness Accuracy
	Awareness Precision	Awareness Correctness
	Awareness Precision	Awareness Uncertainty
	Awareness Precision	Shared Awareness Precision
	Awareness Precision	Understanding Precision
Alertness	Awareness Relevance	
Field Independence	Awareness Relevance	
Information Relevance	Awareness Relevance	
Memory Performance	Awareness Relevance	
Mental Models Relevance	Awareness Relevance	
Shared Information Relevance	Awareness Relevance	
Situational Familiarity	Awareness Relevance	
	Awareness Relevance	Awareness Consistency
	Awareness Relevance	Shared Awareness Relevance
	Awareness Relevance	Understanding Relevance
Awareness Currency	Awareness Timeliness	
Commanders Risk Propensity	Awareness Timeliness	
Information Currency	Awareness Timeliness	
Information Timeliness	Awareness Timeliness	
Shared Information Timeliness	Awareness Timeliness	
	Awareness Timeliness	Shared Awareness Timeliness
	Awareness Timeliness	Understanding Timeliness
Alertness	Awareness Uncertainty	
Ambiguity Tolerance	Awareness Uncertainty	
Awareness Consistency	Awareness Uncertainty	
Awareness Correctness	Awareness Uncertainty	
Awareness Precision	Awareness Uncertainty	
Cognitive Flexibility	Awareness Uncertainty	
Information Uncertainty	Awareness Uncertainty	
Levelling	Awareness Uncertainty	
Mental Models Confidence	Awareness Uncertainty	
Mental Models Relevance	Awareness Uncertainty	
Mental Models Richness	Awareness Uncertainty	
Mood	Awareness Uncertainty	
Motivation	Awareness Uncertainty	
Shared Information Uncertainty	Awareness Uncertainty	

Is Influenced By (Input)	Variable	Influences (Output)
Situational Familiarity	Awareness Uncertainty	
Sleep Deprivation	Awareness Uncertainty	
Stress Level	Awareness Uncertainty	
Uncertainty of Situation	Awareness Uncertainty	
	Awareness Uncertainty	Shared Awareness Uncertainty
	Awareness Uncertainty	Understanding Uncertainty
	Blood Sugar Level	Alertness
Allocation of Decision Rights	C2 Doctrine	
Constraint Enforcement	C2 Doctrine	
Dynamics Across Purpose (Command)	C2 Doctrine	
Dynamics Across Purpose (Control)	C2 Doctrine	
Dynamics Across Time (Command)	C2 Doctrine	
Dynamics Across Time (Control)	C2 Doctrine	
Information Distribution	C2 Doctrine	
Patterns of Interaction Enabled	C2 Doctrine	
Patterns of Interaction Not Allowed	C2 Doctrine	
Restriction of Decision Rights	C2 Doctrine	
Restriction on Information Distribution	C2 Doctrine	
Selectivity	C2 Doctrine	
	C2 Doctrine	Decision Relevance
	C2 Doctrine	Likelihood of Success
Alertness	Cognitive Capacity	
Mental Models Richness	Cognitive Capacity	
Stress Level	Cognitive Capacity	
	Cognitive Capacity	Awareness Completeness
	Cognitive Capacity	Cognitive Complexity
	Cognitive Capacity	Commanders Decision Style
	Cognitive Capacity	Decision Accuracy
	Cognitive Capacity	Decision Completeness
	Cognitive Capacity	Decision Correctness
	Cognitive Capacity	Decision Precision
	Cognitive Capacity	Decision Relevance
	Cognitive Capacity	Decision Style
	Cognitive Capacity	Decision Uncertainty
	Cognitive Capacity	General Intelligence
	Cognitive Capacity	Levelling

Is Influenced By (Input)	Variable	Influences (Output)
	Cognitive Capacity	Memory Performance
	Cognitive Capacity	Perceptual Filters
	Cognitive Capacity	Problem Solving Style
Ambiguity Tolerance	Cognitive Complexity	
Anxiety	Cognitive Complexity	
Cognitive Capacity	Cognitive Complexity	
Levelling	Cognitive Complexity	
Mental Models Richness	Cognitive Complexity	
Stress Level	Cognitive Complexity	
	Cognitive Complexity	Adaptive Behaviour
	Cognitive Complexity	Ambiguity Tolerance
	Cognitive Complexity	Awareness Completeness
	Cognitive Complexity	Awareness Correctness
	Cognitive Complexity	Awareness Precision
	Cognitive Complexity	Cognitive Flexibility
	Cognitive Complexity	Commanders Decision Style
	Cognitive Complexity	Decision Style
	Cognitive Complexity	Memory Performance
	Cognitive Complexity	Mental Models Richness
	Cognitive Complexity	Problem Solving Style
Alertness	Cognitive Flexibility	
Ambiguity Tolerance	Cognitive Flexibility	
Anxiety	Cognitive Flexibility	
Cognitive Complexity	Cognitive Flexibility	
General Intelligence	Cognitive Flexibility	
Mental Models Richness	Cognitive Flexibility	
State of Mental Health	Cognitive Flexibility	
Stress Level	Cognitive Flexibility	
	Cognitive Flexibility	Adaptive Behaviour
	Cognitive Flexibility	Awareness Correctness
	Cognitive Flexibility	Awareness Currency
	Cognitive Flexibility	Awareness Precision
	Cognitive Flexibility	Awareness Uncertainty
	Cognitive Flexibility	Cooperability
	Cognitive Flexibility	Flexibility
	Cognitive Flexibility	Innovation
	Cognitive Flexibility	Mental Models Richness
	Cognitive Flexibility	Problem Solving Style
Achievement Orientation: Personal Values	Cohesion	
Commanders Leadership Behaviour	Cohesion	
Commitment/Loyalty	Cohesion	
Conscientiousness	Cohesion	
Cooperative Behaviour	Cohesion	

Is Influenced By (Input)	Variable	Influences (Output)
Extra-Role behaviour	Cohesion	
Extraversion	Cohesion	
Force Will	Cohesion	
Goal Consistency	Cohesion	
Hardness	Cohesion	
Homogeneity	Cohesion	
Individualism: Personal Values	Cohesion	
Interdependence	Cohesion	
Intra Group Conflict	Cohesion	
Leadership Behaviour	Cohesion	
Leadership Culture	Cohesion	
Needs	Cohesion	
Norm Strength	Cohesion	
Nurturing: Personal Values	Cohesion	
Persistence	Cohesion	
Team Scale	Cohesion	
Team Shape	Cohesion	
Temporal Orientation: Personal Values	Cohesion	
Trust	Cohesion	
Trust Propensity	Cohesion	
Willingness to Interact	Cohesion	
	Cohesion	Action Consistency
	Cohesion	Action Efficiency
	Cohesion	Action Synchronization
	Cohesion	Commitment/Loyalty
	Cohesion	Conformity
	Cohesion	Cooperability
	Cohesion	Cooperative Behaviour
	Cohesion	Extra-Role behaviour
	Cohesion	Force Will
	Cohesion	Group Pressure
	Cohesion	Intra Group Conflict
	Cohesion	Leadership Behaviour
	Cohesion	Norm Strength
	Cohesion	Stress Level
	Cohesion	Trust
Information Accuracy	Collaboration	
Information Completeness	Collaboration	
Information Consistency	Collaboration	
Information Correctness	Collaboration	
Information Currency	Collaboration	
Information Networks	Collaboration	
Information Precision	Collaboration	

Is Influenced By (Input)	Variable	Influences (Output)
Information Relevance	Collaboration	
Information Timeliness	Collaboration	
Information Uncertainty	Collaboration	
Quality of Interactions	Collaboration	
Shared Understanding Accuracy	Collaboration	
Shared Understanding Completeness	Collaboration	
Shared Understanding Consistency	Collaboration	
Shared Understanding Correctness	Collaboration	
Shared Understanding Currency	Collaboration	
Shared Understanding Precision	Collaboration	
Shared Understanding Relevance	Collaboration	
Shared Understanding Timeliness	Collaboration	
Shared Understanding Uncertainty	Collaboration	
Uncertainty of Situation	Collaboration	
	Collaboration	Communications Interoperability
	Collaboration	Decision Accuracy
	Collaboration	Decision Completeness
	Collaboration	Decision Consistency
	Collaboration	Decision Correctness
	Collaboration	Decision Currency
	Collaboration	Decision Precision
	Collaboration	Decision Relevance
	Collaboration	Decision Timeliness
	Collaboration	Decision Uncertainty
	Collaboration	Shared Awareness Accuracy
	Collaboration	Shared Awareness Completeness
	Collaboration	Shared Awareness Consistency
	Collaboration	Shared Awareness Correctness
	Collaboration	Shared Awareness Currency
	Collaboration	Shared Awareness Precision
	Collaboration	Shared Awareness Relevance
	Collaboration	Shared Awareness Timeliness
	Collaboration	Shared Awareness Uncertainty
Ambiguity of Situation	Collaboration Completeness	

Is Influenced By (Input)	Variable	Influences (Output)
Cooperability	Collaboration Completeness	
Decision Participants	Collaboration Completeness	
Equivocality of Situation	Collaboration Completeness	
Situational Familiarity	Collaboration Completeness	
Uncertainty of Situation	Collaboration Completeness	
	Collaboration Completeness	Awareness Completeness
	Collaboration Completeness	Information Completeness
	Collaboration Completeness	Plan Completeness
	Collaboration Completeness	Understanding Completeness
Information Networks	Collaboration Mechanism	
Patterns of Interaction Not Allowed	Collaboration Mechanism	
Quality of Communications Equipment	Collaboration Mechanism	
Quantity of Communications Equipment	Collaboration Mechanism	
	Collaboration Mechanism	Communications Interoperability
	Collaboration Mechanism	Patterns of Interaction Enabled
Cooperability	Collaboration Participants	
Patterns of Interaction Not Allowed	Collaboration Participants	
	Collaboration Participants	Communications Interoperability
Allocation of Decision Rights	Co-Located / Distributed	
Patterns of Interaction Enabled	Co-Located / Distributed	
	Co-Located / Distributed	Communications Interoperability
	Co-Located / Distributed	Data Interoperability
	Co-Located / Distributed	Decision Participants
	Co-Located / Distributed	Goal Consistency
	Co-Located / Distributed	Individual Task Efficiency
	Co-Located / Distributed	Information Richness
	Co-Located / Distributed	Network Availability
	Co-Located / Distributed	Network Reach
	Co-Located / Distributed	Network Reliability
	Co-Located / Distributed	Network Richness
	Co-Located / Distributed	Selectivity
	Co-Located / Distributed	System Semantic Interoperability
	Co-Located / Distributed	Task Efficiency

Is Influenced By (Input)	Variable	Influences (Output)
	Co-Located / Distributed	Task Speed
Action Synchronization	Command Speed	
Decision Type	Command Speed	
Dynamics Across Time (Command)	Command Speed	
Dynamics Across Time (Control)	Command Speed	
Hardness	Command Speed	
Homogeneity	Command Speed	
Planning Speed	Command Speed	
Task Efficiency	Command Speed	
Task Speed	Command Speed	
	Command Speed	Likelihood of Success
	Command Speed	Perceived Likelihood of Success
	Command Speed	Task Speed
Agreeableness	Commanders Decision Style	
Ambiguity Tolerance	Commanders Decision Style	
Cognitive Capacity	Commanders Decision Style	
Cognitive Complexity	Commanders Decision Style	
Conscientiousness	Commanders Decision Style	
Mental Models Confidence	Commanders Decision Style	
Mental Models Relevance	Commanders Decision Style	
Mental Models Richness	Commanders Decision Style	
Problem Solving Style	Commanders Decision Style	
Task Understanding	Commanders Decision Style	
Temporal Orientation: Personal Values	Commanders Decision Style	
	Commanders Decision Style	Decision Congruence
	Commanders Decision Style	Decision Timeliness
	Commanders Decision Style	Intra Group Conflict
	Commanders Decision Style	Problem Solving Style
	Commanders Decision Style	Response Speed
Achievement Orientation: Personal Values	Commanders Leadership Behaviour	
Commitment/Loyalty	Commanders Leadership Behaviour	
Conscientiousness	Commanders Leadership Behaviour	
Needs	Commanders Leadership Behaviour	
Nurturing: Personal Values	Commanders Leadership Behaviour	
Position-Based Power	Commanders Leadership Behaviour	

Is Influenced By (Input)	Variable	Influences (Output)
Relation to Environment	Commanders Leadership Behaviour	
Role of Emotion	Commanders Leadership Behaviour	
Task Competence	Commanders Leadership Behaviour	
Temporal Orientation: Personal Values	Commanders Leadership Behaviour	
Trust	Commanders Leadership Behaviour	
Willingness to Interact	Commanders Leadership Behaviour	
	Commanders Leadership Behaviour	Cohesion
	Commanders Leadership Behaviour	Cooperative Behaviour
	Commanders Leadership Behaviour	Goal Consistency
	Commanders Leadership Behaviour	Group Pressure
	Commanders Leadership Behaviour	Hardness
	Commanders Leadership Behaviour	Intra Group Conflict
	Commanders Leadership Behaviour	Persistence
Openness to Experience	Commanders Myers-Briggs Style	
Role of Emotion	Commanders Myers-Briggs Style	
	Commanders Myers-Briggs Style	Awareness Completeness
	Commanders Myers-Briggs Style	Awareness Correctness
	Commanders Myers-Briggs Style	Awareness Precision
	Commanders Myers-Briggs Style	Cooperative Behaviour
	Commanders Myers-Briggs Style	Decision Style
	Commanders Myers-Briggs Style	Field Independence
	Commanders Myers-Briggs Style	Needs
	Commanders Myers-Briggs Style	Openness to Experience

Is Influenced By (Input)	Variable	Influences (Output)
	Commanders Myers-Briggs Style	Problem Solving Style
	Commanders Myers-Briggs Style	Role of Emotion
	Commanders Myers-Briggs Style	Willingness to Interact
Ambiguity Tolerance	Commanders Risk Propensity	
Conscientiousness	Commanders Risk Propensity	
Task Competence	Commanders Risk Propensity	
Task Understanding	Commanders Risk Propensity	
	Commanders Risk Propensity	Action Timeliness
	Commanders Risk Propensity	Alertness
	Commanders Risk Propensity	Anxiety
	Commanders Risk Propensity	Awareness Timeliness
	Commanders Risk Propensity	Decision Relevance
	Commanders Risk Propensity	Decision Speed
	Commanders Risk Propensity	Impulsivity
	Commanders Risk Propensity	Repression
	Commanders Risk Propensity	Risk Taking
	Commanders Risk Propensity	State of Mental Health
	Commanders Risk Propensity	Stress Level
	Commanders Risk Propensity	Trust
	Commanders Risk Propensity	Trust Propensity
Achievement Orientation: Personal Values	Commitment/Loyalty	
Cohesion	Commitment/Loyalty	
Goal Consistency	Commitment/Loyalty	
Group Pressure	Commitment/Loyalty	
Nurturing: Personal Values	Commitment/Loyalty	
Power Distance: Personal Values	Commitment/Loyalty	
Team Scale	Commitment/Loyalty	
Trust	Commitment/Loyalty	
	Commitment/Loyalty	Action Appropriateness
	Commitment/Loyalty	Adaptive Behaviour
	Commitment/Loyalty	Cohesion
	Commitment/Loyalty	Commanders Leadership Behaviour
	Commitment/Loyalty	Conformity
	Commitment/Loyalty	Conscientiousness
	Commitment/Loyalty	Cooperability
	Commitment/Loyalty	Cooperative Behaviour
	Commitment/Loyalty	Extra-Role behaviour
	Commitment/Loyalty	Intent Motivation
	Commitment/Loyalty	Intra Group Conflict

Is Influenced By (Input)	Variable	Influences (Output)
	Commitment/Loyalty	Leadership Behaviour
	Commitment/Loyalty	Motivation
	Commitment/Loyalty	Persistence
	Commitment/Loyalty	Trust
	Commitment/Loyalty	Willingness to Interact
	Communication System Characteristics	Network Availability
	Communication System Characteristics	Network Reach
	Communication System Characteristics	Network Reliability
	Communication System Characteristics	Network Richness
Collaboration	Communications Interoperability	
Collaboration Mechanism	Communications Interoperability	
Collaboration Participants	Communications Interoperability	
Co-Located / Distributed	Communications Interoperability	
Quality of Communication of Command Intent	Communications Interoperability	
Quality of Communications Equipment	Communications Interoperability	
Quantity of Communications Equipment	Communications Interoperability	
	Communications Interoperability	Network Richness
	Communications Interoperability	System Semantic Interoperability
Complicated-ness	Complexity of Situation	
Fusion	Complexity of Situation	
	Complexity of Situation	Awareness Completeness
	Complexity of Situation	Information Completeness
	Complexity of Situation	Information Consistency
	Complexity of Situation	Information Correctness
	Complexity of Situation	Information Timeliness
Enemy Forces	Complicated-ness	
Friendly Forces	Complicated-ness	
Neutral Forces	Complicated-ness	
	Complicated-ness	Ambiguity of Situation
	Complicated-ness	Complexity of Situation

Is Influenced By (Input)	Variable	Influences (Output)
	Complicated-ness	Consistency of Command Intent
	Complicated-ness	Equivocality of Situation
	Complicated-ness	Information Completeness
	Complicated-ness	Information Consistency
	Complicated-ness	Predictability Type
	Complicated-ness	Type I Error (False Alarm Rate)
	Complicated-ness	Type II Error
	Complicated-ness	Uncertainty of Situation
Authentication	Confidentiality	
Quality of Communications Equipment	Confidentiality	
Quality of Computing Equipment	Confidentiality	
Quantity of Communications Equipment	Confidentiality	
Quantity of Computing Equipment	Confidentiality	
	Confidentiality	Information Uncertainty
Achievement Orientation: Personal Values	Conformity	
Cohesion	Conformity	
Commitment/Loyalty	Conformity	
Extraversion	Conformity	
Goal Consistency	Conformity	
Hardness	Conformity	
Homogeneity	Conformity	
Individualism: Personal Values	Conformity	
Mental Models Confidence	Conformity	
Needs	Conformity	
Norm Strength	Conformity	
Position-Based Power	Conformity	
Power Distance: Personal Values	Conformity	
Relation to Environment	Conformity	
Role of Emotion	Conformity	
Sleep Deprivation	Conformity	
Team Scale	Conformity	
Team Shape	Conformity	
Trust	Conformity	
Trust Propensity	Conformity	

Is Influenced By (Input)	Variable	Influences (Output)
	Conformity	Cooperability
	Conformity	Intra Group Conflict
Commitment/Loyalty	Conscientiousness	
Locus of Control	Conscientiousness	
Temporal Orientation: Personal Values	Conscientiousness	
	Conscientiousness	Adaptive Behaviour
	Conscientiousness	Cohesion
	Conscientiousness	Commanders Decision Style
	Conscientiousness	Commanders Leadership Behaviour
	Conscientiousness	Commanders Risk Propensity
	Conscientiousness	Cooperability
	Conscientiousness	Cooperative Behaviour
	Conscientiousness	Decision Style
	Conscientiousness	Impulsivity
	Conscientiousness	Intra Group Conflict
	Conscientiousness	Risk Propensity
Allocation of Decision Rights	Consistency of Command Intent	
Complicated-ness	Consistency of Command Intent	
Cooperability	Consistency of Command Intent	
Development of Intent	Consistency of Command Intent	
	Consistency of Command Intent	Action Appropriateness
	Consistency of Command Intent	Action Correctness
	Consistency of Command Intent	Innovation
	Consistency of Command Intent	Synchronization
Restriction of Decision Rights	Constraint Enforcement	
	Constraint Enforcement	Action Synchronization
	Constraint Enforcement	C2 Doctrine
Restriction of Decision Rights	Constraint Setting	
	Constraint Setting	Plan Consistency
Willingness to Interact	Continuity of Interactions	
	Continuity of Interactions	Hardness
Achievement Orientation: Personal Values	Cooperability	

Is Influenced By (Input)	Variable	Influences (Output)
Adaptive Behaviour	Cooperability	
Agreeableness	Cooperability	
Ambiguity Tolerance	Cooperability	
Cognitive Flexibility	Cooperability	
Cohesion	Cooperability	
Commitment/Loyalty	Cooperability	
Conformity	Cooperability	
Conscientiousness	Cooperability	
Cooperative Behaviour	Cooperability	
Emotional Stability	Cooperability	
Extra-Role behaviour	Cooperability	
Extraversion	Cooperability	
General Intelligence	Cooperability	
Goal Consistency	Cooperability	
Group Pressure	Cooperability	
Hardness	Cooperability	
Impulsivity	Cooperability	
Individualism: Personal Values	Cooperability	
Intra Group Conflict	Cooperability	
Leadership Behaviour	Cooperability	
Locus of Control	Cooperability	
Norm Strength	Cooperability	
Persistence	Cooperability	
Problem Solving Style	Cooperability	
Relation to Environment	Cooperability	
Role Clarity	Cooperability	
Task Competence	Cooperability	
Team Scale	Cooperability	
Team Shape	Cooperability	
Temporal Orientation: Personal Values	Cooperability	
Trust	Cooperability	
Understanding Relevance	Cooperability	
Understanding Timeliness	Cooperability	
Understanding Uncertainty	Cooperability	
	Cooperability	Action Efficiency
	Cooperability	Action Synchronization
	Cooperability	Collaboration Completeness
	Cooperability	Collaboration Participants
	Cooperability	Consistency of Command Intent
	Cooperability	Information Sharability
	Cooperability	Interaction Quality

Is Influenced By (Input)	Variable	Influences (Output)
	Cooperability	Quality of Communication of Command Intent
Achievement Orientation: Personal Values	Cooperative Behaviour	
Agreeableness	Cooperative Behaviour	
Cohesion	Cooperative Behaviour	
Commanders Leadership Behaviour	Cooperative Behaviour	
Commanders Myers-Briggs Style	Cooperative Behaviour	
Commitment/Loyalty	Cooperative Behaviour	
Conscientiousness	Cooperative Behaviour	
Extraversion	Cooperative Behaviour	
Goal Consistency	Cooperative Behaviour	
Group Pressure	Cooperative Behaviour	
Homogeneity	Cooperative Behaviour	
Individualism: Personal Values	Cooperative Behaviour	
Interdependence	Cooperative Behaviour	
Intra Group Conflict	Cooperative Behaviour	
Leadership Behaviour	Cooperative Behaviour	
Mood	Cooperative Behaviour	
Myers-Briggs Style	Cooperative Behaviour	
Needs	Cooperative Behaviour	
Norm Strength	Cooperative Behaviour	
Nurturing: Personal Values	Cooperative Behaviour	
Persistence	Cooperative Behaviour	
Relation to Environment	Cooperative Behaviour	
Team Scale	Cooperative Behaviour	
Team Shape	Cooperative Behaviour	
Training	Cooperative Behaviour	
Trust	Cooperative Behaviour	
Trust Propensity	Cooperative Behaviour	
Willingness to Interact	Cooperative Behaviour	
	Cooperative Behaviour	Cohesion
	Cooperative Behaviour	Cooperability
	Cooperative Behaviour	Intra Group Conflict
	Criticality	Allocation of Decision Rights
	Criticality	Restriction of Decision Rights
Co-Located / Distributed	Data Interoperability	
Quality of Communications Equipment	Data Interoperability	
Quality of Computing Equipment	Data Interoperability	

Is Influenced By (Input)	Variable	Influences (Output)
Quantity of Communications Equipment	Data Interoperability	
Quantity of Computing Equipment	Data Interoperability	
	Data Interoperability	Network Richness
	Data Interoperability	System Semantic Interoperability
Information Source Characteristics	Databases	
Open Sources	Databases	
Cognitive Capacity	Decision Accuracy	
Collaboration	Decision Accuracy	
Decision Style	Decision Accuracy	
Experience of Personnel	Decision Accuracy	
Mental Models Relevance	Decision Accuracy	
Understanding Accuracy	Decision Accuracy	
	Decision Accuracy	Action Accuracy
	Decision Accuracy	Quality of Command Intent
Cognitive Capacity	Decision Completeness	
Collaboration	Decision Completeness	
Decision Style	Decision Completeness	
Experience of Personnel	Decision Completeness	
Mental Models Relevance	Decision Completeness	
Situational Familiarity	Decision Completeness	
Task Competence	Decision Completeness	
Understanding Completeness	Decision Completeness	
	Decision Completeness	Action Completeness
	Decision Completeness	Quality of Command Intent
Commanders Decision Style	Decision Congruence	
Decision Style	Decision Congruence	
Goal Consistency	Decision Congruence	
Individualism: Personal Values	Decision Congruence	
	Decision Congruence	Action Consistency
	Decision Congruence	Action Efficiency
	Decision Congruence	Action Synchronization
Collaboration	Decision Consistency	
Decision Participants	Decision Consistency	
Decision Style	Decision Consistency	
Education	Decision Consistency	
Quality of Personnel	Decision Consistency	
Training	Decision Consistency	

Is Influenced By (Input)	Variable	Influences (Output)
Understanding Consistency	Decision Consistency	
	Decision Consistency	Action Consistency
	Decision Consistency	Action Efficiency
	Decision Consistency	Quality of Command Intent
Cognitive Capacity	Decision Correctness	
Collaboration	Decision Correctness	
Decision Style	Decision Correctness	
Decision Uncertainty	Decision Correctness	
Experience of Personnel	Decision Correctness	
Understanding Correctness	Decision Correctness	
	Decision Correctness	Action Appropriateness
	Decision Correctness	Action Synchronization
	Decision Correctness	Quality of Command Intent
Collaboration	Decision Currency	
Decision Speed	Decision Currency	
Decision Style	Decision Currency	
Extraversion	Decision Currency	
Understanding Currency	Decision Currency	
	Decision Currency	Action Timeliness
	Decision Currency	Quality of Command Intent
Co-Located / Distributed	Decision Participants	
	Decision Participants	Action Completeness
	Decision Participants	Collaboration Completeness
	Decision Participants	Decision Consistency
	Decision Participants	Plan Feasibility
Cognitive Capacity	Decision Precision	
Collaboration	Decision Precision	
Decision Style	Decision Precision	
Mental Models Relevance	Decision Precision	
Situational Familiarity	Decision Precision	
Task Competence	Decision Precision	
Understanding Precision	Decision Precision	
	Decision Precision	Action Precision
	Decision Precision	Quality of Command Intent
C2 Doctrine	Decision Relevance	
Cognitive Capacity	Decision Relevance	
Collaboration	Decision Relevance	
Commanders Risk Propensity	Decision Relevance	
Decision Style	Decision Relevance	
Mental Models Relevance	Decision Relevance	
Risk Propensity	Decision Relevance	
Situational Familiarity	Decision Relevance	
Stress Level	Decision Relevance	

Is Influenced By (Input)	Variable	Influences (Output)
Understanding Relevance	Decision Relevance	
	Decision Relevance	Action Appropriateness
	Decision Relevance	Quality of Command Intent
Commanders Risk Propensity	Decision Speed	
Decision Type	Decision Speed	
Decision Uncertainty	Decision Speed	
Dynamics Across Time (Command)	Decision Speed	
Dynamics Across Time (Control)	Decision Speed	
Hardness	Decision Speed	
Homogeneity	Decision Speed	
Human Semantic Interoperability	Decision Speed	
Intent Motivation	Decision Speed	
Mental Models Relevance	Decision Speed	
Mental Models Richness	Decision Speed	
Risk Propensity	Decision Speed	
Risk Taking	Decision Speed	
Task Currency/Latency	Decision Speed	
Task Efficiency	Decision Speed	
Task Speed	Decision Speed	
Understanding Accuracy	Decision Speed	
	Decision Speed	Action Efficiency
	Decision Speed	Decision Currency
Agreeableness	Decision Style	
Ambiguity Tolerance	Decision Style	
Cognitive Capacity	Decision Style	
Cognitive Complexity	Decision Style	
Commanders Myers-Briggs Style	Decision Style	
Conscientiousness	Decision Style	
Mental Models Confidence	Decision Style	
Mental Models Relevance	Decision Style	
Mental Models Richness	Decision Style	
Myers-Briggs Style	Decision Style	
Open / Closed	Decision Style	
Perceptual Filters	Decision Style	
Problem Solving Style	Decision Style	
Task Understanding	Decision Style	
Temporal Orientation: Personal Values	Decision Style	
	Decision Style	Action Appropriateness
	Decision Style	Decision Accuracy

Is Influenced By (Input)	Variable	Influences (Output)
	Decision Style	Decision Completeness
	Decision Style	Decision Congruence
	Decision Style	Decision Consistency
	Decision Style	Decision Correctness
	Decision Style	Decision Currency
	Decision Style	Decision Precision
	Decision Style	Decision Relevance
	Decision Style	Decision Timeliness
	Decision Style	Decision Uncertainty
	Decision Style	Intra Group Conflict
	Decision Style	Quality of Communication of Command Intent
	Decision Style	Response Speed
Collaboration	Decision Timeliness	
Commanders Decision Style	Decision Timeliness	
Decision Style	Decision Timeliness	
Extraversion	Decision Timeliness	
State of Mental Health	Decision Timeliness	
Understanding Timeliness	Decision Timeliness	
	Decision Timeliness	Action Timeliness
	Decision Timeliness	Quality of Command Intent
Mental Models Confidence	Decision Type	
	Decision Type	Command Speed
	Decision Type	Decision Speed
	Decision Type	Quality of Communication of Command Intent
Cognitive Capacity	Decision Uncertainty	
Collaboration	Decision Uncertainty	
Decision Style	Decision Uncertainty	
Experience of Personnel	Decision Uncertainty	
Information Uncertainty	Decision Uncertainty	
Understanding Uncertainty	Decision Uncertainty	
	Decision Uncertainty	Decision Correctness
	Decision Uncertainty	Decision Speed
	Decision Uncertainty	Quality of Command Intent
Intent Motivation	Development of Intent	
	Development of Intent	Consistency of Command Intent
	Development of Intent	Quality of Command Intent
	Direct Sensing	Discovery
Direct Sensing	Discovery	
Experience of Personnel	Discovery	
Indirect Sensing	Discovery	
Information Networks	Discovery	

Is Influenced By (Input)	Variable	Influences (Output)
Information Service Characteristics	Discovery	
Personnel Resources	Discovery	
Quality of Computing Equipment	Discovery	
Quality of Personnel	Discovery	
Quantity of Computing Equipment	Discovery	
Sensor Coverage (Medium)	Discovery	
Sensor Coverage (Spatial)	Discovery	
Sensor Coverage (Spectrum)	Discovery	
Sensor Persistence	Discovery	
	Discovery	Mental Models Richness
	Discovery	Network Richness
	Distances	Action Efficiency
	Distances	Action Timeliness
	Distances	Enemy Forces
	Distances	Friendly Forces
	Distances	Mobility
	Distances	Neutral Forces
	Distances	Sensor Coverage (Spatial)
	Dynamics Across Purpose (Command)	C2 Doctrine
	Dynamics Across Purpose (Command)	Individual Task Efficiency
	Dynamics Across Purpose (Command)	Task Efficiency
	Dynamics Across Purpose (Command)	Team Shape
	Dynamics Across Purpose (Control)	C2 Doctrine
	Dynamics Across Purpose (Control)	Individual Task Efficiency
	Dynamics Across Purpose (Control)	Task Efficiency
	Dynamics Across Time (Command)	C2 Doctrine
	Dynamics Across Time (Command)	Command Speed
	Dynamics Across Time (Command)	Decision Speed
	Dynamics Across Time (Command)	Planning Speed

Is Influenced By (Input)	Variable	Influences (Output)
	Dynamics Across Time (Command)	Task Speed
	Dynamics Across Time (Command)	Team Shape
	Dynamics Across Time (Control)	C2 Doctrine
	Dynamics Across Time (Control)	Command Speed
	Dynamics Across Time (Control)	Decision Speed
	Dynamics Across Time (Control)	Planning Speed
	Dynamics Across Time (Control)	Task Speed
History	Economic Situation	
Political Situation	Economic Situation	
	Economic Situation	Enemy Forces
	Economic Situation	Financial Resources
	Economic Situation	Friendly Forces
	Economic Situation	Political Situation
	Economic Situation	Social Situation
	Education	Decision Consistency
	Education	Human Semantic Interoperability
	Education	Mental Models Richness
	Education	Open / Closed
	Education	Perceptual Filters
	Education	Quality of Personnel
	Education	Situational Familiarity
	Education	Task Competence
Ambiguity Tolerance	Emotional Stability	
Extraversion	Emotional Stability	
Locus of Control	Emotional Stability	
State of Mental Health	Emotional Stability	
	Emotional Stability	Agreeableness
	Emotional Stability	Anxiety
	Emotional Stability	Cooperability
	Emotional Stability	Impulsivity
	Emotional Stability	Intra Group Conflict
	Emotional Stability	Mood
	Emotional Stability	Repression
	Emotional Stability	Risk Taking
	Emotional Stability	Self-Esteem
	Emotional Stability	State of Mental Health
	Emotional Stability	Stress Level

Is Influenced By (Input)	Variable	Influences (Output)
Distances	Enemy Forces	
Economic Situation	Enemy Forces	
History	Enemy Forces	
Quality of Communications Equipment	Enemy Forces	
Quality of Computing Equipment	Enemy Forces	
Quality of Consumable Equipment	Enemy Forces	
Quality of Non-Consumable Equipment	Enemy Forces	
Quality of Personnel	Enemy Forces	
Quality of Sets of Unit Equipment	Enemy Forces	
Trafficability	Enemy Forces	
	Enemy Forces	Complicated-ness
Complicated-ness	Equivocality of Situation	
Fusion	Equivocality of Situation	
	Equivocality of Situation	Collaboration Completeness
	Equivocality of Situation	Information Consistency
	Equivocality of Situation	Information Correctness
	Equivocality of Situation	Information Precision
History	Experience of Personnel	
Training	Experience of Personnel	
	Experience of Personnel	Awareness Accuracy
	Experience of Personnel	Decision Accuracy
	Experience of Personnel	Decision Completeness
	Experience of Personnel	Decision Correctness
	Experience of Personnel	Decision Uncertainty
	Experience of Personnel	Discovery
	Experience of Personnel	Extent of Shared Information
	Experience of Personnel	Fusion
	Experience of Personnel	Human Semantic Interoperability
	Experience of Personnel	Open / Closed
	Experience of Personnel	Perceptual Filters
	Experience of Personnel	Shared Awareness Accuracy
	Experience of Personnel	Shared Awareness Completeness
	Experience of Personnel	Shared Awareness Consistency
	Experience of Personnel	Shared Awareness Correctness
	Experience of Personnel	Shared Awareness Currency
	Experience of Personnel	Shared Awareness Precision
	Experience of Personnel	Shared Awareness Relevance

Is Influenced By (Input)	Variable	Influences (Output)
	Experience of Personnel	Shared Awareness Timeliness
	Experience of Personnel	Shared Awareness Uncertainty
	Experience of Personnel	Shared Information Accuracy
	Experience of Personnel	Shared Information Completeness
	Experience of Personnel	Shared Information Consistency
	Experience of Personnel	Shared Information Correctness
	Experience of Personnel	Shared Information Currency
	Experience of Personnel	Shared Information Precision
	Experience of Personnel	Shared Information Relevance
	Experience of Personnel	Shared Information Timeliness
	Experience of Personnel	Shared Information Uncertainty
	Experience of Personnel	Shared Understanding Accuracy
	Experience of Personnel	Shared Understanding Completeness
	Experience of Personnel	Shared Understanding Consistency
	Experience of Personnel	Shared Understanding Correctness
	Experience of Personnel	Shared Understanding Currency
	Experience of Personnel	Shared Understanding Precision
	Experience of Personnel	Shared Understanding Relevance
	Experience of Personnel	Shared Understanding Timeliness
	Experience of Personnel	Shared Understanding Uncertainty
	Experience of Personnel	Task Competence
Experience of Personnel	Extent of Shared Information	
Information Transfer Approach	Extent of Shared Information	
Training	Extent of Shared Information	
	Extent of Shared Information	Information Completeness
	Extent of Shared Information	Information Consistency
	Extent of Shared Information	Information Correctness
	Extent of Shared Information	Shared Information Completeness
	Extent of Shared Information	Shared Information Consistency

Is Influenced By (Input)	Variable	Influences (Output)
	Extent of Shared Information	Shared Information Correctness
Agreeableness	Extra-Role behaviour	
Cohesion	Extra-Role behaviour	
Commitment/Loyalty	Extra-Role behaviour	
Group Pressure	Extra-Role behaviour	
Hardness	Extra-Role behaviour	
Individualism: Personal Values	Extra-Role behaviour	
Intra Group Conflict	Extra-Role behaviour	
Motivation	Extra-Role behaviour	
Needs	Extra-Role behaviour	
Power Distance: Personal Values	Extra-Role behaviour	
Team Scale	Extra-Role behaviour	
Team Shape	Extra-Role behaviour	
Trust	Extra-Role behaviour	
	Extra-Role behaviour	Cohesion
	Extra-Role behaviour	Cooperability
	Extra-Role behaviour	Intra Group Conflict
Individualism: Personal Values	Extraversion	
	Extraversion	Agreeableness
	Extraversion	Anxiety
	Extraversion	Cohesion
	Extraversion	Conformity
	Extraversion	Cooperability
	Extraversion	Cooperative Behaviour
	Extraversion	Decision Currency
	Extraversion	Decision Timeliness
	Extraversion	Emotional Stability
	Extraversion	Group Pressure
	Extraversion	Hardness
	Extraversion	Myers-Briggs Style
	Extraversion	Needs
	Extraversion	Norm Strength
	Extraversion	Openness to Experience
	Extraversion	Relation to Environment
	Extraversion	Role of Emotion
	Extraversion	Trust Propensity
	Extraversion	Willingness to Interact
Commanders Myers-Briggs Style	Field Independence	
Myers-Briggs Style	Field Independence	
	Field Independence	Awareness Correctness

Is Influenced By (Input)	Variable	Influences (Output)
	Field Independence	Awareness Precision
	Field Independence	Awareness Relevance
Economic Situation	Financial Resources	
	Financial Resources	Lethal Effectors
	Financial Resources	Non-Lethal Effectors
	Financial Resources	Number of Personnel
	Financial Resources	Personnel Resources
	Financial Resources	Quality of Communications Equipment
	Financial Resources	Quality of Computing Equipment
	Financial Resources	Quality of Consumable Equipment
	Financial Resources	Quality of Facilities
	Financial Resources	Quality of Non-Consumable Equipment
	Financial Resources	Quality of Personnel
	Financial Resources	Quality of Sets of Unit Equipment
	Financial Resources	Quantity of Communications Equipment
	Financial Resources	Quantity of Computing Equipment
	Financial Resources	Quantity of Consumable Equipment
	Financial Resources	Quantity of Facilities
	Financial Resources	Quantity of Non-Consumable Equipment
	Financial Resources	Quantity of Sets of Unit Equipment
Adaptive Behaviour	Flexibility	
Cognitive Flexibility	Flexibility	
Openness to Experience	Flexibility	
Risk Taking	Flexibility	
Action Synchronization	Force Effectiveness	
Individual Task Efficiency	Force Effectiveness	
Individual Task Quality	Force Effectiveness	
Mission Effectiveness	Force Effectiveness	
Task Efficiency	Force Effectiveness	
Task Speed	Force Effectiveness	
	Force Effectiveness	Policy Effectiveness
Cohesion	Force Will	
Role of Emotion	Force Will	
	Force Will	Cohesion
	Force Will	Hardness

Is Influenced By (Input)	Variable	Influences (Output)
	Force Will	Persistence
Willingness to Interact	Frequency of Interactions	
	Frequency of Interactions	Quality of Interactions
Distances	Friendly Forces	
Economic Situation	Friendly Forces	
History	Friendly Forces	
Quality of Communications Equipment	Friendly Forces	
Quality of Computing Equipment	Friendly Forces	
Quality of Consumable Equipment	Friendly Forces	
Quality of Non-Consumable Equipment	Friendly Forces	
Quality of Personnel	Friendly Forces	
Quality of Sets of Unit Equipment	Friendly Forces	
Trafficability	Friendly Forces	
	Friendly Forces	Complicated-ness
Experience of Personnel	Fusion	
Indirect Sensing	Fusion	
Information Networks	Fusion	
Information Service Characteristics	Fusion	
Personnel Resources	Fusion	
Quality of Computing Equipment	Fusion	
Quality of Personnel	Fusion	
Quantity of Computing Equipment	Fusion	
Sensor Coverage (Medium)	Fusion	
Sensor Coverage (Spatial)	Fusion	
Sensor Coverage (Spectrum)	Fusion	
Sensor Persistence	Fusion	
	Fusion	Ambiguity of Situation
	Fusion	Complexity of Situation
	Fusion	Equivocality of Situation
	Fusion	Network Richness
	Fusion	Uncertainty of Situation
Cognitive Capacity	General Intelligence	
	General Intelligence	Ambiguity Tolerance
	General Intelligence	Awareness Correctness

Is Influenced By (Input)	Variable	Influences (Output)
	General Intelligence	Cognitive Flexibility
	General Intelligence	Cooperability
	General Intelligence	Memory Performance
	General Intelligence	Mental Models Richness
	General Intelligence	Open / Closed
	General Intelligence	Perceptual Filters
	General Intelligence	Response Speed
	General Intelligence	Understanding Correctness
Co-Located / Distributed	Goal Consistency	
Commanders Leadership Behaviour	Goal Consistency	
Hardness	Goal Consistency	
Homogeneity	Goal Consistency	
Individualism: Personal Values	Goal Consistency	
Interdependence	Goal Consistency	
Leadership Behaviour	Goal Consistency	
Leadership Culture	Goal Consistency	
Norm Strength	Goal Consistency	
Team Scale	Goal Consistency	
Team Shape	Goal Consistency	
	Goal Consistency	Cohesion
	Goal Consistency	Commitment/Loyalty
	Goal Consistency	Conformity
	Goal Consistency	Cooperability
	Goal Consistency	Cooperative Behaviour
	Goal Consistency	Decision Congruence
	Goal Consistency	Group Pressure
	Goal Consistency	Intent Motivation
	Goal Consistency	Intra Group Conflict
	Goal Consistency	Motivation
	Goal Consistency	Persistence
Achievement Orientation: Personal Values	Group Pressure	
Cohesion	Group Pressure	
Commanders Leadership Behaviour	Group Pressure	
Extraversion	Group Pressure	
Goal Consistency	Group Pressure	
Hardness	Group Pressure	
Homogeneity	Group Pressure	
Interdependence	Group Pressure	
Leadership Behaviour	Group Pressure	
Norm Strength	Group Pressure	
Role Clarity	Group Pressure	

Is Influenced By (Input)	Variable	Influences (Output)
Team Scale	Group Pressure	
Team Shape	Group Pressure	
	Group Pressure	Commitment/Loyalty
	Group Pressure	Cooperability
	Group Pressure	Cooperative Behaviour
	Group Pressure	Extra-Role behaviour
	Group Pressure	Intent Motivation
	Group Pressure	Motivation
	Group Pressure	Norm Strength
	Group Pressure	Risk Taking
	Group Pressure	Stress Level
	Group Pressure	Trust
Commanders Leadership Behaviour	Hardness	
Continuity of Interactions	Hardness	
Extraversion	Hardness	
Force Will	Hardness	
Individualism: Personal Values	Hardness	
Leadership Behaviour	Hardness	
Locus of Control	Hardness	
Persistence	Hardness	
Uncertainty Avoidance: Culture	Hardness	
Uncertainty Avoidance: Personal Values	Hardness	
	Hardness	Cohesion
	Hardness	Command Speed
	Hardness	Conformity
	Hardness	Cooperability
	Hardness	Decision Speed
	Hardness	Extra-Role behaviour
	Hardness	Goal Consistency
	Hardness	Group Pressure
	Hardness	Information Pedigree
	Hardness	Intra Group Conflict
	Hardness	Perceived Likelihood of Success
	Hardness	Plan Timeliness
	Hardness	Planning Speed
	Hardness	Risk Propensity
	History	Economic Situation
	History	Enemy Forces
	History	Experience of Personnel
	History	Friendly Forces

Is Influenced By (Input)	Variable	Influences (Output)
	History	Mental Models Richness
	History	Political Situation
Number of Personnel	Homogeneity	
Team Scale	Homogeneity	
	Homogeneity	Cohesion
	Homogeneity	Command Speed
	Homogeneity	Conformity
	Homogeneity	Cooperative Behaviour
	Homogeneity	Decision Speed
	Homogeneity	Goal Consistency
	Homogeneity	Group Pressure
	Homogeneity	Intra Group Conflict
	Homogeneity	Leadership Behaviour
	Homogeneity	Mental Models Confidence
	Homogeneity	Norm Strength
	Homogeneity	Persistence
	Homogeneity	Plan Timeliness
	Homogeneity	Planning Speed
	Homogeneity	Risk Propensity
	Homogeneity	Risk Taking
Education	Human Semantic Interoperability	
Experience of Personnel	Human Semantic Interoperability	
Training	Human Semantic Interoperability	
	Human Semantic Interoperability	Decision Speed
	Human Semantic Interoperability	Planning Speed
Ambiguity Tolerance	Impulsivity	
Commanders Risk Propensity	Impulsivity	
Conscientiousness	Impulsivity	
Emotional Stability	Impulsivity	
Mental Models Confidence	Impulsivity	
Mental Models Relevance	Impulsivity	
Risk Propensity	Impulsivity	
Role of Emotion	Impulsivity	
Stress Level	Impulsivity	
	Impulsivity	Adaptive Behaviour
	Impulsivity	Awareness Accuracy
	Impulsivity	Cooperability
	Impulsivity	Intra Group Conflict
	Impulsivity	Response Speed

Is Influenced By (Input)	Variable	Influences (Output)
	Impulsivity	Self-Monitoring
Information Source Characteristics	Indirect Sensing	
	Indirect Sensing	Discovery
	Indirect Sensing	Fusion
Co-Located / Distributed	Individual Task Efficiency	
Dynamics Across Purpose (Command)	Individual Task Efficiency	
Dynamics Across Purpose (Control)	Individual Task Efficiency	
Individual Task Quality	Individual Task Efficiency	
Task Speed	Individual Task Efficiency	
	Individual Task Efficiency	Force Effectiveness
	Individual Task Efficiency	Planning Speed
Allocation of Decision Rights	Individual Task Quality	
Information Distribution	Individual Task Quality	
Patterns of Interaction Enabled	Individual Task Quality	
	Individual Task Quality	Force Effectiveness
	Individual Task Quality	Individual Task Efficiency
Achievement Orientation: Culture	Individualism: Culture	
Power Distance: Culture	Individualism: Culture	
Temporal Orientation: Culture	Individualism: Culture	
	Individualism: Culture	Achievement Orientation: Culture
	Individualism: Culture	Achievement Orientation: Personal Values
	Individualism: Culture	Leadership Culture
	Individualism: Culture	Nurturing: Culture
	Individualism: Culture	Patterns of Interaction Enabled
	Individualism: Culture	Team Shape
Power Distance: Personal Values	Individualism: Personal Values	
Temporal Orientation: Personal Values	Individualism: Personal Values	
	Individualism: Personal Values	Achievement Orientation: Personal Values
	Individualism: Personal Values	Adaptive Behaviour
	Individualism: Personal Values	Agreeableness
	Individualism: Personal Values	Cohesion
	Individualism: Personal Values	Conformity
	Individualism: Personal Values	Cooperability

Is Influenced By (Input)	Variable	Influences (Output)
	Individualism: Personal Values	Cooperative Behaviour
	Individualism: Personal Values	Decision Congruence
	Individualism: Personal Values	Extra-Role behaviour
	Individualism: Personal Values	Extraversion
	Individualism: Personal Values	Goal Consistency
	Individualism: Personal Values	Hardness
	Individualism: Personal Values	Intra Group Conflict
	Individualism: Personal Values	Leadership Behaviour
	Individualism: Personal Values	Likelihood of Success
	Individualism: Personal Values	Locus of Control
	Individualism: Personal Values	Needs
	Individualism: Personal Values	Nurturing: Personal Values
	Individualism: Personal Values	Relation to Environment
	Individualism: Personal Values	Self-Monitoring
	Individualism: Personal Values	Trust
	Individualism: Personal Values	Trust Propensity
	Individualism: Personal Values	Willingness to Interact
Information Richness	Information Accuracy	
Quality of Visualization	Information Accuracy	
Type I Error (False Alarm Rate)	Information Accuracy	
Type II Error	Information Accuracy	
	Information Accuracy	Awareness Accuracy
	Information Accuracy	Collaboration
	Information Accuracy	Information Completeness
	Information Accuracy	Information Correctness
	Information Accuracy	Information Timeliness
Collaboration Completeness	Information Completeness	
Complexity of Situation	Information Completeness	
Complicated-ness	Information Completeness	
Extent of Shared Information	Information Completeness	
Information Accuracy	Information Completeness	
Information Richness	Information Completeness	
Information Transfer Approach	Information Completeness	
Integrity	Information Completeness	
Mobility	Information Completeness	
Network Richness	Information Completeness	
Quality of Visualization	Information Completeness	
Sensor Coverage (Medium)	Information Completeness	
Sensor Coverage (Spatial)	Information Completeness	

Is Influenced By (Input)	Variable	Influences (Output)
Sensor Coverage (Spectrum)	Information Completeness	
Sensor Persistence	Information Completeness	
	Information Completeness	Awareness Completeness
	Information Completeness	Collaboration
	Information Completeness	Shared Information Completeness
	Information Completeness	Understanding Completeness
Ambiguity of Situation	Information Consistency	
Complexity of Situation	Information Consistency	
Complicated-ness	Information Consistency	
Equivocality of Situation	Information Consistency	
Extent of Shared Information	Information Consistency	
Information Relevance	Information Consistency	
Information Richness	Information Consistency	
Information Transfer Approach	Information Consistency	
Mobility	Information Consistency	
Quality of Visualization	Information Consistency	
Sensor Coverage (Medium)	Information Consistency	
Sensor Coverage (Spatial)	Information Consistency	
Sensor Coverage (Spectrum)	Information Consistency	
Sensor Persistence	Information Consistency	
	Information Consistency	Awareness Consistency
	Information Consistency	Collaboration
	Information Consistency	Shared Information Consistency
	Information Consistency	Understanding Consistency
Ambiguity of Situation	Information Correctness	
Complexity of Situation	Information Correctness	
Equivocality of Situation	Information Correctness	
Extent of Shared Information	Information Correctness	
Information Accuracy	Information Correctness	
Information Networks	Information Correctness	
Information Transfer Approach	Information Correctness	
Mobility	Information Correctness	
Quality of Visualization	Information Correctness	
Sensor Coverage (Medium)	Information Correctness	
Sensor Coverage (Spatial)	Information Correctness	

Is Influenced By (Input)	Variable	Influences (Output)
Sensor Coverage (Spectrum)	Information Correctness	
Sensor Persistence	Information Correctness	
	Information Correctness	Awareness Correctness
	Information Correctness	Collaboration
	Information Correctness	Shared Information Correctness
	Information Correctness	Understanding Correctness
Information Networks	Information Currency	
Information Relevance	Information Currency	
Information Transfer Approach	Information Currency	
Quality of Visualization	Information Currency	
Sensor Coverage (Medium)	Information Currency	
Sensor Coverage (Spatial)	Information Currency	
Sensor Coverage (Spectrum)	Information Currency	
	Information Currency	Awareness Currency
	Information Currency	Awareness Timeliness
	Information Currency	Collaboration
	Information Currency	Plan Timeliness
	Information Currency	Shared Information Currency
	Information Currency	Task Currency/Latency
	Information Currency	Understanding Currency
	Information Currency	Understanding Timeliness
	Information Distribution	Action Completeness
	Information Distribution	Action Correctness
	Information Distribution	Action Synchronization
	Information Distribution	C2 Doctrine
	Information Distribution	Individual Task Quality
	Information Distribution	Interdependence
Quality of Communications Equipment	Information Networks	
Quality of Computing Equipment	Information Networks	
Quantity of Communications Equipment	Information Networks	
Quantity of Computing Equipment	Information Networks	
	Information Networks	Collaboration
	Information Networks	Collaboration Mechanism
	Information Networks	Discovery

Is Influenced By (Input)	Variable	Influences (Output)
	Information Networks	Fusion
	Information Networks	Information Correctness
	Information Networks	Information Currency
	Information Networks	Information Timeliness
	Information Networks	Patterns of Interaction Enabled
	Information Networks	Patterns of Interaction Not Allowed
Hardness	Information Pedigree	
	Information Pedigree	Information Uncertainty
Ambiguity of Situation	Information Precision	
Equivocality of Situation	Information Precision	
Information Transfer Approach	Information Precision	
Quality of Visualization	Information Precision	
Sensor Coverage (Medium)	Information Precision	
Sensor Coverage (Spatial)	Information Precision	
Sensor Coverage (Spectrum)	Information Precision	
Sensor Persistence	Information Precision	
Type I Error (False Alarm Rate)	Information Precision	
Type II Error	Information Precision	
	Information Precision	Awareness Precision
	Information Precision	Collaboration
	Information Precision	Shared Information Precision
	Information Precision	Understanding Precision
Quality of Visualization	Information Relevance	
	Information Relevance	Awareness Relevance
	Information Relevance	Collaboration
	Information Relevance	Information Consistency
	Information Relevance	Information Currency
Co-Located / Distributed	Information Richness	
	Information Richness	Information Accuracy
	Information Richness	Information Completeness
	Information Richness	Information Consistency
Information Transfer Approach	Information Service Characteristics	
	Information Service Characteristics	Discovery
	Information Service Characteristics	Fusion
Cooperability	Information Sharability	
	Information Sharability	Shared Information Completeness

Is Influenced By (Input)	Variable	Influences (Output)
Information Transfer Approach	Information Source Characteristics	
Sensor Coverage (Medium)	Information Source Characteristics	
Sensor Coverage (Spatial)	Information Source Characteristics	
Sensor Coverage (Spectrum)	Information Source Characteristics	
	Information Source Characteristics	Databases
	Information Source Characteristics	Indirect Sensing
	Information Source Characteristics	Open Sources
Complexity of Situation	Information Timeliness	
Information Accuracy	Information Timeliness	
Information Networks	Information Timeliness	
Information Transfer Approach	Information Timeliness	
Mobility	Information Timeliness	
Quality of Visualization	Information Timeliness	
Sensor Coverage (Medium)	Information Timeliness	
Sensor Coverage (Spatial)	Information Timeliness	
Sensor Coverage (Spectrum)	Information Timeliness	
Sensor Persistence	Information Timeliness	
	Information Timeliness	Awareness Timeliness
	Information Timeliness	Collaboration
	Information Timeliness	Shared Information Timeliness
	Information Timeliness	Understanding Timeliness
Patterns of Interaction Enabled	Information Transfer Approach	
	Information Transfer Approach	Extent of Shared Information
	Information Transfer Approach	Information Completeness
	Information Transfer Approach	Information Consistency
	Information Transfer Approach	Information Correctness
	Information Transfer Approach	Information Currency
	Information Transfer Approach	Information Precision
	Information Transfer Approach	Information Service Characteristics
	Information Transfer Approach	Information Source Characteristics
	Information Transfer Approach	Information Timeliness
	Information Transfer Approach	Shared Information Accuracy

Is Influenced By (Input)	Variable	Influences (Output)
	Information Transfer Approach	Shared Information Completeness
	Information Transfer Approach	Shared Information Consistency
	Information Transfer Approach	Shared Information Correctness
	Information Transfer Approach	Shared Information Currency
	Information Transfer Approach	Shared Information Precision
	Information Transfer Approach	Shared Information Relevance
Confidentiality	Information Uncertainty	
Information Pedigree	Information Uncertainty	
Quality of Visualization	Information Uncertainty	
	Information Uncertainty	Awareness Uncertainty
	Information Uncertainty	Collaboration
	Information Uncertainty	Decision Uncertainty
	Information Uncertainty	Plan Uncertainty
Adaptive Behaviour	Innovation	
Cognitive Flexibility	Innovation	
Consistency of Command Intent	Innovation	
Openness to Experience	Innovation	
Problem Solving Style	Innovation	
Quality of Command Intent	Innovation	
Risk Taking	Innovation	
Authentication	Integrity	
Non-Repudiation	Integrity	
Quality of Communications Equipment	Integrity	
Quality of Computing Equipment	Integrity	
Quantity of Communications Equipment	Integrity	
Quantity of Computing Equipment	Integrity	
	Integrity	Information Completeness
	Integrity	Shared Information Completeness
Commitment/Loyalty	Intent Motivation	
Goal Consistency	Intent Motivation	
Group Pressure	Intent Motivation	
Mood	Intent Motivation	
Openness to Experience	Intent Motivation	

Is Influenced By (Input)	Variable	Influences (Output)
Self-Efficacy	Intent Motivation	
Sleep Deprivation	Intent Motivation	
	Intent Motivation	Anxiety
	Intent Motivation	Decision Speed
	Intent Motivation	Development of Intent
	Intent Motivation	Planning Speed
	Intent Motivation	Response Speed
Cooperability	Interaction Quality	
Patterns of Interaction Not Allowed	Interaction Quality	
	Interaction Quality	Shared Information Completeness
	Interaction Quality	Shared Information Consistency
	Interaction Quality	Shared Information Correctness
Allocation of Decision Rights	Interdependence	
Information Distribution	Interdependence	
Patterns of Interaction Enabled	Interdependence	
	Interdependence	Adaptive Behaviour
	Interdependence	Cohesion
	Interdependence	Cooperative Behaviour
	Interdependence	Goal Consistency
	Interdependence	Group Pressure
	Interdependence	Intra Group Conflict
	Interdependence	Leadership Behaviour
Agreeableness	Intra Group Conflict	
Ambiguity Tolerance	Intra Group Conflict	
Cohesion	Intra Group Conflict	
Commanders Decision Style	Intra Group Conflict	
Commanders Leadership Behaviour	Intra Group Conflict	
Commitment/Loyalty	Intra Group Conflict	
Conformity	Intra Group Conflict	
Conscientiousness	Intra Group Conflict	
Cooperative Behaviour	Intra Group Conflict	
Decision Style	Intra Group Conflict	
Emotional Stability	Intra Group Conflict	
Extra-Role behaviour	Intra Group Conflict	
Goal Consistency	Intra Group Conflict	
Hardness	Intra Group Conflict	
Homogeneity	Intra Group Conflict	

Is Influenced By (Input)	Variable	Influences (Output)
Impulsivity	Intra Group Conflict	
Individualism: Personal Values	Intra Group Conflict	
Interdependence	Intra Group Conflict	
Leadership Behaviour	Intra Group Conflict	
Needs	Intra Group Conflict	
Norm Strength	Intra Group Conflict	
Relation to Environment	Intra Group Conflict	
Role Clarity	Intra Group Conflict	
Team Scale	Intra Group Conflict	
Team Shape	Intra Group Conflict	
Temporal Orientation: Personal Values	Intra Group Conflict	
Trust	Intra Group Conflict	
Trust Propensity	Intra Group Conflict	
	Intra Group Conflict	Action Consistency
	Intra Group Conflict	Cohesion
	Intra Group Conflict	Cooperability
	Intra Group Conflict	Cooperative Behaviour
	Intra Group Conflict	Extra-Role behaviour
	Intra Group Conflict	Stress Level
Achievement Orientation: Personal Values	Leadership Behaviour	
Cohesion	Leadership Behaviour	
Commitment/Loyalty	Leadership Behaviour	
Homogeneity	Leadership Behaviour	
Individualism: Personal Values	Leadership Behaviour	
Interdependence	Leadership Behaviour	
Leadership Culture	Leadership Behaviour	
Needs	Leadership Behaviour	
Position-Based Power	Leadership Behaviour	
Power Distance: Personal Values	Leadership Behaviour	
Quality of Command Intent	Leadership Behaviour	
Quality of Communication of Command Intent	Leadership Behaviour	
Relation to Environment	Leadership Behaviour	
Team Scale	Leadership Behaviour	
Team Shape	Leadership Behaviour	
Temporal Orientation: Personal Values	Leadership Behaviour	
Training	Leadership Behaviour	
Trust	Leadership Behaviour	

Is Influenced By (Input)	Variable	Influences (Output)
Willingness to Interact	Leadership Behaviour	
	Leadership Behaviour	Cohesion
	Leadership Behaviour	Cooperability
	Leadership Behaviour	Cooperative Behaviour
	Leadership Behaviour	Goal Consistency
	Leadership Behaviour	Group Pressure
	Leadership Behaviour	Hardness
	Leadership Behaviour	Intra Group Conflict
	Leadership Behaviour	Motivation
	Leadership Behaviour	Quality of Command Intent
	Leadership Behaviour	Trust
	Leadership Behaviour	Trust Propensity
Achievement Orientation: Culture	Leadership Culture	
Allocation of Decision Rights	Leadership Culture	
Individualism: Culture	Leadership Culture	
Nurturing: Culture	Leadership Culture	
Patterns of Interaction Enabled	Leadership Culture	
Patterns of Interaction Not Allowed	Leadership Culture	
Power Distance: Culture	Leadership Culture	
Restriction of Decision Rights	Leadership Culture	
Temporal Orientation: Culture	Leadership Culture	
	Leadership Culture	Cohesion
	Leadership Culture	Goal Consistency
	Leadership Culture	Leadership Behaviour
	Leadership Culture	Persistence
	Leadership Culture	Team Shape
Financial Resources	Lethal Effectors	
Mobility	Lethal Effectors	
Quality of Consumable Equipment	Lethal Effectors	
Quality of Sets of Unit Equipment	Lethal Effectors	
	Lethal Effectors	Likelihood of Success
	Lethal Effectors	Network Availability
	Lethal Effectors	Perceived Likelihood of Success
Ambiguity Tolerance	Levelling	
Cognitive Capacity	Levelling	
Mental Models Confidence	Levelling	

Is Influenced By (Input)	Variable	Influences (Output)
Mental Models Richness	Levelling	
Openness to Experience	Levelling	
	Levelling	Awareness Completeness
	Levelling	Awareness Correctness
	Levelling	Awareness Precision
	Levelling	Awareness Uncertainty
	Levelling	Cognitive Complexity
	Levelling	Memory Performance
	Levelling	Mental Models Richness
Action Accuracy	Likelihood of Success	
Action Appropriateness	Likelihood of Success	
Action Completeness	Likelihood of Success	
Action Consistency	Likelihood of Success	
Action Correctness	Likelihood of Success	
Action Efficiency	Likelihood of Success	
Action Precision	Likelihood of Success	
Action Timeliness	Likelihood of Success	
C2 Doctrine	Likelihood of Success	
Command Speed	Likelihood of Success	
Individualism: Personal Values	Likelihood of Success	
Lethal Effectors	Likelihood of Success	
Non-Lethal Effectors	Likelihood of Success	
Number of Personnel	Likelihood of Success	
Plan Feasibility	Likelihood of Success	
Planning Speed	Likelihood of Success	
Quality of Computing Equipment	Likelihood of Success	
Quality of Consumable Equipment	Likelihood of Success	
Quality of Non-Consumable Equipment	Likelihood of Success	
Quality of Sets of Unit Equipment	Likelihood of Success	
Quantity of Consumable Equipment	Likelihood of Success	
Quantity of Non-Consumable Equipment	Likelihood of Success	
Quantity of Sets of Unit Equipment	Likelihood of Success	
Response Speed	Likelihood of Success	
	Likelihood of Success	Mission Effectiveness
Allocation of Decision Rights	Locus of Control	

Is Influenced By (Input)	Variable	Influences (Output)
Individualism: Personal Values	Locus of Control	
	Locus of Control	Achievement Orientation: Personal Values
	Locus of Control	Adaptive Behaviour
	Locus of Control	Awareness Accuracy
	Locus of Control	Awareness Completeness
	Locus of Control	Conscientiousness
	Locus of Control	Cooperability
	Locus of Control	Emotional Stability
	Locus of Control	Hardness
	Locus of Control	Motivation
	Locus of Control	Relation to Environment
Plan Accuracy	Measures of C2 Effectiveness	
Plan Completeness	Measures of C2 Effectiveness	
Plan Correctness	Measures of C2 Effectiveness	
Plan Feasibility	Measures of C2 Effectiveness	
Ambiguity Tolerance	Memory Performance	
Cognitive Capacity	Memory Performance	
Cognitive Complexity	Memory Performance	
General Intelligence	Memory Performance	
Levelling	Memory Performance	
Motivation	Memory Performance	
Sleep Deprivation	Memory Performance	
Training	Memory Performance	
	Memory Performance	Awareness Accuracy
	Memory Performance	Awareness Completeness
	Memory Performance	Awareness Precision
	Memory Performance	Awareness Relevance
Homogeneity	Mental Models Confidence	
Mental Models Relevance	Mental Models Confidence	
Mental Models Richness	Mental Models Confidence	
Understanding Completeness	Mental Models Confidence	
Understanding Consistency	Mental Models Confidence	
Understanding Precision	Mental Models Confidence	
Understanding Uncertainty	Mental Models Confidence	
	Mental Models Confidence	Ambiguity Tolerance
	Mental Models Confidence	Awareness Uncertainty
	Mental Models Confidence	Commanders Decision Style
	Mental Models Confidence	Conformity
	Mental Models Confidence	Decision Style
	Mental Models Confidence	Decision Type
	Mental Models Confidence	Impulsivity

Is Influenced By (Input)	Variable	Influences (Output)
	Mental Models Confidence	Levelling
	Mental Models Confidence	Risk Taking
	Mental Models Confidence	Stress Level
	Mental Models Confidence	Uncertainty Avoidance: Culture
	Mental Models Confidence	Uncertainty Avoidance: Personal Values
	Mental Models Confidence	Understanding Uncertainty
Relation to Environment	Mental Models Relevance	
Situational Familiarity	Mental Models Relevance	
	Mental Models Relevance	Ambiguity Tolerance
	Mental Models Relevance	Awareness Consistency
	Mental Models Relevance	Awareness Correctness
	Mental Models Relevance	Awareness Currency
	Mental Models Relevance	Awareness Relevance
	Mental Models Relevance	Awareness Uncertainty
	Mental Models Relevance	Commanders Decision Style
	Mental Models Relevance	Decision Accuracy
	Mental Models Relevance	Decision Completeness
	Mental Models Relevance	Decision Precision
	Mental Models Relevance	Decision Relevance
	Mental Models Relevance	Decision Speed
	Mental Models Relevance	Decision Style
	Mental Models Relevance	Impulsivity
	Mental Models Relevance	Mental Models Confidence
	Mental Models Relevance	Response Speed
	Mental Models Relevance	Risk Taking
	Mental Models Relevance	Self-Efficacy
	Mental Models Relevance	Shared Understanding Accuracy
	Mental Models Relevance	Shared Understanding Completeness
	Mental Models Relevance	Shared Understanding Consistency
	Mental Models Relevance	Shared Understanding Correctness
	Mental Models Relevance	Shared Understanding Currency
	Mental Models Relevance	Shared Understanding Precision
	Mental Models Relevance	Shared Understanding Relevance
	Mental Models Relevance	Shared Understanding Timeliness

Is Influenced By (Input)	Variable	Influences (Output)
	Mental Models Relevance	Shared Understanding Uncertainty
	Mental Models Relevance	Task Understanding
	Mental Models Relevance	Understanding Accuracy
	Mental Models Relevance	Understanding Completeness
	Mental Models Relevance	Understanding Consistency
	Mental Models Relevance	Understanding Correctness
	Mental Models Relevance	Understanding Currency
	Mental Models Relevance	Understanding Relevance
	Mental Models Relevance	Understanding Timeliness
	Mental Models Relevance	Understanding Uncertainty
Ambiguity Tolerance	Mental Models Richness	
Cognitive Complexity	Mental Models Richness	
Cognitive Flexibility	Mental Models Richness	
Discovery	Mental Models Richness	
Education	Mental Models Richness	
General Intelligence	Mental Models Richness	
History	Mental Models Richness	
Levelling	Mental Models Richness	
Openness to Experience	Mental Models Richness	
Repression	Mental Models Richness	
Self-Monitoring	Mental Models Richness	
Stress Level	Mental Models Richness	
Training	Mental Models Richness	
Understanding Completeness	Mental Models Richness	
Understanding Precision	Mental Models Richness	
	Mental Models Richness	Ambiguity Tolerance
	Mental Models Richness	Awareness Accuracy
	Mental Models Richness	Awareness Completeness
	Mental Models Richness	Awareness Consistency
	Mental Models Richness	Awareness Correctness
	Mental Models Richness	Awareness Precision
	Mental Models Richness	Awareness Uncertainty
	Mental Models Richness	Cognitive Capacity
	Mental Models Richness	Cognitive Complexity
	Mental Models Richness	Cognitive Flexibility
	Mental Models Richness	Commanders Decision Style
	Mental Models Richness	Decision Speed
	Mental Models Richness	Decision Style
	Mental Models Richness	Levelling
	Mental Models Richness	Mental Models Confidence
	Mental Models Richness	Problem Solving Style
	Mental Models Richness	Situational Familiarity
	Mental Models Richness	Task Understanding

Is Influenced By (Input)	Variable	Influences (Output)
	Mental Models Richness	Understanding Completeness
	Mental Models Richness	Understanding Consistency
	Mental Models Richness	Understanding Correctness
	Mental Models Richness	Understanding Precision
	Mental Models Richness	Understanding Uncertainty
Action Appropriateness	Mission Effectiveness	
Action Completeness	Mission Effectiveness	
Action Correctness	Mission Effectiveness	
Action Synchronization	Mission Effectiveness	
Action Timeliness	Mission Effectiveness	
Likelihood of Success	Mission Effectiveness	
	Mission Effectiveness	Force Effectiveness
Distances	Mobility	
Trafficability	Mobility	
Weather (Atmospheric)	Mobility	
	Mobility	Information Completeness
	Mobility	Information Consistency
	Mobility	Information Correctness
	Mobility	Information Timeliness
	Mobility	Lethal Effectors
	Mobility	Network Richness
Anxiety	Mood	
Emotional Stability	Mood	
Self-Efficacy	Mood	
Sleep Deprivation	Mood	
	Mood	Awareness Correctness
	Mood	Awareness Precision
	Mood	Awareness Uncertainty
	Mood	Cooperative Behaviour
	Mood	Intent Motivation
	Mood	Motivation
	Mood	Risk Taking
	Mood	Stress Level
Achievement Orientation: Personal Values	Motivation	
Commitment/Loyalty	Motivation	
Goal Consistency	Motivation	
Group Pressure	Motivation	
Leadership Behaviour	Motivation	
Locus of Control	Motivation	
Mood	Motivation	
Openness to Experience	Motivation	
Self-Efficacy	Motivation	
Self-Esteem	Motivation	

Is Influenced By (Input)	Variable	Influences (Output)
Sleep Deprivation	Motivation	
Team Scale	Motivation	
	Motivation	Action Accuracy
	Motivation	Action Completeness
	Motivation	Action Correctness
	Motivation	Action Efficiency
	Motivation	Adaptive Behaviour
	Motivation	Alertness
	Motivation	Anxiety
	Motivation	Awareness Completeness
	Motivation	Awareness Correctness
	Motivation	Awareness Currency
	Motivation	Awareness Precision
	Motivation	Awareness Uncertainty
	Motivation	Extra-Role behaviour
	Motivation	Memory Performance
	Motivation	Response Speed
	Motivation	Self-Efficacy
	Motivation	Stress Level
Other Physical Abilities	Motor Skill	
Physical Flexibility	Motor Skill	
Physical Strength	Motor Skill	
Sleep Deprivation	Motor Skill	
State of Physical Health	Motor Skill	
	Motor Skill	Response Speed
Extraversion	Myers-Briggs Style	
Openness to Experience	Myers-Briggs Style	
	Myers-Briggs Style	Awareness Completeness
	Myers-Briggs Style	Awareness Correctness
	Myers-Briggs Style	Awareness Precision
	Myers-Briggs Style	Cooperative Behaviour
	Myers-Briggs Style	Decision Style
	Myers-Briggs Style	Field Independence
	Myers-Briggs Style	Needs
	Myers-Briggs Style	Openness to Experience
	Myers-Briggs Style	Problem Solving Style
	Myers-Briggs Style	Role of Emotion
	Myers-Briggs Style	Willingness to Interact
Achievement Orientation: Personal Values	Needs	
Commanders Myers-Briggs Style	Needs	
Extraversion	Needs	
Individualism: Personal Values	Needs	

Is Influenced By (Input)	Variable	Influences (Output)
Myers-Briggs Style	Needs	
Power Distance: Personal Values	Needs	
	Needs	Adaptive Behaviour
	Needs	Agreeableness
	Needs	Cohesion
	Needs	Commanders Leadership Behaviour
	Needs	Conformity
	Needs	Cooperative Behaviour
	Needs	Extra-Role behaviour
	Needs	Intra Group Conflict
	Needs	Leadership Behaviour
	Needs	Relation to Environment
	Needs	Self-Monitoring
	Needs	Trust Propensity
	Needs	Willingness to Interact
Network Availability	Network Assurance	
Network Reach	Network Assurance	
Network Reliability	Network Assurance	
Network Richness	Network Assurance	
Network Sustainability	Network Assurance	
	Network Assurance	Patterns of Interaction Enabled
Co-Located / Distributed	Network Availability	
Communication System Characteristics	Network Availability	
Lethal Effectors	Network Availability	
Network Reliability	Network Availability	
Network Sustainability	Network Availability	
Non-Lethal Effectors	Network Availability	
Quality of Communications Equipment	Network Availability	
Quality of Computing Equipment	Network Availability	
Quality of Facilities	Network Availability	
Quantity of Communications Equipment	Network Availability	
Quantity of Computing Equipment	Network Availability	
Quantity of Facilities	Network Availability	
	Network Availability	Network Assurance
Co-Located / Distributed	Network Reach	

Is Influenced By (Input)	Variable	Influences (Output)
Communication System Characteristics	Network Reach	
Patterns of Interaction Not Allowed	Network Reach	
	Network Reach	Network Assurance
Quality of Communications Equipment	Network Redundancy	
Quality of Computing Equipment	Network Redundancy	
Quantity of Communications Equipment	Network Redundancy	
Quantity of Computing Equipment	Network Redundancy	
	Network Redundancy	Network Reliability
	Network Redundancy	Network Sustainability
Co-Located / Distributed	Network Reliability	
Communication System Characteristics	Network Reliability	
Network Redundancy	Network Reliability	
Quality of Communications Equipment	Network Reliability	
Quality of Computing Equipment	Network Reliability	
Quantity of Communications Equipment	Network Reliability	
Quantity of Computing Equipment	Network Reliability	
	Network Reliability	Network Assurance
	Network Reliability	Network Availability
Co-Located / Distributed	Network Richness	
Communication System Characteristics	Network Richness	
Communications Interoperability	Network Richness	
Data Interoperability	Network Richness	
Discovery	Network Richness	
Fusion	Network Richness	
Mobility	Network Richness	
Resolution	Network Richness	
Sensor Persistence	Network Richness	

Is Influenced By (Input)	Variable	Influences (Output)
System Semantic Interoperability	Network Richness	
	Network Richness	Information Completeness
	Network Richness	Network Assurance
Network Redundancy	Network Sustainability	
Quality of Communications Equipment	Network Sustainability	
Quality of Computing Equipment	Network Sustainability	
Quantity of Communications Equipment	Network Sustainability	
Quantity of Computing Equipment	Network Sustainability	
	Network Sustainability	Network Assurance
	Network Sustainability	Network Availability
Distances	Neutral Forces	
Trafficability	Neutral Forces	
	Neutral Forces	Complicated-ness
Financial Resources	Non-Lethal Effectors	
Quality of Consumable Equipment	Non-Lethal Effectors	
Quality of Facilities	Non-Lethal Effectors	
	Non-Lethal Effectors	Likelihood of Success
	Non-Lethal Effectors	Network Availability
	Non-Lethal Effectors	Perceived Likelihood of Success
Authentication	Non-Repudiation	
Quality of Communications Equipment	Non-Repudiation	
Quality of Computing Equipment	Non-Repudiation	
Quantity of Communications Equipment	Non-Repudiation	
Quantity of Computing Equipment	Non-Repudiation	
	Non-Repudiation	Integrity
Cohesion	Norm Strength	
Extraversion	Norm Strength	
Group Pressure	Norm Strength	
Homogeneity	Norm Strength	
	Norm Strength	Cohesion

Is Influenced By (Input)	Variable	Influences (Output)
	Norm Strength	Conformity
	Norm Strength	Cooperability
	Norm Strength	Cooperative Behaviour
	Norm Strength	Goal Consistency
	Norm Strength	Group Pressure
	Norm Strength	Intra Group Conflict
	Norm Strength	Persistence
Financial Resources	Number of Personnel	
	Number of Personnel	Action Completeness
	Number of Personnel	Homogeneity
	Number of Personnel	Likelihood of Success
	Number of Personnel	Perceived Likelihood of Success
Individualism: Culture	Nurturing: Culture	
	Nurturing: Culture	Leadership Culture
	Nurturing: Culture	Nurturing: Personal Values
Individualism: Personal Values	Nurturing: Personal Values	
Nurturing: Culture	Nurturing: Personal Values	
	Nurturing: Personal Values	Agreeableness
	Nurturing: Personal Values	Cohesion
	Nurturing: Personal Values	Commanders Leadership Behaviour
	Nurturing: Personal Values	Commitment/Loyalty
	Nurturing: Personal Values	Cooperative Behaviour
	Nurturing: Personal Values	Role of Emotion
Education	Open / Closed	
Experience of Personnel	Open / Closed	
General Intelligence	Open / Closed	
Training	Open / Closed	
	Open / Closed	Decision Style
	Open / Closed	Problem Solving Style
Information Source Characteristics	Open Sources	
	Open Sources	Databases
Achievement Orientation: Personal Values	Openness to Experience	
Ambiguity Tolerance	Openness to Experience	
Commanders Myers-Briggs Style	Openness to Experience	
Extraversion	Openness to Experience	
Myers-Briggs Style	Openness to Experience	
	Openness to Experience	Alertness
	Openness to Experience	Ambiguity Tolerance
	Openness to Experience	Awareness Completeness

Is Influenced By (Input)	Variable	Influences (Output)
	Openness to Experience	Awareness Correctness
	Openness to Experience	Awareness Precision
	Openness to Experience	Commanders Myers-Briggs Style
	Openness to Experience	Flexibility
	Openness to Experience	Innovation
	Openness to Experience	Intent Motivation
	Openness to Experience	Levelling
	Openness to Experience	Mental Models Richness
	Openness to Experience	Motivation
	Openness to Experience	Myers-Briggs Style
	Openness to Experience	Problem Solving Style
	Openness to Experience	Task Competence
	Openness to Experience	Task Understanding
	Openness to Experience	Willingness to Interact
State of Physical Health	Other Physical Abilities	
	Other Physical Abilities	Motor Skill
Allocation of Decision Rights	Patterns of Interaction Enabled	
Collaboration Mechanism	Patterns of Interaction Enabled	
Individualism: Culture	Patterns of Interaction Enabled	
Information Networks	Patterns of Interaction Enabled	
Network Assurance	Patterns of Interaction Enabled	
Power Distance: Culture	Patterns of Interaction Enabled	
	Patterns of Interaction Enabled	C2 Doctrine
	Patterns of Interaction Enabled	Co-Located / Distributed
	Patterns of Interaction Enabled	Individual Task Quality
	Patterns of Interaction Enabled	Information Transfer Approach
	Patterns of Interaction Enabled	Interdependence
	Patterns of Interaction Enabled	Leadership Culture
Information Networks	Patterns of Interaction Not Allowed	
	Patterns of Interaction Not Allowed	C2 Doctrine
	Patterns of Interaction Not Allowed	Collaboration Mechanism
	Patterns of Interaction Not Allowed	Collaboration Participants
	Patterns of Interaction Not Allowed	Interaction Quality
	Patterns of Interaction Not Allowed	Leadership Culture
	Patterns of Interaction Not Allowed	Network Reach

Is Influenced By (Input)	Variable	Influences (Output)
Command Speed	Perceived Likelihood of Success	
Hardness	Perceived Likelihood of Success	
Lethal Effectors	Perceived Likelihood of Success	
Non-Lethal Effectors	Perceived Likelihood of Success	
Number of Personnel	Perceived Likelihood of Success	
Quality of Computing Equipment	Perceived Likelihood of Success	
Quality of Consumable Equipment	Perceived Likelihood of Success	
Quality of Non-Consumable Equipment	Perceived Likelihood of Success	
Quality of Sets of Unit Equipment	Perceived Likelihood of Success	
Quantity of Consumable Equipment	Perceived Likelihood of Success	
Quantity of Non-Consumable Equipment	Perceived Likelihood of Success	
Quantity of Sets of Unit Equipment	Perceived Likelihood of Success	
Understanding Accuracy	Perceived Likelihood of Success	
	Perceived Likelihood of Success	Action Precision
	Perceived Likelihood of Success	Plan Feasibility
Cognitive Capacity	Perceptual Filters	
Education	Perceptual Filters	
Experience of Personnel	Perceptual Filters	
General Intelligence	Perceptual Filters	
Task Competence	Perceptual Filters	
Task Understanding	Perceptual Filters	
Training	Perceptual Filters	
	Perceptual Filters	Decision Style
Commanders Leadership Behaviour	Persistence	
Commitment/Loyalty	Persistence	
Force Will	Persistence	
Goal Consistency	Persistence	
Homogeneity	Persistence	
Leadership Culture	Persistence	

Is Influenced By (Input)	Variable	Influences (Output)
Norm Strength	Persistence	
Team Scale	Persistence	
Team Shape	Persistence	
Temporal Orientation: Personal Values	Persistence	
	Persistence	Cohesion
	Persistence	Cooperability
	Persistence	Cooperative Behaviour
	Persistence	Hardness
Financial Resources	Personnel Resources	
Training	Personnel Resources	
	Personnel Resources	Discovery
	Personnel Resources	Fusion
Sleep Deprivation	Physical Flexibility	
State of Physical Health	Physical Flexibility	
	Physical Flexibility	Motor Skill
	Physical Flexibility	Response Speed
Sleep Deprivation	Physical Strength	
State of Physical Health	Physical Strength	
	Physical Strength	Motor Skill
Quality of Command Intent	Plan Accuracy	
	Plan Accuracy	Action Accuracy
	Plan Accuracy	Measures of C2 Effectiveness
Collaboration Completeness	Plan Completeness	
Quality of Command Intent	Plan Completeness	
	Plan Completeness	Action Completeness
	Plan Completeness	Action Consistency
	Plan Completeness	Measures of C2 Effectiveness
Constraint Setting	Plan Consistency	
Quality of Command Intent	Plan Consistency	
	Plan Consistency	Action Consistency
Quality of Command Intent	Plan Correctness	
	Plan Correctness	Action Correctness
	Plan Correctness	Measures of C2 Effectiveness
Quality of Command Intent	Plan Currency	
Temporal Focus	Plan Currency	
	Plan Currency	Action Timeliness
Decision Participants	Plan Feasibility	

Is Influenced By (Input)	Variable	Influences (Output)
Perceived Likelihood of Success	Plan Feasibility	
Quality of Command Intent	Plan Feasibility	
Synchronization	Plan Feasibility	
	Plan Feasibility	Action Appropriateness
	Plan Feasibility	Action Correctness
	Plan Feasibility	Likelihood of Success
	Plan Feasibility	Measures of C2 Effectiveness
Quality of Command Intent	Plan Precision	
	Plan Precision	Action Precision
Quality of Command Intent	Plan Relevance	
	Plan Relevance	Action Appropriateness
Hardness	Plan Timeliness	
Homogeneity	Plan Timeliness	
Information Currency	Plan Timeliness	
Quality of Command Intent	Plan Timeliness	
Response Speed	Plan Timeliness	
	Plan Timeliness	Action Timeliness
Information Uncertainty	Plan Uncertainty	
Quality of Command Intent	Plan Uncertainty	
Temporal Focus	Plan Uncertainty	
	Plan Uncertainty	Action Consistency
	Plan Uncertainty	Action Efficiency
Dynamics Across Time (Command)	Planning Speed	
Dynamics Across Time (Control)	Planning Speed	
Hardness	Planning Speed	
Homogeneity	Planning Speed	
Human Semantic Interoperability	Planning Speed	
Individual Task Efficiency	Planning Speed	
Intent Motivation	Planning Speed	
Response Speed	Planning Speed	
Task Currency/Latency	Planning Speed	
Task Efficiency	Planning Speed	
Task Speed	Planning Speed	
Task Understanding	Planning Speed	
	Planning Speed	Action Timeliness
	Planning Speed	Command Speed

Is Influenced By (Input)	Variable	Influences (Output)
	Planning Speed	Likelihood of Success
Force Effectiveness	Policy Effectiveness	
Economic Situation	Political Situation	
History	Political Situation	
	Political Situation	Economic Situation
Allocation of Decision Rights	Position-Based Power	
Restriction of Decision Rights	Position-Based Power	
	Position-Based Power	Adaptive Behaviour
	Position-Based Power	Commanders Leadership Behaviour
	Position-Based Power	Conformity
	Position-Based Power	Leadership Behaviour
Allocation of Decision Rights	Power Distance: Culture	
Restriction of Decision Rights	Power Distance: Culture	
	Power Distance: Culture	Individualism: Culture
	Power Distance: Culture	Leadership Culture
	Power Distance: Culture	Patterns of Interaction Enabled
	Power Distance: Culture	Power Distance: Personal Values
	Power Distance: Culture	Source of Status
	Power Distance: Culture	Team Shape
Ambiguity Tolerance	Power Distance: Personal Values	
Power Distance: Culture	Power Distance: Personal Values	
Source of Status	Power Distance: Personal Values	
	Power Distance: Personal Values	Commitment/Loyalty
	Power Distance: Personal Values	Conformity
	Power Distance: Personal Values	Extra-Role behaviour
	Power Distance: Personal Values	Individualism: Personal Values
	Power Distance: Personal Values	Leadership Behaviour
	Power Distance: Personal Values	Needs
	Power Distance: Personal Values	Relation to Environment

Is Influenced By (Input)	Variable	Influences (Output)
	Power Distance: Personal Values	Trust
	Power Distance: Personal Values	Trust Propensity
Complicated-ness	Predictability Type	
	Predictability Type	Situational Familiarity
Authentication	Privacy	
Quality of Communications Equipment	Privacy	
Quality of Computing Equipment	Privacy	
Quantity of Communications Equipment	Privacy	
Quantity of Computing Equipment	Privacy	
	Privacy	Trust Propensity
Cognitive Capacity	Problem Solving Style	
Cognitive Complexity	Problem Solving Style	
Cognitive Flexibility	Problem Solving Style	
Commanders Decision Style	Problem Solving Style	
Commanders Myers-Briggs Style	Problem Solving Style	
Mental Models Richness	Problem Solving Style	
Myers-Briggs Style	Problem Solving Style	
Open / Closed	Problem Solving Style	
Openness to Experience	Problem Solving Style	
Task Understanding	Problem Solving Style	
	Problem Solving Style	Commanders Decision Style
	Problem Solving Style	Cooperability
	Problem Solving Style	Decision Style
	Problem Solving Style	Innovation
	Problem Solving Style	Response Speed
Decision Accuracy	Quality of Command Intent	
Decision Completeness	Quality of Command Intent	
Decision Consistency	Quality of Command Intent	
Decision Correctness	Quality of Command Intent	
Decision Currency	Quality of Command Intent	
Decision Precision	Quality of Command Intent	
Decision Relevance	Quality of Command Intent	
Decision Timeliness	Quality of Command Intent	
Decision Uncertainty	Quality of Command Intent	
Development of Intent	Quality of Command Intent	

Is Influenced By (Input)	Variable	Influences (Output)
Leadership Behaviour	Quality of Command Intent	
	Quality of Command Intent	Action Appropriateness
	Quality of Command Intent	Innovation
	Quality of Command Intent	Leadership Behaviour
	Quality of Command Intent	Plan Accuracy
	Quality of Command Intent	Plan Completeness
	Quality of Command Intent	Plan Consistency
	Quality of Command Intent	Plan Correctness
	Quality of Command Intent	Plan Currency
	Quality of Command Intent	Plan Feasibility
	Quality of Command Intent	Plan Precision
	Quality of Command Intent	Plan Relevance
	Quality of Command Intent	Plan Timeliness
	Quality of Command Intent	Plan Uncertainty
	Quality of Command Intent	Synchronization
Cooperability	Quality of Communication of Command Intent	
Decision Style	Quality of Communication of Command Intent	
Decision Type	Quality of Communication of Command Intent	
	Quality of Communication of Command Intent	Action Correctness
	Quality of Communication of Command Intent	Action Timeliness
	Quality of Communication of Command Intent	Communications Interoperability
	Quality of Communication of Command Intent	Leadership Behaviour
Financial Resources	Quality of Communications Equipment	
	Quality of Communications Equipment	Authentication
	Quality of Communications Equipment	Collaboration Mechanism
	Quality of Communications Equipment	Communications Interoperability
	Quality of Communications Equipment	Confidentiality
	Quality of Communications Equipment	Data Interoperability
	Quality of Communications Equipment	Enemy Forces
	Quality of Communications Equipment	Friendly Forces

Is Influenced By (Input)	Variable	Influences (Output)
	Quality of Communications Equipment	Information Networks
	Quality of Communications Equipment	Integrity
	Quality of Communications Equipment	Network Availability
	Quality of Communications Equipment	Network Redundancy
	Quality of Communications Equipment	Network Reliability
	Quality of Communications Equipment	Network Sustainability
	Quality of Communications Equipment	Non-Repudiation
	Quality of Communications Equipment	Privacy
	Quality of Communications Equipment	System Semantic Interoperability
Financial Resources	Quality of Computing Equipment	
	Quality of Computing Equipment	Authentication
	Quality of Computing Equipment	Confidentiality
	Quality of Computing Equipment	Data Interoperability
	Quality of Computing Equipment	Discovery
	Quality of Computing Equipment	Enemy Forces
	Quality of Computing Equipment	Friendly Forces
	Quality of Computing Equipment	Fusion
	Quality of Computing Equipment	Information Networks
	Quality of Computing Equipment	Integrity
	Quality of Computing Equipment	Likelihood of Success
	Quality of Computing Equipment	Network Availability
	Quality of Computing Equipment	Network Redundancy
	Quality of Computing Equipment	Network Reliability

Is Influenced By (Input)	Variable	Influences (Output)
	Quality of Computing Equipment	Network Sustainability
	Quality of Computing Equipment	Non-Repudiation
	Quality of Computing Equipment	Perceived Likelihood of Success
	Quality of Computing Equipment	Privacy
	Quality of Computing Equipment	Quality of Visualization
	Quality of Computing Equipment	System Semantic Interoperability
Financial Resources	Quality of Consumable Equipment	
	Quality of Consumable Equipment	Enemy Forces
	Quality of Consumable Equipment	Friendly Forces
	Quality of Consumable Equipment	Lethal Effectors
	Quality of Consumable Equipment	Likelihood of Success
	Quality of Consumable Equipment	Non-Lethal Effectors
	Quality of Consumable Equipment	Perceived Likelihood of Success
Financial Resources	Quality of Facilities	
	Quality of Facilities	Network Availability
	Quality of Facilities	Non-Lethal Effectors
Frequency of Interactions	Quality of Interactions	
	Quality of Interactions	Collaboration
Financial Resources	Quality of Non-Consumable Equipment	
	Quality of Non-Consumable Equipment	Enemy Forces
	Quality of Non-Consumable Equipment	Friendly Forces
	Quality of Non-Consumable Equipment	Likelihood of Success
	Quality of Non-Consumable Equipment	Perceived Likelihood of Success
Education	Quality of Personnel	
Financial Resources	Quality of Personnel	
Training	Quality of Personnel	
	Quality of Personnel	Decision Consistency

Is Influenced By (Input)	Variable	Influences (Output)
	Quality of Personnel	Discovery
	Quality of Personnel	Enemy Forces
	Quality of Personnel	Friendly Forces
	Quality of Personnel	Fusion
Financial Resources	Quality of Sets of Unit Equipment	
	Quality of Sets of Unit Equipment	Enemy Forces
	Quality of Sets of Unit Equipment	Friendly Forces
	Quality of Sets of Unit Equipment	Lethal Effectors
	Quality of Sets of Unit Equipment	Likelihood of Success
	Quality of Sets of Unit Equipment	Perceived Likelihood of Success
Quality of Computing Equipment	Quality of Visualization	
	Quality of Visualization	Information Accuracy
	Quality of Visualization	Information Completeness
	Quality of Visualization	Information Consistency
	Quality of Visualization	Information Correctness
	Quality of Visualization	Information Currency
	Quality of Visualization	Information Precision
	Quality of Visualization	Information Relevance
	Quality of Visualization	Information Timeliness
	Quality of Visualization	Information Uncertainty
Financial Resources	Quantity of Communications Equipment	
	Quantity of Communications Equipment	Authentication
	Quantity of Communications Equipment	Collaboration Mechanism
	Quantity of Communications Equipment	Communications Interoperability
	Quantity of Communications Equipment	Confidentiality
	Quantity of Communications Equipment	Data Interoperability
	Quantity of Communications Equipment	Information Networks
	Quantity of Communications Equipment	Integrity
	Quantity of Communications Equipment	Network Availability

Is Influenced By (Input)	Variable	Influences (Output)
	Quantity of Communications Equipment	Network Redundancy
	Quantity of Communications Equipment	Network Reliability
	Quantity of Communications Equipment	Network Sustainability
	Quantity of Communications Equipment	Non-Repudiation
	Quantity of Communications Equipment	Privacy
	Quantity of Communications Equipment	System Semantic Interoperability
Financial Resources	Quantity of Computing Equipment	
	Quantity of Computing Equipment	Authentication
	Quantity of Computing Equipment	Confidentiality
	Quantity of Computing Equipment	Data Interoperability
	Quantity of Computing Equipment	Discovery
	Quantity of Computing Equipment	Fusion
	Quantity of Computing Equipment	Information Networks
	Quantity of Computing Equipment	Integrity
	Quantity of Computing Equipment	Network Availability
	Quantity of Computing Equipment	Network Redundancy
	Quantity of Computing Equipment	Network Reliability
	Quantity of Computing Equipment	Network Sustainability
	Quantity of Computing Equipment	Non-Repudiation
	Quantity of Computing Equipment	Privacy
	Quantity of Computing Equipment	System Semantic Interoperability
Financial Resources	Quantity of Consumable Equipment	
	Quantity of Consumable Equipment	Likelihood of Success

Is Influenced By (Input)	Variable	Influences (Output)
	Quantity of Consumable Equipment	Perceived Likelihood of Success
Financial Resources	Quantity of Facilities	
	Quantity of Facilities	Network Availability
Financial Resources	Quantity of Non-Consumable Equipment	
	Quantity of Non-Consumable Equipment	Likelihood of Success
	Quantity of Non-Consumable Equipment	Perceived Likelihood of Success
Financial Resources	Quantity of Sets of Unit Equipment	
	Quantity of Sets of Unit Equipment	Action Completeness
	Quantity of Sets of Unit Equipment	Likelihood of Success
	Quantity of Sets of Unit Equipment	Perceived Likelihood of Success
Extraversion	Relation to Environment	
Individualism: Personal Values	Relation to Environment	
Locus of Control	Relation to Environment	
Needs	Relation to Environment	
Power Distance: Personal Values	Relation to Environment	
	Relation to Environment	Adaptive Behaviour
	Relation to Environment	Commanders Leadership Behaviour
	Relation to Environment	Conformity
	Relation to Environment	Cooperability
	Relation to Environment	Cooperative Behaviour
	Relation to Environment	Intra Group Conflict
	Relation to Environment	Leadership Behaviour
	Relation to Environment	Mental Models Relevance
	Relation to Environment	Self-Monitoring
Ambiguity Tolerance	Repression	
Commanders Risk Propensity	Repression	
Emotional Stability	Repression	
Risk Propensity	Repression	
Role of Emotion	Repression	
	Repression	Anxiety
	Repression	Awareness Completeness
	Repression	Awareness Correctness
	Repression	Awareness Precision

Is Influenced By (Input)	Variable	Influences (Output)
	Repression	Mental Models Richness
	Repression	Stress Level
Adaptive Behaviour	Resilience	
Weather (Atmospheric)	Resolution	
	Resolution	Network Richness
Alertness	Response Speed	
Anxiety	Response Speed	
Commanders Decision Style	Response Speed	
Decision Style	Response Speed	
General Intelligence	Response Speed	
Impulsivity	Response Speed	
Intent Motivation	Response Speed	
Mental Models Relevance	Response Speed	
Motivation	Response Speed	
Motor Skill	Response Speed	
Physical Flexibility	Response Speed	
Problem Solving Style	Response Speed	
Sleep Deprivation	Response Speed	
Task Competence	Response Speed	
Task Efficiency	Response Speed	
Task Speed	Response Speed	
Training	Response Speed	
Understanding Relevance	Response Speed	
	Response Speed	Action Efficiency
	Response Speed	Likelihood of Success
	Response Speed	Plan Timeliness
	Response Speed	Planning Speed
Adaptive Behaviour	Responsiveness	
Criticality	Restriction of Decision Rights	
	Restriction of Decision Rights	C2 Doctrine
	Restriction of Decision Rights	Constraint Enforcement
	Restriction of Decision Rights	Constraint Setting
	Restriction of Decision Rights	Leadership Culture
	Restriction of Decision Rights	Position-Based Power
	Restriction of Decision Rights	Power Distance: Culture
	Restriction on Information Distribution	C2 Doctrine
Achievement Orientation: Personal Values	Risk Propensity	
Ambiguity Tolerance	Risk Propensity	
Conscientiousness	Risk Propensity	
Hardness	Risk Propensity	
Homogeneity	Risk Propensity	
Task Competence	Risk Propensity	

Is Influenced By (Input)	Variable	Influences (Output)
Task Understanding	Risk Propensity	
Team Scale	Risk Propensity	
	Risk Propensity	Alertness
	Risk Propensity	Anxiety
	Risk Propensity	Decision Relevance
	Risk Propensity	Decision Speed
	Risk Propensity	Impulsivity
	Risk Propensity	Repression
	Risk Propensity	Risk Taking
	Risk Propensity	State of Mental Health
	Risk Propensity	Stress Level
	Risk Propensity	Trust
	Risk Propensity	Trust Propensity
Anxiety	Risk Taking	
Commanders Risk Propensity	Risk Taking	
Emotional Stability	Risk Taking	
Group Pressure	Risk Taking	
Homogeneity	Risk Taking	
Mental Models Confidence	Risk Taking	
Mental Models Relevance	Risk Taking	
Mood	Risk Taking	
Risk Propensity	Risk Taking	
Self-Efficacy	Risk Taking	
Self-Esteem	Risk Taking	
Stress Level	Risk Taking	
Team Shape	Risk Taking	
Temporal Orientation: Personal Values	Risk Taking	
Trust	Risk Taking	
Trust Propensity	Risk Taking	
Uncertainty Avoidance: Culture	Risk Taking	
Uncertainty Avoidance: Personal Values	Risk Taking	
Understanding Uncertainty	Risk Taking	
	Risk Taking	Action Appropriateness
	Risk Taking	Decision Speed
	Risk Taking	Flexibility
	Risk Taking	Innovation
Adaptive Behaviour	Robustness	
Allocation of Decision Rights	Role Clarity	
Team Shape	Role Clarity	
	Role Clarity	Action Appropriateness

Is Influenced By (Input)	Variable	Influences (Output)
	Role Clarity	Action Completeness
	Role Clarity	Action Synchronization
	Role Clarity	Cooperability
	Role Clarity	Group Pressure
	Role Clarity	Intra Group Conflict
Commanders Myers-Briggs Style	Role of Emotion	
Extraversion	Role of Emotion	
Myers-Briggs Style	Role of Emotion	
Nurturing: Personal Values	Role of Emotion	
Social Situation	Role of Emotion	
	Role of Emotion	Commanders Leadership Behaviour
	Role of Emotion	Commanders Myers-Briggs Style
	Role of Emotion	Conformity
	Role of Emotion	Force Will
	Role of Emotion	Impulsivity
	Role of Emotion	Repression
	Role of Emotion	State of Mental Health
	Role of Emotion	Stress Level
Co-Located / Distributed	Selectivity	
	Selectivity	C2 Doctrine
Anxiety	Self-Efficacy	
Mental Models Relevance	Self-Efficacy	
Motivation	Self-Efficacy	
Task Competence	Self-Efficacy	
Task Understanding	Self-Efficacy	
	Self-Efficacy	Anxiety
	Self-Efficacy	Intent Motivation
	Self-Efficacy	Mood
	Self-Efficacy	Motivation
	Self-Efficacy	Risk Taking
	Self-Efficacy	Self-Esteem
	Self-Efficacy	Stress Level
Emotional Stability	Self-Esteem	
Self-Efficacy	Self-Esteem	
	Self-Esteem	Anxiety
	Self-Esteem	Motivation
	Self-Esteem	Risk Taking
	Self-Esteem	Stress Level
Impulsivity	Self-Monitoring	
Individualism: Personal Values	Self-Monitoring	
Needs	Self-Monitoring	

Is Influenced By (Input)	Variable	Influences (Output)
Relation to Environment	Self-Monitoring	
Task Competence	Self-Monitoring	
Training	Self-Monitoring	
	Self-Monitoring	Adaptive Behaviour
	Self-Monitoring	Mental Models Richness
	Sensor Coverage (Medium)	Discovery
	Sensor Coverage (Medium)	Fusion
	Sensor Coverage (Medium)	Information Completeness
	Sensor Coverage (Medium)	Information Consistency
	Sensor Coverage (Medium)	Information Correctness
	Sensor Coverage (Medium)	Information Currency
	Sensor Coverage (Medium)	Information Precision
	Sensor Coverage (Medium)	Information Source Characteristics
	Sensor Coverage (Medium)	Information Timeliness
Distances	Sensor Coverage (Spatial)	
	Sensor Coverage (Spatial)	Discovery
	Sensor Coverage (Spatial)	Fusion
	Sensor Coverage (Spatial)	Information Completeness
	Sensor Coverage (Spatial)	Information Consistency
	Sensor Coverage (Spatial)	Information Correctness
	Sensor Coverage (Spatial)	Information Currency
	Sensor Coverage (Spatial)	Information Precision
	Sensor Coverage (Spatial)	Information Source Characteristics
	Sensor Coverage (Spatial)	Information Timeliness
	Sensor Coverage (Spectrum)	Discovery
	Sensor Coverage (Spectrum)	Fusion
	Sensor Coverage (Spectrum)	Information Completeness
	Sensor Coverage (Spectrum)	Information Consistency
	Sensor Coverage (Spectrum)	Information Correctness
	Sensor Coverage (Spectrum)	Information Currency
	Sensor Coverage (Spectrum)	Information Precision
	Sensor Coverage (Spectrum)	Information Source Characteristics
	Sensor Coverage (Spectrum)	Information Timeliness
Weather (Atmospheric)	Sensor Persistence	
	Sensor Persistence	Discovery
	Sensor Persistence	Fusion
	Sensor Persistence	Information Completeness
	Sensor Persistence	Information Consistency
	Sensor Persistence	Information Correctness
	Sensor Persistence	Information Precision
	Sensor Persistence	Information Timeliness
	Sensor Persistence	Network Richness

Is Influenced By (Input)	Variable	Influences (Output)
Awareness Accuracy	Shared Awareness Accuracy	
Collaboration	Shared Awareness Accuracy	
Experience of Personnel	Shared Awareness Accuracy	
Training	Shared Awareness Accuracy	
	Shared Awareness Accuracy	Shared Understanding Accuracy
Awareness Completeness	Shared Awareness Completeness	
Collaboration	Shared Awareness Completeness	
Experience of Personnel	Shared Awareness Completeness	
Training	Shared Awareness Completeness	
	Shared Awareness Completeness	Shared Understanding Completeness
Awareness Consistency	Shared Awareness Consistency	
Collaboration	Shared Awareness Consistency	
Experience of Personnel	Shared Awareness Consistency	
Training	Shared Awareness Consistency	
	Shared Awareness Consistency	Shared Understanding Consistency
Awareness Correctness	Shared Awareness Correctness	
Collaboration	Shared Awareness Correctness	
Experience of Personnel	Shared Awareness Correctness	
Training	Shared Awareness Correctness	
	Shared Awareness Correctness	Shared Understanding Correctness
Awareness Currency	Shared Awareness Currency	
Collaboration	Shared Awareness Currency	
Experience of Personnel	Shared Awareness Currency	
Training	Shared Awareness Currency	
	Shared Awareness Currency	Shared Understanding Currency
Awareness Precision	Shared Awareness Precision	
Collaboration	Shared Awareness Precision	
Experience of Personnel	Shared Awareness Precision	
Training	Shared Awareness Precision	
	Shared Awareness Precision	Shared Understanding Precision
Awareness Relevance	Shared Awareness Relevance	
Collaboration	Shared Awareness Relevance	
Experience of Personnel	Shared Awareness Relevance	
Training	Shared Awareness Relevance	

Is Influenced By (Input)	Variable	Influences (Output)
	Shared Awareness Relevance	Shared Understanding Relevance
Awareness Timeliness	Shared Awareness Timeliness	
Collaboration	Shared Awareness Timeliness	
Experience of Personnel	Shared Awareness Timeliness	
Training	Shared Awareness Timeliness	
	Shared Awareness Timeliness	Shared Understanding Timeliness
Awareness Uncertainty	Shared Awareness Uncertainty	
Collaboration	Shared Awareness Uncertainty	
Experience of Personnel	Shared Awareness Uncertainty	
Training	Shared Awareness Uncertainty	
	Shared Awareness Uncertainty	Shared Understanding Uncertainty
Experience of Personnel	Shared Information Accuracy	
Information Transfer Approach	Shared Information Accuracy	
Training	Shared Information Accuracy	
	Shared Information Accuracy	Awareness Accuracy
Experience of Personnel	Shared Information Completeness	
Extent of Shared Information	Shared Information Completeness	
Information Completeness	Shared Information Completeness	
Information Sharability	Shared Information Completeness	
Information Transfer Approach	Shared Information Completeness	
Integrity	Shared Information Completeness	
Interaction Quality	Shared Information Completeness	
Training	Shared Information Completeness	
	Shared Information Completeness	Awareness Completeness
Experience of Personnel	Shared Information Consistency	
Extent of Shared Information	Shared Information Consistency	
Information Consistency	Shared Information Consistency	
Information Transfer Approach	Shared Information Consistency	

Is Influenced By (Input)	Variable	Influences (Output)
Interaction Quality	Shared Information Consistency	
Training	Shared Information Consistency	
	Shared Information Consistency	Awareness Consistency
Experience of Personnel	Shared Information Correctness	
Extent of Shared Information	Shared Information Correctness	
Information Correctness	Shared Information Correctness	
Information Transfer Approach	Shared Information Correctness	
Interaction Quality	Shared Information Correctness	
Training	Shared Information Correctness	
	Shared Information Correctness	Awareness Correctness
Experience of Personnel	Shared Information Currency	
Information Currency	Shared Information Currency	
Information Transfer Approach	Shared Information Currency	
Training	Shared Information Currency	
	Shared Information Currency	Awareness Currency
Experience of Personnel	Shared Information Precision	
Information Precision	Shared Information Precision	
Information Transfer Approach	Shared Information Precision	
Training	Shared Information Precision	
	Shared Information Precision	Awareness Precision
Experience of Personnel	Shared Information Relevance	
Information Transfer Approach	Shared Information Relevance	
Training	Shared Information Relevance	
	Shared Information Relevance	Awareness Relevance
Experience of Personnel	Shared Information Timeliness	
Information Timeliness	Shared Information Timeliness	
Training	Shared Information Timeliness	
	Shared Information Timeliness	Awareness Timeliness
Experience of Personnel	Shared Information Uncertainty	
Training	Shared Information Uncertainty	
	Shared Information Uncertainty	Awareness Uncertainty
Experience of Personnel	Shared Understanding Accuracy	
Mental Models Relevance	Shared Understanding Accuracy	
Shared Awareness Accuracy	Shared Understanding Accuracy	

Is Influenced By (Input)	Variable	Influences (Output)
Training	Shared Understanding Accuracy	
Understanding Accuracy	Shared Understanding Accuracy	
	Shared Understanding Accuracy	Collaboration
Experience of Personnel	Shared Understanding Completeness	
Mental Models Relevance	Shared Understanding Completeness	
Shared Awareness Completeness	Shared Understanding Completeness	
Training	Shared Understanding Completeness	
Understanding Completeness	Shared Understanding Completeness	
	Shared Understanding Completeness	Collaboration
Experience of Personnel	Shared Understanding Consistency	
Mental Models Relevance	Shared Understanding Consistency	
Shared Awareness Consistency	Shared Understanding Consistency	
Training	Shared Understanding Consistency	
Understanding Consistency	Shared Understanding Consistency	
	Shared Understanding Consistency	Collaboration
Experience of Personnel	Shared Understanding Correctness	
Mental Models Relevance	Shared Understanding Correctness	
Shared Awareness Correctness	Shared Understanding Correctness	
Training	Shared Understanding Correctness	
Understanding Correctness	Shared Understanding Correctness	
	Shared Understanding Correctness	Collaboration
Experience of Personnel	Shared Understanding Currency	
Mental Models Relevance	Shared Understanding Currency	
Shared Awareness Currency	Shared Understanding Currency	

Is Influenced By (Input)	Variable	Influences (Output)
Training	Shared Understanding Currency	
Understanding Currency	Shared Understanding Currency	
	Shared Understanding Currency	Collaboration
Experience of Personnel	Shared Understanding Precision	
Mental Models Relevance	Shared Understanding Precision	
Shared Awareness Precision	Shared Understanding Precision	
Training	Shared Understanding Precision	
Understanding Precision	Shared Understanding Precision	
	Shared Understanding Precision	Collaboration
Experience of Personnel	Shared Understanding Relevance	
Mental Models Relevance	Shared Understanding Relevance	
Shared Awareness Relevance	Shared Understanding Relevance	
Training	Shared Understanding Relevance	
Understanding Relevance	Shared Understanding Relevance	
	Shared Understanding Relevance	Collaboration
Experience of Personnel	Shared Understanding Timeliness	
Mental Models Relevance	Shared Understanding Timeliness	
Shared Awareness Timeliness	Shared Understanding Timeliness	
Training	Shared Understanding Timeliness	
Understanding Timeliness	Shared Understanding Timeliness	
	Shared Understanding Timeliness	Collaboration
Experience of Personnel	Shared Understanding Uncertainty	
Mental Models Relevance	Shared Understanding Uncertainty	
Shared Awareness Uncertainty	Shared Understanding Uncertainty	
Training	Shared Understanding Uncertainty	
Understanding Uncertainty	Shared Understanding Uncertainty	

Is Influenced By (Input)	Variable	Influences (Output)
	Shared Understanding Uncertainty	Collaboration
Education	Situational Familiarity	
Mental Models Richness	Situational Familiarity	
Predictability Type	Situational Familiarity	
Training	Situational Familiarity	
	Situational Familiarity	Awareness Relevance
	Situational Familiarity	Awareness Uncertainty
	Situational Familiarity	Collaboration Completeness
	Situational Familiarity	Decision Completeness
	Situational Familiarity	Decision Precision
	Situational Familiarity	Decision Relevance
	Situational Familiarity	Mental Models Relevance
	Sleep Deprivation	Alertness
	Sleep Deprivation	Awareness Completeness
	Sleep Deprivation	Awareness Correctness
	Sleep Deprivation	Awareness Currency
	Sleep Deprivation	Awareness Precision
	Sleep Deprivation	Awareness Uncertainty
	Sleep Deprivation	Conformity
	Sleep Deprivation	Intent Motivation
	Sleep Deprivation	Memory Performance
	Sleep Deprivation	Mood
	Sleep Deprivation	Motivation
	Sleep Deprivation	Motor Skill
	Sleep Deprivation	Physical Flexibility
	Sleep Deprivation	Physical Strength
	Sleep Deprivation	Response Speed
	Sleep Deprivation	State of Mental Health
Economic Situation	Social Situation	
	Social Situation	Role of Emotion
Achievement Orientation: Culture	Source of Status	
Power Distance: Culture	Source of Status	
	Source of Status	Achievement Orientation: Personal Values
	Source of Status	Power Distance: Personal Values
Agreeableness	State of Mental Health	
Ambiguity Tolerance	State of Mental Health	
Commanders Risk Propensity	State of Mental Health	
Emotional Stability	State of Mental Health	
Risk Propensity	State of Mental Health	
Role of Emotion	State of Mental Health	

Is Influenced By (Input)	Variable	Influences (Output)
Sleep Deprivation	State of Mental Health	
State of Physical Health	State of Mental Health	
Trust Propensity	State of Mental Health	
	State of Mental Health	Cognitive Flexibility
	State of Mental Health	Decision Timeliness
	State of Mental Health	Emotional Stability
	State of Mental Health	State of Physical Health
	State of Mental Health	Stress Level
State of Mental Health	State of Physical Health	
	State of Physical Health	Motor Skill
	State of Physical Health	Other Physical Abilities
	State of Physical Health	Physical Flexibility
	State of Physical Health	Physical Strength
	State of Physical Health	State of Mental Health
Achievement Orientation: Personal Values	Stress Level	
Ambiguity Tolerance	Stress Level	
Anxiety	Stress Level	
Cohesion	Stress Level	
Commanders Risk Propensity	Stress Level	
Emotional Stability	Stress Level	
Group Pressure	Stress Level	
Intra Group Conflict	Stress Level	
Mental Models Confidence	Stress Level	
Mood	Stress Level	
Motivation	Stress Level	
Repression	Stress Level	
Risk Propensity	Stress Level	
Role of Emotion	Stress Level	
Self-Efficacy	Stress Level	
Self-Esteem	Stress Level	
State of Mental Health	Stress Level	
Task Understanding	Stress Level	
Trust	Stress Level	
Understanding Completeness	Stress Level	
Understanding Consistency	Stress Level	
Understanding Uncertainty	Stress Level	
	Stress Level	Alertness
	Stress Level	Awareness Accuracy
	Stress Level	Awareness Completeness
	Stress Level	Awareness Correctness
	Stress Level	Awareness Precision

Is Influenced By (Input)	Variable	Influences (Output)
	Stress Level	Awareness Uncertainty
	Stress Level	Cognitive Capacity
	Stress Level	Cognitive Complexity
	Stress Level	Cognitive Flexibility
	Stress Level	Decision Relevance
	Stress Level	Impulsivity
	Stress Level	Mental Models Richness
	Stress Level	Risk Taking
Consistency of Command Intent	Synchronization	
Quality of Command Intent	Synchronization	
	Synchronization	Action Synchronization
	Synchronization	Plan Feasibility
Co-Located / Distributed	System Semantic Interoperability	
Communications Interoperability	System Semantic Interoperability	
Data Interoperability	System Semantic Interoperability	
Quality of Communications Equipment	System Semantic Interoperability	
Quality of Computing Equipment	System Semantic Interoperability	
Quantity of Communications Equipment	System Semantic Interoperability	
Quantity of Computing Equipment	System Semantic Interoperability	
	System Semantic Interoperability	Network Richness
Education	Task Competence	
Experience of Personnel	Task Competence	
Openness to Experience	Task Competence	
Training	Task Competence	
	Task Competence	Action Correctness
	Task Competence	Action Efficiency
	Task Competence	Commanders Leadership Behaviour
	Task Competence	Commanders Risk Propensity
	Task Competence	Cooperability
	Task Competence	Decision Completeness
	Task Competence	Decision Precision
	Task Competence	Perceptual Filters

Is Influenced By (Input)	Variable	Influences (Output)
	Task Competence	Response Speed
	Task Competence	Risk Propensity
	Task Competence	Self-Efficacy
	Task Competence	Self-Monitoring
	Task Competence	Task Understanding
	Task Competence	Uncertainty Avoidance: Culture
	Task Competence	Uncertainty Avoidance: Personal Values
Information Currency	Task Currency/Latency	
	Task Currency/Latency	Decision Speed
	Task Currency/Latency	Planning Speed
Action Synchronization	Task Efficiency	
Co-Located / Distributed	Task Efficiency	
Dynamics Across Purpose (Command)	Task Efficiency	
Dynamics Across Purpose (Control)	Task Efficiency	
	Task Efficiency	Command Speed
	Task Efficiency	Decision Speed
	Task Efficiency	Force Effectiveness
	Task Efficiency	Planning Speed
	Task Efficiency	Response Speed
	Task Efficiency	Task Speed
Action Synchronization	Task Speed	
Co-Located / Distributed	Task Speed	
Command Speed	Task Speed	
Dynamics Across Time (Command)	Task Speed	
Dynamics Across Time (Control)	Task Speed	
Task Efficiency	Task Speed	
	Task Speed	Command Speed
	Task Speed	Decision Speed
	Task Speed	Force Effectiveness
	Task Speed	Individual Task Efficiency
	Task Speed	Planning Speed
	Task Speed	Response Speed
Mental Models Relevance	Task Understanding	
Mental Models Richness	Task Understanding	
Openness to Experience	Task Understanding	
Task Competence	Task Understanding	
Understanding Accuracy	Task Understanding	
Understanding Completeness	Task Understanding	

Is Influenced By (Input)	Variable	Influences (Output)
Understanding Correctness	Task Understanding	
Understanding Relevance	Task Understanding	
Understanding Uncertainty	Task Understanding	
	Task Understanding	Commanders Decision Style
	Task Understanding	Commanders Risk Propensity
	Task Understanding	Decision Style
	Task Understanding	Perceptual Filters
	Task Understanding	Planning Speed
	Task Understanding	Problem Solving Style
	Task Understanding	Risk Propensity
	Task Understanding	Self-Efficacy
	Task Understanding	Stress Level
	Team Scale	Cohesion
	Team Scale	Commitment/Loyalty
	Team Scale	Conformity
	Team Scale	Cooperability
	Team Scale	Cooperative Behaviour
	Team Scale	Extra-Role behaviour
	Team Scale	Goal Consistency
	Team Scale	Group Pressure
	Team Scale	Homogeneity
	Team Scale	Intra Group Conflict
	Team Scale	Leadership Behaviour
	Team Scale	Motivation
	Team Scale	Persistence
	Team Scale	Risk Propensity
	Team Scale	Team Shape
Allocation of Decision Rights	Team Shape	
Dynamics Across Purpose (Command)	Team Shape	
Dynamics Across Time (Command)	Team Shape	
Individualism: Culture	Team Shape	
Leadership Culture	Team Shape	
Power Distance: Culture	Team Shape	
Team Scale	Team Shape	
	Team Shape	Action Efficiency
	Team Shape	Cohesion
	Team Shape	Conformity
	Team Shape	Cooperability
	Team Shape	Cooperative Behaviour
	Team Shape	Extra-Role behaviour
	Team Shape	Goal Consistency
	Team Shape	Group Pressure

Is Influenced By (Input)	Variable	Influences (Output)
	Team Shape	Intra Group Conflict
	Team Shape	Leadership Behaviour
	Team Shape	Persistence
	Team Shape	Risk Taking
	Team Shape	Role Clarity
	Temporal Focus	Plan Currency
	Temporal Focus	Plan Uncertainty
	Temporal Focus	Understanding Currency
	Temporal Focus	Understanding Timeliness
	Temporal Focus	Understanding Uncertainty
	Temporal Orientation: Culture	Individualism: Culture
	Temporal Orientation: Culture	Leadership Culture
	Temporal Orientation: Culture	Temporal Orientation: Personal Values
Temporal Orientation: Culture	Temporal Orientation: Personal Values	
	Temporal Orientation: Personal Values	Cohesion
	Temporal Orientation: Personal Values	Commanders Decision Style
	Temporal Orientation: Personal Values	Commanders Leadership Behaviour
	Temporal Orientation: Personal Values	Conscientiousness
	Temporal Orientation: Personal Values	Cooperability
	Temporal Orientation: Personal Values	Decision Style
	Temporal Orientation: Personal Values	Individualism: Personal Values
	Temporal Orientation: Personal Values	Intra Group Conflict
	Temporal Orientation: Personal Values	Leadership Behaviour
	Temporal Orientation: Personal Values	Persistence
	Temporal Orientation: Personal Values	Risk Taking
	Temporal Orientation: Personal Values	Trust Propensity
	Temporal Orientation: Personal Values	Willingness to Interact
	Trafficability	Enemy Forces
	Trafficability	Friendly Forces
	Trafficability	Mobility

Is Influenced By (Input)	Variable	Influences (Output)
	Trafficability	Neutral Forces
	Training	Adaptive Behaviour
	Training	Awareness Accuracy
	Training	Cooperative Behaviour
	Training	Decision Consistency
	Training	Experience of Personnel
	Training	Extent of Shared Information
	Training	Human Semantic Interoperability
	Training	Leadership Behaviour
	Training	Memory Performance
	Training	Mental Models Richness
	Training	Open / Closed
	Training	Perceptual Filters
	Training	Personnel Resources
	Training	Quality of Personnel
	Training	Response Speed
	Training	Self-Monitoring
	Training	Shared Awareness Accuracy
	Training	Shared Awareness Completeness
	Training	Shared Awareness Consistency
	Training	Shared Awareness Correctness
	Training	Shared Awareness Currency
	Training	Shared Awareness Precision
	Training	Shared Awareness Relevance
	Training	Shared Awareness Timeliness
	Training	Shared Awareness Uncertainty
	Training	Shared Information Accuracy
	Training	Shared Information Completeness
	Training	Shared Information Consistency
	Training	Shared Information Correctness
	Training	Shared Information Currency
	Training	Shared Information Precision
	Training	Shared Information Relevance
	Training	Shared Information Timeliness
	Training	Shared Information Uncertainty
	Training	Shared Understanding Accuracy
	Training	Shared Understanding Completeness

Is Influenced By (Input)	Variable	Influences (Output)
	Training	Shared Understanding Consistency
	Training	Shared Understanding Correctness
	Training	Shared Understanding Currency
	Training	Shared Understanding Precision
	Training	Shared Understanding Relevance
	Training	Shared Understanding Timeliness
	Training	Shared Understanding Uncertainty
	Training	Situational Familiarity
	Training	Task Competence
Cohesion	Trust	
Commanders Risk Propensity	Trust	
Commitment/Loyalty	Trust	
Group Pressure	Trust	
Individualism: Personal Values	Trust	
Leadership Behaviour	Trust	
Power Distance: Personal Values	Trust	
Risk Propensity	Trust	
Trust Propensity	Trust	
	Trust	Agreeableness
	Trust	Anxiety
	Trust	Cohesion
	Trust	Commanders Leadership Behaviour
	Trust	Commitment/Loyalty
	Trust	Conformity
	Trust	Cooperability
	Trust	Cooperative Behaviour
	Trust	Extra-Role behaviour
	Trust	Intra Group Conflict
	Trust	Leadership Behaviour
	Trust	Risk Taking
	Trust	Stress Level
	Trust	Willingness to Interact
Agreeableness	Trust Propensity	

Is Influenced By (Input)	Variable	Influences (Output)
Commanders Risk Propensity	Trust Propensity	
Extraversion	Trust Propensity	
Individualism: Personal Values	Trust Propensity	
Leadership Behaviour	Trust Propensity	
Needs	Trust Propensity	
Power Distance: Personal Values	Trust Propensity	
Privacy	Trust Propensity	
Risk Propensity	Trust Propensity	
Temporal Orientation: Personal Values	Trust Propensity	
	Trust Propensity	Agreeableness
	Trust Propensity	Cohesion
	Trust Propensity	Conformity
	Trust Propensity	Cooperative Behaviour
	Trust Propensity	Intra Group Conflict
	Trust Propensity	Risk Taking
	Trust Propensity	State of Mental Health
	Trust Propensity	Trust
	Trust Propensity	Willingness to Interact
Complicated-ness	Type I Error (False Alarm Rate)	
Weather (Atmospheric)	Type I Error (False Alarm Rate)	
Weather (Space)	Type I Error (False Alarm Rate)	
	Type I Error (False Alarm Rate)	Information Accuracy
	Type I Error (False Alarm Rate)	Information Precision
Complicated-ness	Type II Error	
Weather (Atmospheric)	Type II Error	
Weather (Space)	Type II Error	
	Type II Error	Information Accuracy
	Type II Error	Information Precision
Mental Models Confidence	Uncertainty Avoidance: Culture	
Task Competence	Uncertainty Avoidance: Culture	
	Uncertainty Avoidance: Culture	Hardness
	Uncertainty Avoidance: Culture	Risk Taking
Mental Models Confidence	Uncertainty Avoidance: Personal Values	
Task Competence	Uncertainty Avoidance: Personal Values	
	Uncertainty Avoidance: Personal Values	Hardness
	Uncertainty Avoidance: Personal Values	Risk Taking
Complicated-ness	Uncertainty of Situation	

Is Influenced By (Input)	Variable	Influences (Output)
Fusion	Uncertainty of Situation	
	Uncertainty of Situation	Awareness Uncertainty
	Uncertainty of Situation	Collaboration
	Uncertainty of Situation	Collaboration Completeness
Awareness Accuracy	Understanding Accuracy	
Mental Models Relevance	Understanding Accuracy	
Understanding Precision	Understanding Accuracy	
	Understanding Accuracy	Decision Accuracy
	Understanding Accuracy	Decision Speed
	Understanding Accuracy	Perceived Likelihood of Success
	Understanding Accuracy	Shared Understanding Accuracy
	Understanding Accuracy	Task Understanding
Ambiguity Tolerance	Understanding Completeness	
Awareness Completeness	Understanding Completeness	
Collaboration Completeness	Understanding Completeness	
Information Completeness	Understanding Completeness	
Mental Models Relevance	Understanding Completeness	
Mental Models Richness	Understanding Completeness	
	Understanding Completeness	Decision Completeness
	Understanding Completeness	Mental Models Confidence
	Understanding Completeness	Mental Models Richness
	Understanding Completeness	Shared Understanding Completeness
	Understanding Completeness	Stress Level
	Understanding Completeness	Task Understanding
	Understanding Completeness	Understanding Uncertainty
Ambiguity Tolerance	Understanding Consistency	
Awareness Consistency	Understanding Consistency	
Information Consistency	Understanding Consistency	
Mental Models Relevance	Understanding Consistency	
Mental Models Richness	Understanding Consistency	
Understanding Relevance	Understanding Consistency	
	Understanding Consistency	Ambiguity Tolerance
	Understanding Consistency	Decision Consistency
	Understanding Consistency	Mental Models Confidence
	Understanding Consistency	Shared Understanding Consistency
	Understanding Consistency	Stress Level
	Understanding Consistency	Understanding Uncertainty
Ambiguity Tolerance	Understanding Correctness	
Awareness Consistency	Understanding Correctness	
Awareness Correctness	Understanding Correctness	

Is Influenced By (Input)	Variable	Influences (Output)
General Intelligence	Understanding Correctness	
Information Correctness	Understanding Correctness	
Mental Models Relevance	Understanding Correctness	
Mental Models Richness	Understanding Correctness	
	Understanding Correctness	Decision Correctness
	Understanding Correctness	Shared Understanding Correctness
	Understanding Correctness	Task Understanding
	Understanding Correctness	Understanding Uncertainty
Awareness Currency	Understanding Currency	
Information Currency	Understanding Currency	
Mental Models Relevance	Understanding Currency	
Temporal Focus	Understanding Currency	
	Understanding Currency	Decision Currency
	Understanding Currency	Shared Understanding Currency
	Understanding Currency	Understanding Timeliness
Ambiguity Tolerance	Understanding Precision	
Awareness Precision	Understanding Precision	
Information Precision	Understanding Precision	
Mental Models Richness	Understanding Precision	
	Understanding Precision	Decision Precision
	Understanding Precision	Mental Models Confidence
	Understanding Precision	Mental Models Richness
	Understanding Precision	Shared Understanding Precision
	Understanding Precision	Understanding Accuracy
Awareness Relevance	Understanding Relevance	
Mental Models Relevance	Understanding Relevance	
	Understanding Relevance	Cooperability
	Understanding Relevance	Decision Relevance
	Understanding Relevance	Response Speed
	Understanding Relevance	Shared Understanding Relevance
	Understanding Relevance	Task Understanding
	Understanding Relevance	Understanding Consistency
Awareness Timeliness	Understanding Timeliness	
Information Currency	Understanding Timeliness	
Information Timeliness	Understanding Timeliness	
Mental Models Relevance	Understanding Timeliness	
Temporal Focus	Understanding Timeliness	
Understanding Currency	Understanding Timeliness	
	Understanding Timeliness	Cooperability
	Understanding Timeliness	Decision Timeliness

Is Influenced By (Input)	Variable	Influences (Output)
	Understanding Timeliness	Shared Understanding Timeliness
Awareness Consistency	Understanding Uncertainty	
Awareness Uncertainty	Understanding Uncertainty	
Mental Models Confidence	Understanding Uncertainty	
Mental Models Relevance	Understanding Uncertainty	
Mental Models Richness	Understanding Uncertainty	
Temporal Focus	Understanding Uncertainty	
Understanding Completeness	Understanding Uncertainty	
Understanding Consistency	Understanding Uncertainty	
Understanding Correctness	Understanding Uncertainty	
	Understanding Uncertainty	Ambiguity Tolerance
	Understanding Uncertainty	Cooperability
	Understanding Uncertainty	Decision Uncertainty
	Understanding Uncertainty	Mental Models Confidence
	Understanding Uncertainty	Risk Taking
	Understanding Uncertainty	Shared Understanding Uncertainty
	Understanding Uncertainty	Stress Level
	Understanding Uncertainty	Task Understanding
	Weather (Atmospheric)	Mobility
	Weather (Atmospheric)	Resolution
	Weather (Atmospheric)	Sensor Persistence
	Weather (Atmospheric)	Type I Error (False Alarm Rate)
	Weather (Atmospheric)	Type II Error
	Weather (Space)	Type I Error (False Alarm Rate)
	Weather (Space)	Type II Error
Agreeableness	Willingness to Interact	
Commanders Myers-Briggs Style	Willingness to Interact	
Commitment/Loyalty	Willingness to Interact	
Extraversion	Willingness to Interact	
Individualism: Personal Values	Willingness to Interact	
Myers-Briggs Style	Willingness to Interact	
Needs	Willingness to Interact	
Openness to Experience	Willingness to Interact	
Temporal Orientation: Personal Values	Willingness to Interact	
Trust	Willingness to Interact	
Trust Propensity	Willingness to Interact	

Is Influenced By (Input)	Variable	Influences (Output)
	Willingness to Interact	Cohesion
	Willingness to Interact	Commanders Leadership Behaviour
	Willingness to Interact	Continuity of Interactions
	Willingness to Interact	Cooperative Behaviour
	Willingness to Interact	Frequency of Interactions
	Willingness to Interact	Leadership Behaviour

Annex H – AF2T2EA: ILLUSTRATIVE EXAMPLE

1. MAPPING CONCEPTUAL MODEL VARIABLES TO THE AF2T2EA "KILL-CHAIN" PROCESS (PROCESS VIEW)

1.1 "Anticipate" Event

Table H-1: "Anticipate" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Atmospheric Weather	Sensor Coverage (Spatial)
	Space Weather	Sensor Coverage (Medium)
	Sensor Persistence	Sensor Coverage (Spectrum)
Information	Accuracy	Information about Forces
	Completeness of Information	Information about Environment
	Completeness of Individual Information	Information about Intentions
	Completeness of Shared Information	Information Uncertainty
	Correctness of Information	Network Reach
	Correctness of Individual Information	Precision of Information
	Correctness of Shared Information	Precision of Individual Information
	Currency of Information	Precision of Shared Information
	Currency of Individual Information	Relevance of Shared Information
	Currency of Shared Information	Richness of Collaborative Environment
	Consistency of Information	Share Information
	Consistency of Individual Information	Timeliness of Information
	Consistency of Shared Information	Timeliness of Individual Information
	Data Interoperability	Timeliness of Shared Information
	Distribution of Information	Trust in Information
	Extent of Shared Information	Uncertainty
	Fusion	Uncertainty of Shared Information
	Information Quality	

Cognitive Pyramid	Conceptual Model Variable	
Awareness	Accuracy of Individual Awareness	Collaboration about Intentions
	Accuracy of Shared Information	Command Approach
	Awareness about Environment	Experience of Personnel
	Awareness about Forces	Frequency of Command Interactions
	Awareness about Intentions	Frequency of Peer-to-Peer Interactions
	Awareness about Mission	History
	Collaboration about Environment	Quality of Interactions
	Collaboration about Forces	Quality of Peer-to-Peer Interactions
Understanding	Understanding about Environment	Understanding about Intentions
Decision or Action	Accuracy of Individual Decisions	Relevance of Individual Decisions
	Consistency of Individual Decisions	Speed of Command
	Completeness of Individual Decisions	Speed of Decision
	Correctness of Individual Decisions	Speed of Planning
	Currency of Individual Decisions	Synchronization of Actions
	Force Effectiveness	Task Speed
	Mode of Decision Making of Individual Decisions	Timeliness of Planning
	Responsiveness	Timeliness of Individual Decisions
	Precision of Individual Decisions	Uncertainty of Individual Decisions
	Quality of Decisions	

1.2 "Find" Event

Table H-2: "Find" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Atmospheric Weather	Sensor Coverage (Spatial)
	Space Weather	Sensor Coverage (Medium)
	Sensor Persistence	Sensor Coverage (Spectrum)
Information	Accuracy	Information about Forces
	Completeness of Information	Information about Environment
	Completeness of Individual Information	Information about Intentions
	Completeness of Shared Information	Information Uncertainty
	Consistency of Information	Network Reach
	Consistency of Individual Information	Precision of Information
	Consistency of Shared Information	Precision of Individual Information
	Correctness of Information	Precision of Shared Information
	Correctness of Individual Information	
	Correctness of Shared Information	Relevance of Shared Information
	Currency of Information	Richness of Collaborative Environment
	Currency of Individual Information	Share Information
	Currency of Shared Information	Timeliness of Information
	Data Interoperability	Timeliness of Individual Information
	Distribution of Information	Timeliness of Shared Information
	Extent of Shared Information	Trust in Information
	Fusion	Uncertainty
	Information Quality	Uncertainty of Shared Information
Awareness	Accuracy of Individual Awareness	Collaboration about Intentions
	Accuracy of Shared Information	Command Approach
	Awareness about Environment	Experience of Personnel

Cognitive Pyramid	Conceptual Model Variable	
	Awareness about Forces	Frequency of Command Interactions
	Awareness about Intentions	Frequency of Peer-to-Peer Interactions
	Awareness about Mission	History
	Collaboration about Environment	Quality of Interactions
	Collaboration about Forces	Quality of Peer-to-Peer Interactions
Understanding	Understanding about Environment	Understanding about Intentions
Decision or Action	Accuracy of Individual Decisions	Speed of Decision
	Consistency of Individual Decisions	Force Effectiveness
	Completeness of Individual Decisions	Mode of Decision Making of Individual Decisions
	Correctness of Individual Decisions	Responsiveness
	Currency of Individual Decisions	Precision of Individual Decisions
	Quality of Decisions	Task Speed
	Relevance of Individual Decisions	Timeliness of Planning
	Speed of Planning	Timeliness of Individual Decisions
	Synchronization of Actions	Uncertainty of Individual Decisions
	Speed of Command	

1.3 "Fix" Event

Table H-3: "Fix" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Analyze	Quality of Computing Equipment
	Network Availability	Sensor Coverage (Spatial)
	Network Reach	Sensor Coverage (Medium)
	Network Reliability	Sensor Coverage (Spectrum)
	Quality of Communications Equipment	Sensor Persistence
Information	Accuracy	Information Ambiguity
	Authentication	Information Complexity
	Completeness of Information	Information Quality
	Consistency of Information	Information Uncertainty
	Consistency of Shared Information	Precision of Individual Information
	Correctness of Information	Precision of Information
	Correctness of Shared Information	Precision of Shared Information
	Currency of Shared Information	Relevance of Shared Information
	Distribution of Information	Share Information
	Extend of Shared Information	Timeliness of Shared Information
	Fusion	Timeliness of Individual Information
	Identification	Timeliness of Information
	Information about Capabilities	Uncertainty of Shared Information
Awareness	Accuracy of Individual Awareness	Identification
	Adaptiveness	Level of Confidence
	Awareness about Capabilities	Task Competence
	Awareness about Intentions	

Cognitive Pyramid	Conceptual Model Variable	
Understanding	Accuracy of Collective understanding	Completeness of Collective Understanding
	Accuracy of Individual Understanding	Identification
	Collective Knowledge	Level of Confidence
Decision or Action	Command Approach	Mission Effectiveness
	Completeness of Individual Decisions	Task Competence
	Identification	Task Speed
	Level of Confidence	

1.4 "Track" Event

Table H-4: "Track" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Accuracy	Network Reach
	Adaptiveness	Responsiveness
	Analyze	Robustness
	Atmospheric Weather	Sensor Coverage (Medium)
	Dynamics across Time	Sensor Coverage (Spatial)
	History	Sensor Coverage (Spectrum)
	Indirect Sensing	Space Weather
	Mobility	
Information	Accuracy	Flexibility
	Accuracy of Shared Information	Fusion
	Completeness of Individual Information	Information about Environment
	Completeness of Information	Information about Forces
	Completeness of Shared Information	Information about Intentions
	Consistency of Individual Information	Information Quality
	Consistency of Information	Information Uncertainty

Cognitive Pyramid	Conceptual Model Variable	
	Consistency of Shared Information	Precision of Individual Information
	Currency of Shared Information	Precision of Information
	Currency of Individual Information	Precision of Shared Information
	Currency of Information	Relevance of Shared Information
	Correctness of Individual Information	Shared Understanding
	Correctness of Shared Information	Timeliness of Shared Information
	Distribution of Information	Timeliness of Individual Information
	Dynamics across Time	Timeliness of Information
	Extend of Shared Information	Uncertainty of Shared Information
Awareness	Accuracy of Collective Awareness	Correctness of Collective Awareness
	Accuracy of Individual Awareness	Correctness of Individual Awareness
	Accuracy of Intersection Awareness	Correctness of Partial Awareness
	Accuracy of Partial Awareness	Currency of Collective Awareness
	Awareness about Environment	Currency of Individual Awareness
	Awareness about Forces	Precision of Individual Awareness
	Awareness about Intentions	Timeliness of Collective Awareness
	Awareness about Mission	Timeliness of Individual Awareness
	Completeness of Individual Awareness	Uncertainty of Collective Awareness
	Consistency of Individual Awareness	
Understanding	Accuracy of Collective Understanding	Correctness of Collective Understanding
	Accuracy of Individual Understanding	Correctness of Individual Understanding

Cognitive Pyramid	Conceptual Model Variable	
	Accuracy of Intersection Understanding	Correctness of Partial Understanding
	Accuracy of Partial Understanding	Currency of Collective Understanding
	Completeness of Collective Understanding	Currency of Individual Understanding
	Completeness of Individual Understanding	Extent of Collective Understanding
	Completeness of Intersection Understanding	Extent of Partial Understanding
	Completeness of Partial Understanding	Shared Understanding
	Consistency of Individual Understanding	Timeliness of Collective Understanding
	Consistency of Intersection Understanding	Timeliness of Individual Understanding
	Consistency of Partial Understanding	Uncertainty of Collective Understanding
Decision or Action	Adaptiveness	Responsiveness
	Analyze	Risk Propensity
	Collaboration about Environment	Robustness
	Collaboration about Forces	Speed of Command
	Collaboration about Intentions	Speed of Decision
	Collaboration about Mission	Speed of Planning
	Command Approach	Synchronization of Decisions
	Distribution of Information	Synchronization of Actions
	Dynamics across Time	Task Competency
	Experience of Personnel	Task Speed
	Flexibility	Timeliness of Individual Decisions
	History	Training
	Innovation	Trust in Information
	Level of Confidence	Understanding about Environment
	Perception of Cause and Effect	Understanding about Forces

Cognitive Pyramid	Conceptual Model Variable	
	Quality of Decisions	Understanding about Intentions
	Quality of Plan	Understanding about Mission

1.5 "Target" Event

Table H-5: "Target" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Atmospheric Weather	Sensor Coverage (Spatial)
	Direct Sensing	Sensor Coverage (Spectrum)
	Indirect Sensing	Sensor Persistence
	Political Situation	Social Situation
	Sensor Coverage (Medium)	Space Weather
Information	Completeness of Information	Information about Mission
	Completeness of Shared Information	Information Quality
	Consistency of Information	Information Uncertainty
	Consistency of Shared Information	Precision of Individual Information
	Correctness of Individual Information	Precision of Information
	Correctness of Shared Information	Precision of Shared Information
	Currency of Individual Information	Relevance of Shared Information
	Currency of Information	Share Information
	Currency of Shared Information	Timeliness of Shared Information
	Data Interoperability	Timeliness of Individual Information
	Distribution of Information	Timeliness of Information
	Extent of Shared Information	Trust in Information
	Information about Environment	Uncertainty of Shared Information
	Information about Forces	
Awareness	Accuracy of Collective Awareness	Awareness about Forces

Cognitive Pyramid	Conceptual Model Variable	
	Accuracy of Intersection Awareness	Awareness about Intentions
	Awareness about Capabilities	Awareness about Mission
	Awareness about Environment	
Understanding	Quality of Understanding	
Decision or Action	Accuracy of Individual Decisions	Political Situation
	Appropriateness of Individual Decisions	Quality of Decisions
	Authentication	Quality of Plan
	C2 Doctrine	Resource Allocation
	Command Approach	Resource Prioritization
	Communication of Intent	Responsiveness
	Constraint Enforcement	Risk Propensity
	Constraint Setting	Robustness
	Control Approach	Role of Authority
	Criticality	Skill
	Decision Participants	Task Speed
	Degree of Decision Concurrence	Social Situation
	Dynamics across Time	Speed of Command
	Experience of Personnel	Synchronization
	Flexibility	Synchronization of Actions
	Force Effectiveness	Task Competence
	Identification	Task Efficiency
	Indirect Sensing	Task Knowledge
	Individual Task Efficiency	Timeliness of Individual Decisions
	Lethal Effectors	Training
	Likelihood of Success	Trust in Information
	Mission Effectiveness	Uncertainty of Individual Decisions

Cognitive Pyramid	Conceptual Model Variable	
	Nature of Rules	Willingness
	Non-Lethal Effectors	

1.6 "Engage" Event

Table H-6: "Engage" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Atmospheric Weather	Network Reliability
	Communications Interoperability	Network Richness
	Complicated-ness	Political Situation
	Data Interoperability	Quality of Communications Equipment
	Electivity	Quality of Computing Equipment
	Network Availability	Social Situation
	Network Reach	
Information	Completeness of Individual Information	Information about Intentions
	Completeness of Shared Information	Information about Mission
	Correctness of Information	Information Quality
	Correctness of Shared Information	Precision of Individual Information
	Currency of Individual Information	Precision of Information
	Currency of Information	Relevance of Shared Information
	Currency of Shared Information	Timeliness of Shared Information
	Distribution of Information	Timeliness of Information
	Extent of Shared Information	Trust in Information
	Information about Environment	Uncertainty of Shared Information
	Information about Forces	
Awareness	Awareness about Capabilities	Completeness of Individual Awareness

Cognitive Pyramid	Conceptual Model Variable	
	Awareness about Environment	Correctness of Collective Awareness
	Awareness about Forces	Currency of Collective Awareness
	Awareness about Intentions	Currency of Individual Awareness
	Awareness about Mission	Shared Awareness (intersection)
Understanding	Completeness of Collective Understanding	Quality of Understanding
	Correctness of Collective Understanding	Uncertainty of Individual Understanding
	Currency of Collective Understanding	
Decision or Action	Accuracy	Resource Prioritization
	Adaptiveness	Responsiveness
	Authentication	Role of Authority
	C2 Doctrine	Risk Propensity
	Clarity about Role	Robustness
	Command Approach	Role of Emotion
	Command Arrangements	Selectivity
	Communication of Intent	Skill
	Constraint Enforcement	Sleep Deprivation
	Constraint Setting	Social Situation
	Control Approach	Speed of Command
	Criticality	Speed of Decision
	Dynamics across Time	State of Mental Health
	Experience of Personnel	State of Physical Health
	Extent of Shared Information	Stress Level
	Force Will	Synchronization
	Identification	Synchronization of Actions
	Leadership	Task Competence
	Lethal effectors	Task Efficiency

Cognitive Pyramid	Conceptual Model Variable	
	Level of Confidence	Task Knowledge
	Likelihood of Success	Task Speed
	Mission Effectiveness	Team Culture
	Mobility	Team Decisions
	Nature of Rules	Training
	Non-Lethal Effectors	Trust in Information
	Perception of Cause and Effect	Trust in People
	Political Situation	Willingness
	Resource Allocation	

1.7 "Assess" Event

Table H-7: "Assess" Event

Cognitive Pyramid	Conceptual Model Variable	
Environment	Collective Knowledge	Number of Mental Models
	Constraint Enforcement	Policy Effectiveness
	Constraint Setting	Political Situation
	Experience of Personnel	Social Situation
	History	Stress Level
	Identification	Team Culture
	Lethal Effectors	Team Sensemaking Behaviour
	Non-Lethal Effectors	Uncertainty
Information	Accuracy of Shared Information	Information about Mission
	Completeness of Individual Information	Information Ambiguity
	Completeness of Shared Information	Information Complexity
	Correctness of Individual Information	Information Quality
	Correctness of Information	Information Uncertainty
	Correctness of Shared Information	Precision of Individual Information
	Currency of Information	Precision of Information

Cognitive Pyramid	Conceptual Model Variable	
	Currency of Shared Information	Precision of Shared Information
	Extent of Shared Information	Relevance of Shared Information
	Fusion	Timeliness of Shared Information
	Information about Capabilities	Timeliness of Information
	Information about Environment	Trust in Information
	Information about Forces	Uncertainty of Shared Information
	Information about Intentions	
Awareness	Accuracy of Collective Awareness	Awareness about Mission
	Accuracy of Individual Awareness	Completeness of Individual Awareness
	Accuracy of Intersection Awareness	Correctness of Collective Awareness
	Accuracy of Partial Awareness	Correctness of Individual Awareness
	Awareness about Capabilities	Correctness of Intersection Awareness
	Awareness about Environment	Correctness of Partial Awareness
	Awareness about Forces	Precision of Collective Awareness
	Awareness about Intentions	Precision of Individual Awareness
Understanding	Accuracy of Collective Understanding	Extent of Collective Understanding
	Accuracy of Individual Understanding	Extent of Intersection Understanding
	Accuracy of Intersection Understanding	Extent of Partial Understanding
	Accuracy of Partial Understanding	Precision of Collective Understanding
	Completeness of Collective Understanding	Precision of Individual Understanding
	Completeness of Individual Understanding	Understanding about Capabilities
	Completeness of Partial Understanding	Understanding about Environment

Cognitive Pyramid	Conceptual Model Variable	
	Correctness of Collective Understanding	Understanding about Forces
	Correctness of Individual Understanding	Understanding about Intentions
	Correctness of Intersection Understanding	Understanding about Mission
	Correctness of Partial Understanding	
Decision or Action	Analyze	Mission Effectiveness
	Assessment	Non-Lethal Effectors
	Constraint Enforcement	Persistence
	Constraint Setting	Stress Level
	Discovery	Task Competence
	Identification	Task Efficiency
	Innovation	Task Knowledge
	Level of Confidence	Task Speed
	Likelihood of Success	

2. DETERMINING THE VALUE OF THE CONCEPTUAL MODEL VARIABLES WITHIN THE AF2T2EA "KILL-CHAIN" PROCESS (VALUE VIEW)

Each of the conceptual model variables were assigned a "value" as to contributing towards the stated capability for each of the seven events within the AF2T2EA "Kill Chain" process. Highest value was highlighted in RED, Medium value was in BLUE and low value was in BLACK.

2.1 "Anticipate" Value

Table H-8: "Anticipate" Value

"Anticipate" Event		
High Value	**Medium Value**	**Low Value**
Ability to model, predict and display possible effects, warn, and report CBRNE and TIM threats		
Understanding about Intentions		Atmospheric Weather
Understanding about Environment		Space Weather
		Sensor Persistence
		Sensor Coverage (Spatial)
		Sensor Coverage (Medium)
		Sensor Coverage (Spectrum)
Predict how actions (Red, Blue, Gray) will cascade into direct and indirect effects in support of effects-based operations		
Correctness of Information	Completeness of Individual Information	Accuracy
Correctness of Individual Information	Completeness of Shared Information	Completeness of Information
Correctness of Shared Information	Precision of Information	Currency of Information
Information about Forces	Precision of Individual Information	Currency of Individual Information
Information about Environment	Precision of Shared Information	Currency of Shared Information
Information about Intentions	Relevance of Shared Information	Consistency of Information

"Anticipate" Event		
High Value	**Medium Value**	**Low Value**
Information Uncertainty	Timeliness of Information	Consistency of Individual Information
Uncertainty	Timeliness of Individual Information	Consistency of Shared Information
	Timeliness of Shared Information	Distribution of Information
	Uncertainty of Shared Information	Data Interoperability
		Extent of Shared Information
		Fusion
		Information Quality
		Network Reach
		Richness of Collaborative Environment
		Share Information
		Trust in Information

Anticipate adversary's action(s) in order to streamline and shorten Find, Fix, Track, Target, Engage, and Assess (F2T2EA) cycle		
Awareness about Environment	Task Speed	Accuracy of Individual Awareness
Awareness about Forces	Timeliness of Planning	Accuracy of Individual Decisions
Awareness about Intentions	Force Effectiveness	Accuracy of Shared Information
Awareness about Mission	Speed of Command	Collaboration about Environment
	Speed of Decision	Collaboration about Forces
	Speed of Planning	Collaboration about Intentions
		Command Approach
		Completeness of Individual Decisions
		Consistency of Individual Decisions

"Anticipate" Event		
High Value	**Medium Value**	**Low Value**
		Correctness of Individual Decisions
		Currency of Individual Decisions
		Experience of Personnel
		Frequency of Command Interactions
		Frequency of Peer-to-Peer Interactions
		History
		Mode of Decision Making of Individual Decisions
		Precision of Individual Decisions
		Quality of Decisions
		Quality of Interactions
		Quality of Peer-to-Peer Interactions
		Relevance of Individual Decisions
		Responsiveness
		Synchronization of Actions
		Timeliness of Individual Decisions
		Uncertainty of Individual Decisions
Ability to model and predict CBRNE and TIM threats and events		
Understanding about Intentions		Atmospheric Weather
Understanding about Environment		Space Weather

"Anticipate" Event		
High Value	**Medium Value**	**Low Value**
		Sensor Persistence
		Sensor Coverage (Spatial)
		Sensor Coverage (Medium)
		Sensor Coverage (Spectrum)

2.2 "Find" Value

Table H-9: "Find" Value

"Find" Event		
High Value	**Medium Value**	**Low Value**
Fully merge and integrate sensor information to support battlespace situational awareness		
Sensor Coverage (Spatial)		Atmospheric Weather
Sensor Coverage (Medium)		Collaboration about Environment
Sensor Coverage (Spectrum)		Command Approach
Sensor Persistence		Frequency of Command Interactions
		Frequency of Peer-to-Peer Interactions
		History
		Quality of Interactions
		Quality of Peer-to-Peer Interactions
		Space Weather
Rapidly and accurately updated situational understanding as a result of changes in situational awareness		
Correctness of Information	Currency of Information	Accuracy

"Find" Event		
High Value	**Medium Value**	**Low Value**
Correctness of Individual Information	Currency of Individual Information	Completeness of Information
Correctness of Shared Information	Currency of Shared Information	Completeness of Individual Information
Timeliness of Information	Precision of Information	Completeness of Shared Information
Timeliness of Individual Information	Precision of Individual Information	Consistency of Information
Timeliness of Shared Information	Precision of Shared Information	Consistency of Individual Information
	Trust in Information	Consistency of Shared Information
		Data Interoperability
		Distribution of Information
		Experience of Personnel
		Extent of Shared Information
		Fusion
		Information Quality
		Information about Forces
		Information about Environment
		Information about Intentions
		Information Uncertainty
		Network Reach
		Relevance of Shared Information
		Richness of Collaborative Environment
		Share Information
		Uncertainty
		Uncertainty of Shared Information

"Find" Event		
High Value	**Medium Value**	**Low Value**
Accurate and real-time situational awareness of the battlespace to enable decision makers to correctly react to dynamic changes		
Awareness about Environment	Accuracy of Individual Awareness	Accuracy of Individual Decisions
Awareness about Forces	Accuracy of Shared Information	Collaboration about Forces
Awareness about Intentions	Force Effectiveness	Collaboration about Intentions
Awareness about Mission	Responsiveness	Command Approach
Speed of Command	Synchronization of Actions	Completeness of Individual Decisions
Speed of Decision		Control Approach
Speed of Planning		Consistency of Individual Decisions
Task Speed		Correctness of Individual Decisions
		Currency of Individual Decisions
		Experience of Personnel
		Mode of Decision Making of Individual Decisions
		Precision of Individual Decisions
		Quality of Decisions
		Relevance of Individual Decisions
		Timeliness of Planning
		Timeliness of Individual Decisions
		Uncertainty of Individual Decisions

2.3 "Fix" Value

Table H-10: "Fix" Value

"Fix" Event		
High Value	**Medium Value**	**Low Value**
Accurate and timely positive combat identification of ground, air, and space objects		
Accuracy of Collective understanding	Accuracy	Analyze
Accuracy of Individual Understanding	Adaptiveness	Awareness about Capabilities
Accuracy of Individual Awareness	Authentication	Awareness about Intentions
Correctness of Information	Currency of Shared Information	Collective Knowledge
Correctness of Shared Information	Completeness of Collective Understanding	Command Approach
Precision of Individual Information	Identification	Completeness of Information
Precision of Information	Level of Confidence	Completeness of Individual Decisions
Precision of Shared Information		Consistency of Information
Sensor Coverage (Spatial)		Consistency of Shared Information
Sensor Coverage (Medium)		Distribution of Information
Sensor Coverage (Spectrum)		Extend of Shared Information
Sensor Persistence		Fusion
Timeliness of Shared Information		Identification
Timeliness of Individual Information		Information about Capabilities
Timeliness of Information		Information Ambiguity
		Information Complexity
		Information Quality
		Information Uncertainty

"Fix" Event		
High Value	**Medium Value**	**Low Value**
		Mission Effectiveness
		Network Availability
		Network Reach
		Network Reliability
		Quality of Communications Equipment
		Quality of Computing Equipment
		Relevance of Shared Information
		Share Information
		Task Competence
		Task Speed
		Uncertainty of Shared Information

2.4 "Track" Value

Table H-11: "Track" Value

"Track" Event		
High Value	**Medium Value**	**Low Value**
Integration and display of operations information in a common operational picture available to entire network		
Accuracy of Shared Information	Accuracy	Adaptiveness
Accuracy of Collective Awareness	Completeness of Information	Atmospheric Weather
Accuracy of Individual Awareness	Completeness of Individual Information	Analyze
Accuracy of Intersection Awareness	Completeness of Shared Information	Awareness about Environment
Accuracy of Partial Awareness	Currency of Individual Information	Awareness about Forces

"Track" Event		
High Value	**Medium Value**	**Low Value**
Accuracy of Collective Understanding	Currency of Information	Awareness about Intentions
Accuracy of Individual Understanding	Currency of Shared Information	Awareness about Mission
Accuracy of Intersection Understanding	Information about Environment	Completeness of Collective Understanding
Accuracy of Partial Understanding	Information about Forces	Completeness of Individual Awareness
Correctness of Collective Awareness	Information about Intentions	Completeness of Individual Understanding
Correctness of Collective Understanding		Completeness of Intersection Understanding
Correctness of Individual Awareness		Completeness of Partial Understanding
Correctness of Individual Information		Consistency of Information
Correctness of Individual Understanding		Consistency of Individual Information
Correctness of Partial Awareness		Consistency of Individual Awareness
Correctness of Partial Understanding		Consistency of Individual Understanding
Correctness of Shared Information		Consistency of Intersection Understanding
Timeliness of Collective Awareness		Consistency of Partial Understanding
Timeliness of Collective Understanding		Consistency of Shared Information
Timeliness of Individual Awareness		Currency of Collective Awareness
Timeliness of Individual Information		Currency of Collective Understanding
Timeliness of Individual Understanding		Currency of Individual Awareness

"Track" Event		
High Value	**Medium Value**	**Low Value**
Timeliness of Information		Currency of Individual Understanding
Timeliness of Shared Information		Distribution of Information
		Dynamics across Time
		Extend of Shared Information
		Extent of Collective Understanding
		Extent of Partial Understanding
		Flexibility
		Fusion
		History
		Information Quality
		Information Uncertainty
		Indirect Sensing
		Network Reach
		Precision of Individual Awareness
		Precision of Individual Information
		Precision of Information
		Precision of Shared Information
		Relevance of Shared Information
		Responsiveness
		Robustness
		Shared Understanding
		Uncertainty of Collective Awareness
		Uncertainty of Collective Understanding

"Track" Event		
High Value	**Medium Value**	**Low Value**
		Uncertainty of Shared Information
Improve, automate, and streamline monitoring of friendly air and space force location		
Understanding about Environment	Adaptiveness	Analyze
Understanding about Forces	Flexibility	Collaboration about Environment
Understanding about Intentions	Responsiveness	Collaboration about Forces
Understanding about Mission	Robustness	Collaboration about Intentions
	Sensor Coverage (Medium)	Collaboration about Mission
	Sensor Coverage (Spatial)	Command Approach
	Sensor Coverage (Spectrum)	Distribution of Information
	Space Weather	Dynamics across Time
	Task Speed	Experience of Personnel
	Trust in Information	History
		Innovation
		Mobility
		Level of Confidence
		Perception of Cause and Effect
		Quality of Decisions
		Quality of Plan
		Risk Propensity
		Speed of Command
		Speed of Decision
		Speed of Planning
		Synchronization of Actions
		Synchronization of Decisions
		Task Competency

"Track" Event		
High Value	**Medium Value**	**Low Value**
		Timeliness of Individual Decisions
		Training

2.5 "Target" Value

Table H-12: "Target" Value

"Target" Event		
High Value	**Medium Value**	**Low Value**
Improve Commander's COA selection and dissemination process		
Accuracy of Collective Awareness	Completeness of Information	Atmospheric Weather
Accuracy of Intersection Awareness	Completeness of Shared Information	Accuracy of Individual Decisions
Awareness about Capabilities	Consistency of Information	Appropriateness of Individual Decisions
Awareness about Environment	Consistency of Shared Information	Authentication
Awareness about Forces	Correctness of Individual Information	C2 Doctrine
Awareness about Intentions	Correctness of Shared Information	Communication of Intent
Awareness about Mission	Command Approach	Constraint Enforcement
Currency of Individual Information	Constraint Setting	Control Approach
Currency of Information	Criticality	Data Interoperability
Currency of Shared Information	Direct Sensing	Distribution of Information
Lethal Effectors	Information about Environment	Decision Participants
Non-Lethal Effectors	Information about Forces	Degree of Decision Concurrence
Political Situation	Indirect Sensing	Dynamics across Time

"Target" Event		
High Value	**Medium Value**	**Low Value**
Social Situation	Information about Mission	Extent of Shared Information
	Information Uncertainty	Experience of Personnel
	Likelihood of Success	Flexibility
	Risk Propensity	Force Effectiveness
	Robustness	Information Quality
	Sensor Persistence	Identification
	Speed of Command	Individual Task Efficiency
	Synchronization	Mission Effectiveness
	Synchronization of Actions	Nature of Rules
	Task Speed	Political Situation
	Trust in Information	Precision of Individual Information
	Uncertainty of Shared Information	Precision of Information
	Willingness	Precision of Shared Information
		Quality of Decisions
		Quality of Plan
		Relevance of Shared Information
		Resource Allocation
		Resource Prioritization
		Responsiveness
		Role of Authority
		Share Information
		Skill
		Sensor Coverage (Medium)
		Sensor Coverage (Spatial)
		Sensor Coverage (Spectrum)
		Space Weather
		Task Competence

"Target" Event		
High Value	**Medium Value**	**Low Value**
		Task Efficiency
		Task Knowledge
		Timeliness of Individual Decisions
		Timeliness of Individual Information
		Timeliness of Information
		Timeliness of Shared Information
		Training
		Uncertainty of Individual Decisions

2.6 "Engage" Value

Table H-13: "Engage" Value

"Engage" Event		
High Value	**Medium Value**	**Low Value**
Better optimized use of the battlespace environment		
	Atmospheric Weather	Complicated-ness
	Communications Interoperability	Data Interoperability
	Direct Sensing	Network Availability
	Indirect Sensing	Network Reach
	Space Weather	Network Reliability
		Network Richness
		Political Situation
		Quality of Communications Equipment

"Engage" Event		
High Value	**Medium Value**	**Low Value**
		Quality of Computing Equipment
		Selectivity
		Social Situation
Real-time collaboration among all C2 entities		
	Completeness of Shared Information	Completeness of Individual Information
	Correctness of Shared Information	Correctness of Information
	Currency of Shared Information	Currency of Individual Information
	Distribution of Information	Currency of Information
	Extent of Shared Information	Information about Environment
	Relevance of Shared Information	Information about Forces
	Timeliness of Shared Information	Information about Intentions
	Trust in Information	Information about Mission
	Uncertainty of Shared Information	Information Quality
		Precision of Individual Information
		Precision of Information
		Timeliness of Information
Conduct real-time effects-based mission execution		
Awareness about Capabilities		Completeness of Individual Awareness
Awareness about Environment		Correctness of Collective Awareness
Awareness about Forces		Currency of Collective Awareness
Awareness about Intentions		Currency of Individual Awareness

"Engage" Event		
High Value	**Medium Value**	**Low Value**
Awareness about Mission		Shared Awareness (intersection)
Capability to achieve self-synchronization of forces		
Lethal Effectors	Adaptiveness	Accuracy
Mission Effectiveness	C2 Doctrine	Authentication
Non-Lethal Effectors	Command Approach	Clarity about Roles
Speed of Command	Command Arrangements	Constraint Enforcement
Speed of Decision	Communication of Intent	Constraint Setting
Task Competence	Control Approach	Completeness of Collective Understanding
Task Efficiency	Dynamics across Time	Correctness of Collective Understanding
Task Knowledge	Force Will	Criticality
Task Speed	Leadership	Currency of Collective Understanding
	Mobility	Experience of Personnel
	Resource Prioritization	Extent of Shared Information
	Role of Authority	Identification
	Risk Propensity	Level of Confidence
	Robustness	Likelihood of Success
	Synchronization	Nature of Rules
	Synchronization of Actions	Perception of Cause and Effect
	Team Culture	Political Situation
	Team Decisions	Quality of Understanding
	Training	Resource Allocation
	Trust in Information	Responsiveness
	Trust in People	Role of Emotion
		Selectivity
		Skill
		Sleep Deprivation

"Engage" Event		
High Value	**Medium Value**	**Low Value**
		Social Situation
		State of Mental Health
		State of Physical Health
		Stress Level
		Uncertainty of Individual Understanding
		Willingness

2.7 "Assess" Value

Table H-14: "Assess" Value

"Assess" Event		
High Value	**Medium Value**	**Low Value**
Real-time Red, Blue Gray force status assessment		
Awareness about Capabilities	Accuracy of Collective Awareness	Constraint Enforcement
Awareness about Environment	Accuracy of Individual Awareness	Constraint Setting
Awareness about Forces	Accuracy of Intersection Awareness	Experience of Personnel
Awareness about Intentions	Accuracy of Partial Awareness	History
Awareness about Mission	Collective Knowledge	Identification
Correctness of Collective Awareness	Completeness of Individual Awareness	Lethal Effectors
Correctness of Individual Awareness	Political Situation	Non-Lethal Effectors
Correctness of Intersection Awareness	Precision of Collective Awareness	Number of Mental Models
Correctness of Partial Awareness	Precision of Individual Awareness	Policy Effectiveness
	Social Situation	Stress Level

"Assess" Event		
High Value	**Medium Value**	**Low Value**
	Uncertainty	Team Culture
		Team Sensemaking Behaviour
Ability to accurately assess air and space operational impacts of physical environmental conditions		
Correctness of Individual Information	Precision of Individual Information	Accuracy of Shared Information
Correctness of Information	Precision of Information	Completeness of Individual Information
Correctness of Shared Information	Precision of Shared Information	Completeness of Shared Information
Currency of Information	Trust in Information	Extent of Shared Information
Currency of Shared Information		Fusion
		Information about Capabilities
		Information about Environment
		Information about Forces
		Information about Intentions
		Information Ambiguity
		Information Complexity
		Information about Mission
		Information Quality
		Information Uncertainty
		Relevance of Shared Information
		Timeliness of Shared Information
		Timeliness of Information
		Uncertainty of Shared Information
Improve COA evaluation and requirements process		

"Assess" Event		
High Value	**Medium Value**	**Low Value**
Correctness of Collective Understanding	Accuracy of Collective Understanding	Completeness of Collective Understanding
Correctness of Individual Understanding	Accuracy of Individual Understanding	Completeness of Individual Understanding
Correctness of Intersection Understanding	Accuracy of Intersection Understanding	Completeness of Partial Understanding
Correctness of Partial Understanding	Accuracy of Partial Understanding	Precision of Collective Understanding
Understanding about Capabilities	Extent of Collective Understanding	Precision of Individual Understanding
Understanding about Environment	Extent of Intersection Understanding	
Understanding about Forces	Extent of Partial Understanding	
Understanding about Intentions		
Understanding about Mission		

Rapid assessment and selection of targets to maximize desired effects		
Mission Effectiveness	Analyze	Constraint Enforcement
Task Competence	Assessment	Constraint Setting
Task Efficiency	Likelihood of Success	Discovery
Task Knowledge	Lethal Effectors	Identification
Task Speed	Non-Lethal Effectors	Innovation
		Level of Confidence
		Persistence
		Stress Level

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14. Abstract

The SAS-050 study group was formed primarily to develop a conceptual model of Command and Control (C2) that could ultimately assist decision makers in understanding C2 concepts and the implications to different approaches to C2. This report provides an in-depth discussion of the SAS-050 Reference Model and the Value View developed by the SAS-050 study group. Several chapters focus on specific sections of the reference model (C2 Approach, the Information Domain, Individual Characteristics and Behaviours, Team Characteristics and Behaviours, and Decisionmaking, Actions, Effects, and Consequences). These chapters are followed by an explanation of the group's approach to validating the model. The paper discusses key variables and relationships within the model, identifies tools that can explore the nature of the relationships among variables, and describes the results of case studies and peer review conducted to test and identify advantages and limitations of the model.

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