

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.

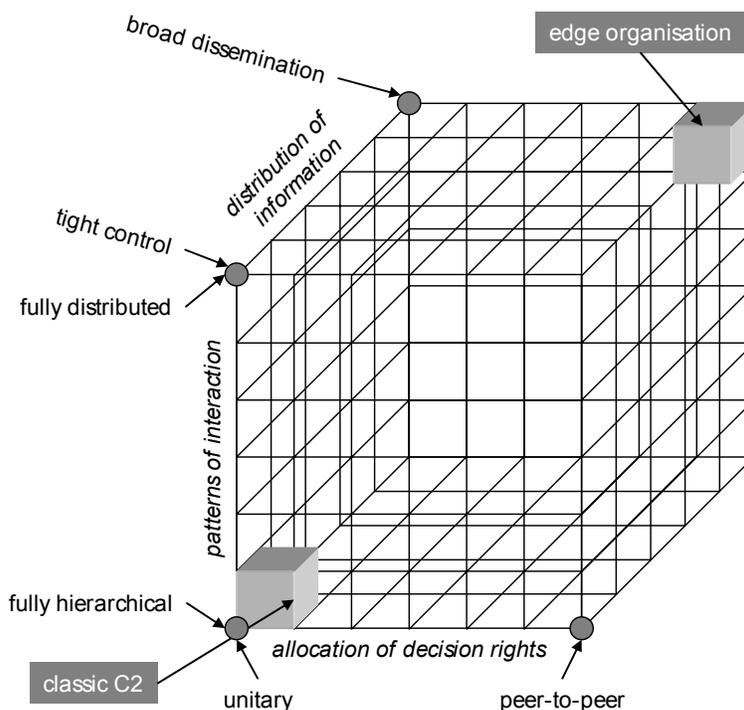


Figure 2-1: Depicts the C2 Approach Space Formed by these Dimensions.

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.

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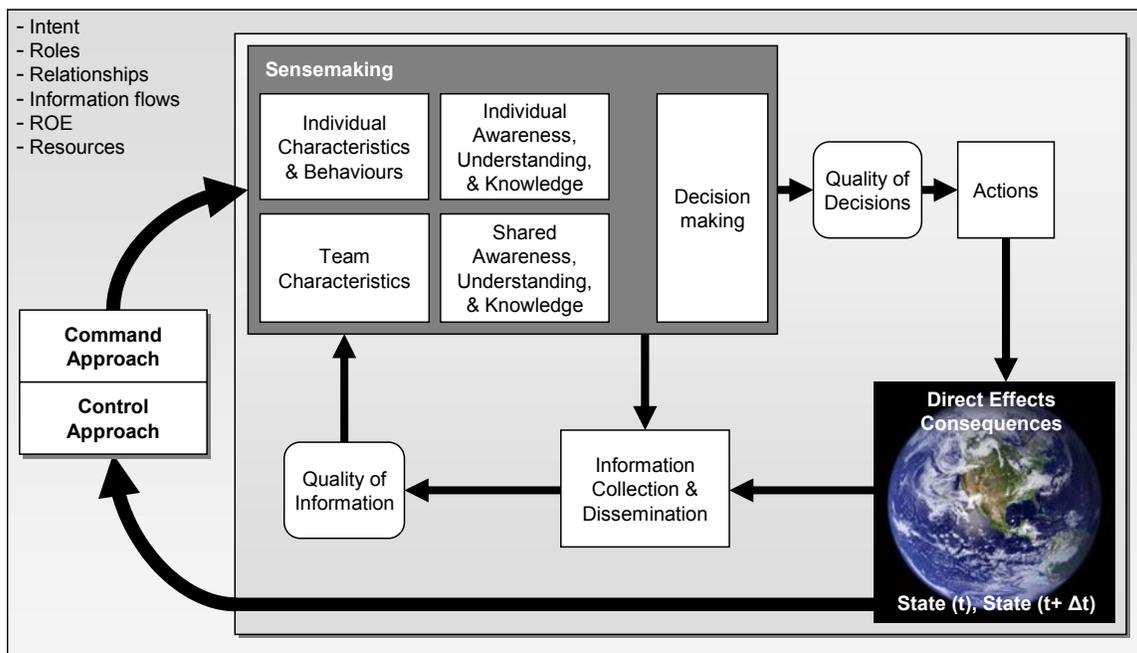


Figure 2-2: C2 Approach.

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.

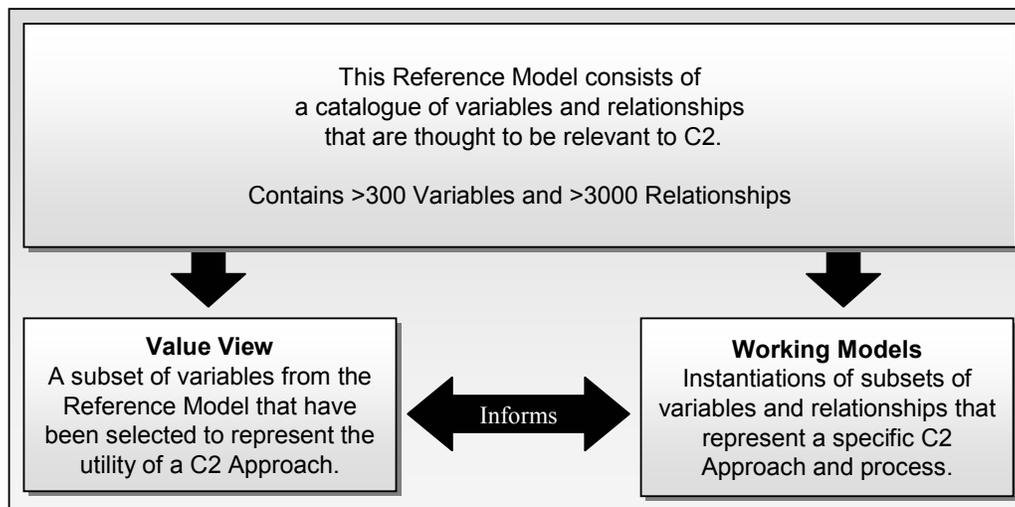


Figure 2-3: Relationships among the Value and Process Views of the C2 Model.

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.

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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.

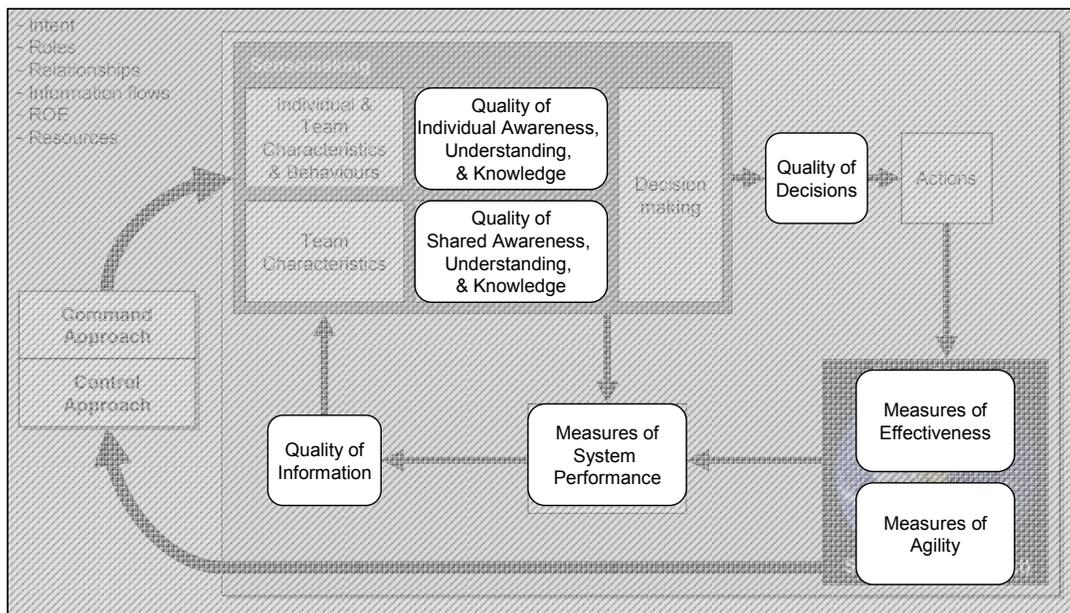


Figure 2-4: The Value Chain.