

**AF2T2EA – An Illustrative Example of the C2 Conceptual Model**

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## Abstract

Over the past three years, a NATO panel (SAS-050) has developed the first version of a Command and Control (C2) Conceptual Model. The Conceptual Model's purpose is to support the exploration of new, networked-enabled approaches to C2 and compare their characteristics, performance, effectiveness, and agility to traditional approaches to C2. The Air Force's "Kill Chain" is a lengthy process that's subdivided into seven "events", namely: anticipate, find, fix, track, target, engage, and assess (AF2T2EA). As an illustrative example of the C2 Conceptual Model, the Model's attributes were applied to each of the seven areas in two test cases. Test case one, the Conceptual Model's variables were mapped into each of the AF2T2EA events via five bins (environment, information, awareness, understanding and decision). The result represented the Conceptual Model's "process view". Test case two, the Conceptual Model's variables were mapped into a set of AF2T2EA required capabilities. For a sub-set of the AF2T2EA capabilities, the Conceptual Model variables were evaluated as to having a high, medium or low correlation to the stated AF2T2EA capabilities. The result represented the Conceptual Model's "value view". Both test cases yielded expected results reaffirming the Conceptual Model's variable listing did not have any major discrepancies.

## Introduction

Ever since the 1999 publication of the book "Network Centric Warfare," countries and organizations have embarked on a journey of transformation to take full advantage 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 Defense, or Edge Organizations, this transformation is predicated on a set of network-centric tenets<sup>1</sup>.

These tenets that form the intellectual foundation for these on-going transformations are: a) a robustly networked force (enterprise) enables the wide spread sharing of information; and, b) wide spread 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-synchronization: the result is a dramatic improvement in operational effectiveness and agility.

Over the past three years, the NATO panel (SAS-050) has developed the first version of a C2 Conceptual Model, whose resultant top level is shown in Figure 1.

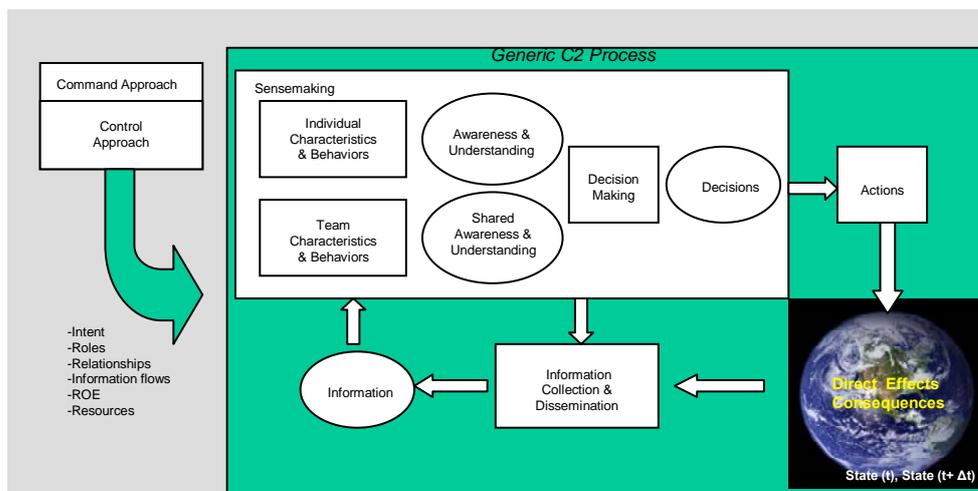
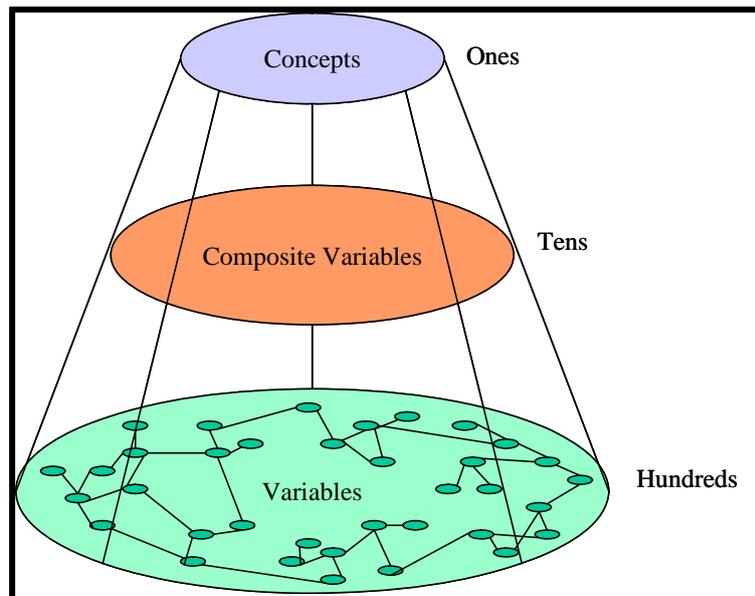


Figure 1: Top Level View of the C2 Conceptual Model

<sup>1</sup> Final Report, SAS-050, March 2006.

The goals and objectives of the SAS-050 panel were to: a) develop a conceptual model of key variables and the relationships among them; b) identify tools that can explore the nature of the relationships among the variables; c) apply, as a test case, the model and tools; d) conduct a peer review of the model; and, e) disseminate model and the findings.<sup>2</sup>

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)<sup>3</sup>. The resultant C2 Conceptual Model reference model has three layers as shown in Figure 2<sup>4</sup>.



**Figure 2: C2 Conceptual Model Reference Model Layers**

The C2 conceptual Model contains three different, but complementary views of the domain of interest. The first is the “event view”; which describes the state of the “system” at any given point in time. The second is the “process view”; which describes how state changes occur in the system. The third view is the “value view”; which represents changes in measures of performance, effectiveness, etc. This view documents goals and objectives, or more generally why one cares about the “system performance” in the first place.<sup>5</sup>

As part of the C2 Conceptual Model’s development, an illustrative example was explored to determine if there were any shortcomings or obvious discrepancies of the model. The Air Force’s AF2T2EA “Kill Chain” process was chosen as the illustrative example.

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 goal of the “Kill Chain” process is to achieve single-digit sensor-to-shooter (i.e. find to engage) accomplishment against a high value target at the right time, anywhere. The current AF2T2EA “Kill Chain”, implies a lengthy process since it is essentially a series of sequential processes. Currently, a minimal collaborative group of users/systems must rapidly exchange information in pursuit of shared goals, interests, missions, or processes and therefore must have a shared vocabulary for the information exchanged. This is an ambitious endeavour to accomplish in “single-digit” minutes.

<sup>2</sup> Alberts, David S., “NATO SAS-050: Exploring New Command and Control Concepts and Capabilities,” Final Report presented to NATO SAS Panel, November 2005.

<sup>3</sup> Final Report, SAS-050, March 2006

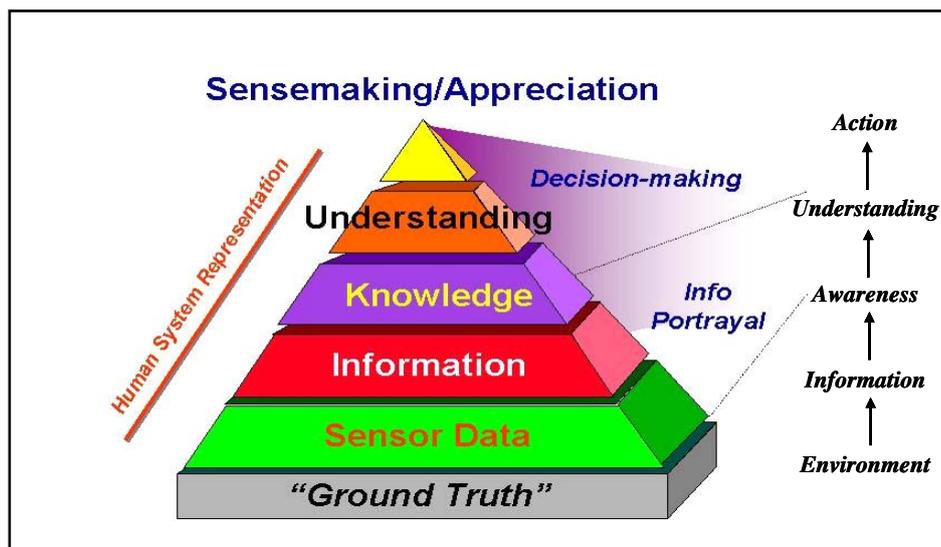
<sup>4</sup> Alberts, David S., “NATO SAS-050: Exploring New Command and Control Concepts and Capabilities,” Final Report presented to NATO SAS Panel, November 2005.

<sup>5</sup> Concept Model Overview, SAS-050 Berlin Workshop, 3 March 2004.

A sub-set of the desired attributes to effectively accomplish the “Kill Chain” process can be summarized as follows<sup>6</sup>:

- Focused, persistent C2ISR for all target categories, to achieve desired effects, such as: adversary’s intent
- C2 of ISR assets to persistently track target entities to predict the adversary’s courses of action in the battlespace
- Full-spectrum, networked ISR focused by anticipation in order to re-detect potential targets quickly, cross-cue assets to precisely geo-locate targets, and trigger the F2T2EA execution cycle
- C2 of ISR to cross-cue assets to precisely geo-locate targets
- Networked, multi-sensor inputs to characterize a target’s operational, physical, functional capabilities, and tactical employment patterns
- Share information across entire operational network (i.e., collaboration)
- 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, decision makers, and strikers to shorten AF2T2EA cycle

### Approach



**Figure 3: The “Cognitive Pyramid”**

Using the cognitive pyramid approach as shown in Figure 3, the C2 Conceptual Models variables were applied to each of the seven events of the “Kill Chain” with the end-goal of assessing their completeness and/or detecting any major discrepancies.

The C2 Conceptual Model’s “event view” can be thought of as the accumulation of the seven “events” that make up the AF2T2EA “Kill Chain”, namely: anticipate, find, fix, track, target, engage, and assess. Overall, the AF2T2EA “Kill Chain” can be thought of as a “process”, which is the second view of the C2 Conceptual Model. The third view, or “value view” can be thought of as those variables within the C2 Conceptual Model that provide “value” to particular measures of performance or effectiveness. For this illustrative example, the performance or effective measures were those variables that had a high/medium/low correlation to the seven “events” of the “Kill Chain”.

<sup>6</sup> Capability statements taken from a 2004 HQ USAF briefing on the same subject.

Using Figure 3 as a template, the concept would be the AF2T2EA “Kill Chain”; the composite variables would be the five groupings (environment, information, awareness, understanding and action or decision); and lastly, the variables would be the list of 233 variables contained within the C2 Conceptual Model as of May 2005.

Utilizing only a sub-set of all the capabilities required to successfully prosecute the AF2T2EA process, the following capabilities were selected for further analysis:

a. 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
- Requires correct, current, consistent and shared information

b. Find:

- Fully merge and integrate sensor/information to support battlespace SA
- Accurate/real-time battlespace SA, enabling decision makers to correctly react to changes
- Rapidly and accurately update situational understanding as a result of changes in SA awareness

c. Fix:

- Accurate and timely positive combat identification of surface, air, and space objects

d. 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

e. Target:

- Improve Commander’s COA selection and dissemination process

f. 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

g. 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

## Test Cases

This illustrative example was subdivided into two test cases.

1. Test Case 1: “Process View”

For each of the seven “events” contained within the AF2T2EA “Kill Chain”, the Conceptual Model’s variables (233 in May 2005) were mapped into: a) environment, b) information, c) awareness, d) understanding and decision (or action) corresponding to the cognitive pyramid shown in Figure 3. The goal was to determine whether or not there were obvious variables missing from the C2 Conceptual Model.

2. Test Case 2: “Value View”

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. The goal was to determine whether or not there were obvious discrepancies contained within the C2 Conceptual Model.

**Results**

The results were presented at a peer-to-peer workshop held in Virginia Beach, VA., 2-6 Oct 2005.<sup>7</sup>

1) Test Case 1: “Process View”

Figure 4 illustrates an example of the mapping of the C2 Conceptual Models 233 variables into the “Assess” event of the AF2T2EA “Kill Chain” process. A complete listing of the “variable-to-event” mapping with the corresponding correlation is contained in Appendix A, tables A-1 through A-7.

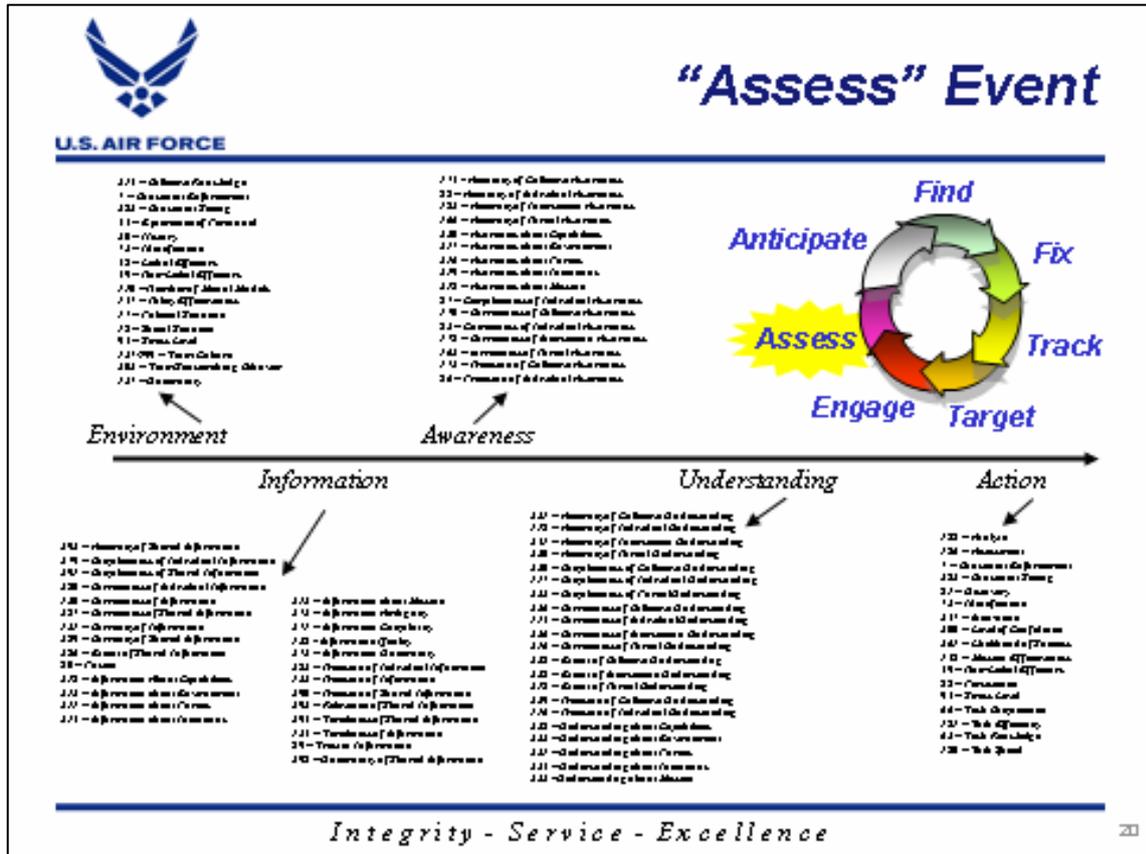


Figure 4: “Assess” Event Variable Mapping

Table 1: Number of Variables Associated with each of the AF2T2EA “Events”

“Event”	Composite Variable				
	Environment	Information	Awareness	Understanding	Action (or Decision)
Anticipate	6	35	16	2	19
Find	6	35	16	2	19
Fix	11	28	8	7	8
Track	15	32	19	22	34
Target	10	27	7	1	47
Engage	13	21	10	5	54
Assess	16	27	16	21	17

Table 1 illustrates the overall results of this mapping. As shown in Table 1, there is a strong correlation of the conceptual models variables to the AF2T2EA “Kill Chain” process as a whole, i.e., for each “event” within the process, the set of variables that should be dominate, are dominate. For example:

<sup>7</sup> Phister, Paul, “AF2T2EA – An Illustrative Example,” presented at the Peer-to-Peer Workshop, 4-6 Oct 2005, Virginia Beach, VA USA.

- a) *Anticipate*: Determining where a potential target could be located relies heavily on: **information** (e.g., completeness of information, currency of information, information about forces/environment/intentions, precision of information and timeliness of information); **action** (e.g., responsiveness, quality of decisions, speed of command/decision/planning, and timeliness of planning); as well as **awareness** (e.g., awareness about environment/forces/intentions/mission, history, and experience of personnel).
- b) *Find*: Determining the location of a particular target relies on **information** (e.g., accuracy, completeness of information, correctness of information, currency of information, consistency of information, information quality, precision of information, timeliness of information, and trust in information); **action** (e.g., responsiveness, quality of decisions, speed of command/decision/planning, task speed, and timeliness of planning); and, **awareness** (e.g., accuracy of shared information, awareness about forces/intentions/mission, experience of personnel, and quality of interactions).
- c) *Fix*: Once a target is located, determining an exact “fix” in order to apply the appropriate weapon relies on **information** (e.g., accuracy, authentication, currency, identification, information ambiguity/complexity/quality, precision, and timeliness); the **environment** (e.g., network availability/reach/reliability, sensor coverage and persistence), and, **awareness** (accuracy, adaptiveness, level of confidence, and task competence).
- d) *Track*: Once a target is found, the ability to continuously track relies on **action** (e.g., adaptiveness, collaboration about environment/forces/intentions/mission, flexibility, innovation, responsiveness, robustness, and speed of command/planning); **information** (e.g., accuracy, completeness, consistency, fusion, information about environment/forces/intentions, precision of information, and timeliness of individual/shared information), and **understanding** (accuracy, completeness, consistency, correctness, currency and timeliness).
- e) *Target*: Once the target is “fixed” the ability to target with a weapon relies on **action** (e.g., accuracy, authentication, constraint enforcement, experience of personnel, lethal and non-lethal effectors, and skill), **information** (e.g., completeness, consistency, correctness, currency, information about environment/forces/mission, precision, timeliness and trust in the information) and the **environment** (atmospheric/space weather, political/social situation, sensor coverage and persistence).
- f) *Engage*: To actually “engage” the target with the appropriate weapon relies on **action** (e.g., accuracy, dynamics across time, lethal and non-lethal effectors, risk propensity, task efficiency, willingness, adaptiveness, trust, speed of command, skill, and criticality); **information** (completeness, correctness, currency, precision, relevance, timeliness, and trust); and, the **environment** (atmospheric weather, network availability/reach/reliability, and the political/social situation).
- g) *Assess*: After the target has been engaged, to adequately assess the “effect” relies on **information** (e.g., accuracy, completeness, correctness, fusion, information ambiguity/complexity/quality/uncertainty, precision, timeliness, and relevance); **understanding** (accuracy, completeness, correctness, precision, and the understanding about capabilities/environment/forces/intentions/mission); and **awareness** (accuracy, correctness, precision, completeness, and the awareness about forces/missions/capabilities/environment).

2) Test Case 2: “Value View”

Figure 5 illustrates an example of the mapping of the C2 Conceptual Models 233 variables into the capabilities associated with the “Assess” event of the AF2T2EA “Kill Chain” process. For each of the variables, an assessment was performed as to its’ high (red)/med (blue)/low (black) correlation to the capability as shown in Figure 5. A complete listing of the “variable-to-capability” mapping for each AF2T2EA “even” with the corresponding correlation is contained in Appendix B, tables B-1 through B-7.

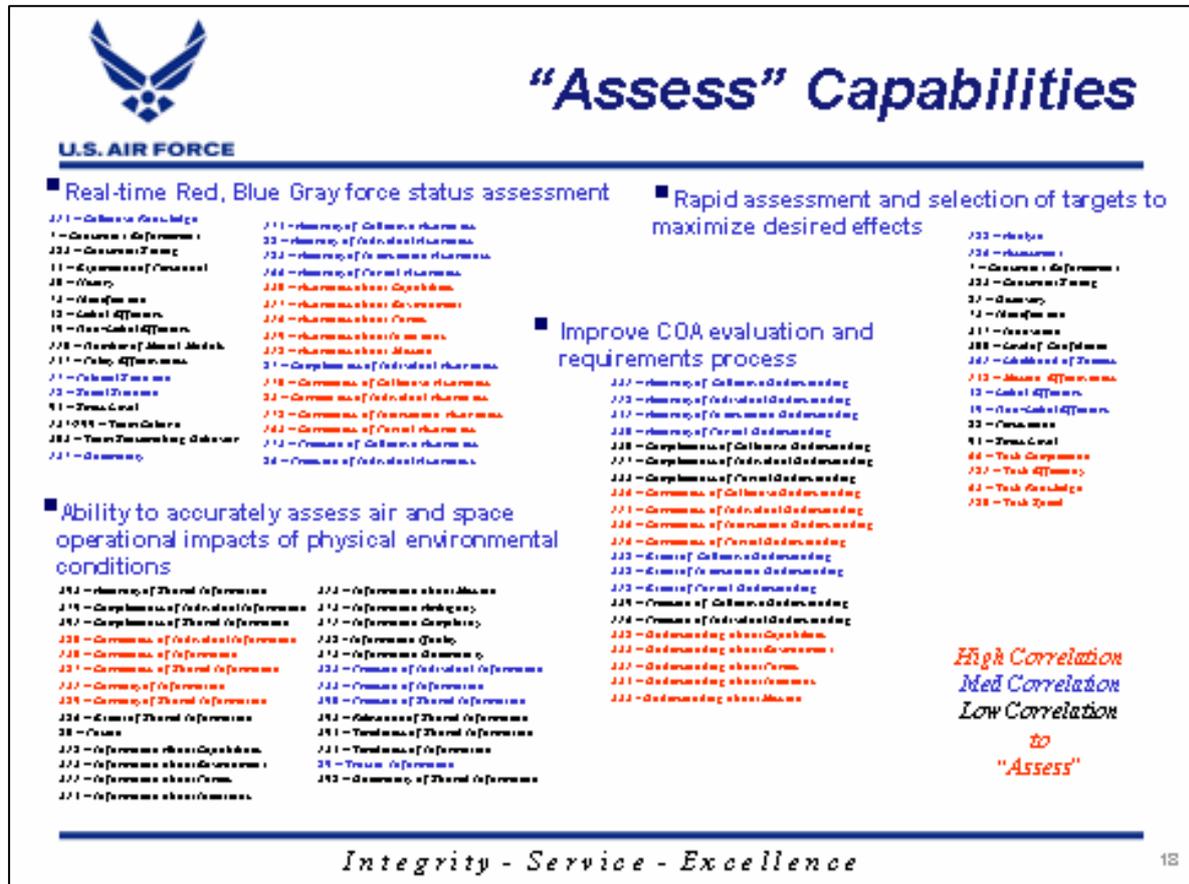


Figure 5: “Assess” Event Value Mapping

Table 2 illustrates the resultant mapping of variables to capabilities for the AF2T2EA “Kill Chain”. A complete listing of the “variable-to-capability” mapping with the corresponding correlation is contained in Appendix C, Table C-1.

Table 2: Variable Mapping to “Event” Capabilities

“Event”	Number of Variables Mapped (not unique)	Number of Capabilities contained within “Event”	Correlations		
			High	Medium	Low
Anticipate	88	4	18	16	54
Find	79	3	18	12	49
Fix	53	1	15	8	30
Track	121	2	28	20	73
Target	88	1	14	26	48
Engage	107	4	14	35	58
Assess	98	4	28	27	43

Table 3 provides a top level summary of the information contained in Appendix C.

**Table 3: Value View of the AF2T2EA “Kill Chain”**

“Event”	Variable (1)	Variable (2)	Variable (3)	Variable (4)	Variable (5)
Anticipate	Understanding	Uncertainty	Information	Awareness	Correctness
Find	Sensor	Correctness	Timeliness	Awareness	Speed
Fix	Correctness	Precision	Timeliness	Accuracy	Level of Confidence
Track	Correctness	Accuracy	Understanding	Sensor	Timeliness
Target	Accuracy	Currency	Lethal and Non-Lethal Effectors	Situation	Awareness
Engage	Awareness	Speed	Task	Mission Effectiveness	Lethal and Non-lethal Effectors
Assess	Understanding	Awareness	Correctness	Task	Mission Effectiveness

As illustrated in the table above, the following information can be extracted:

- a) Anticipate: An understanding of the environment and an adversary’s intentions are paramount if you want to “predict” their next move or determine the most likely location of a potential target. Information and Awareness about forces, the environment, and mission provide much needed information to the decision maker.
- b) Find: Persistent ISR is a must in order to locate targets under a wide range of conditions. Speed of command, speed of decisions, speed of planning, and speed of performing the required tasks play a dominate role in the ability of “finding” potential targets.
- c) Fix: Accuracy is a term that has multiple dimensions within the context of the C2 Conceptual Model. The term includes the accuracy of: individual awareness; individual understanding; and, collective understanding. All of these need to come together in a coherent form in order to provide a continuous “fix” on targets.
- d) Track: Correctness is a term that has multiple dimensions. In the context of the C2 Conceptual Model, this term includes the correctness of: individual information; shared information; individual awareness; collective awareness; partial awareness; individual understanding; partial understanding; and, collective understanding. These are complex entities that must be used collectively in order to determine the exact location of potential targets.
- e) Target: Currency is a term that has multiple dimensions within the C2 Conceptual Model. This term includes the currency of: information; individual information; and shared information. These entities are important ingredients if a potential target is to be successfully engaged.
- f) Engage: Awareness contains the following elements: capabilities; forces; the environment; adversary’s intentions; and the mission. These variables need to successfully come together to successfully engage in a target located anywhere at anytime.
- g) Assess: Correctness is a term that has a significant amount of dimensions within the C2 Concept Model. This term includes the correctness of: information, individual information, shared information, individual awareness, collective awareness, partial awareness, intersection awareness, individual understanding, collective understanding, partial understanding, intersection understanding; the assigned task: competence to perform the assigned task, efficiency of performing the assigned task, knowledge, and speed of execution.

## Summary

As a result of the NATO panel (SAS-050), the first-ever version of a Command and Control Conceptual Model has been developed. The intent of this model is to support the exploration of new, networked-enabled approaches to C2 and compare their characteristics, performance, effectiveness, and agility to traditional approaches to C2. As an illustrative example, the application of the C2 Conceptual Model was applied to each of the seven areas of the AF2T2EA “Kill Chain” process in two test cases. Test case one mapped the model’s variables (233) into each of the AF2T2EA events via five bins (environment, information, awareness, understanding and decision). The result represented the Conceptual Model’s “process view”. The results of test case one provided some insight into the C2 Conceptual Model’s ability to map into the AF2T2EA “Kill Chain”. Test case one did not uncover major shortcomings of the C2 Conceptual Model. Test case two mapped (high, medium, low) the model’s variables into a set of AF2T2EA required capabilities. The result represented the Conceptual Model’s “value view”. Test case two did not uncover any major discrepancies of the C2 Conceptual Model. This illustrative example, demonstrated the viability of two of the C2 Conceptual Model’s primary goals, namely: a conceptual model that contained key variables and the relationships and conducting a test case to demonstrate the Model’s utility. In both test cases, the C2 Conceptual Model was shown to be “viable” and contain no major shortcomings or discrepancies.

## Bibliography



### **Paul W. Phister, Jr., Ph.D., P.E.**

Paul Phister is the Senior Air & Space Strategic Planner at the Air Force Research Laboratory’s *Information Directorate* headquartered in Rome, New York. Dr. Phister is considered both a space and C2 expert and holds two masters degrees and received his Ph.D. in Engineering from California Coast University. Dr. Phister is a licensed Professional Software Engineer from the State of Texas and a senior member of the IEEE.

## APPENDIX A

Mapping Conceptual Model variables to the AF2T2EA “Kill-Chain” Process.

Cognitive Pyramid	Conceptual Model Variable	
<b>Environment</b>	<i>Atmospheric Weather</i>	<i>Sensor Coverage (Spacial)</i>
	<i>Space Weather</i>	<i>Sensor Coverage (Medium)</i>
	<i>Sensor Persistence</i>	<i>Sensor Coverage (Spectrum)</i>
<b>Information</b>	<i>Accuracy</i>	<i>Information about Forces</i>
	<i>Completeness of Information</i>	<i>Information about Environment</i>
	<i>Completeness of Individual Information</i>	<i>Information about intentions</i>
	<i>Completeness of Shared Information</i>	<i>Information Uncertainty</i>
	<i>Correctness of Information</i>	<i>Network Reach</i>
	<i>Correctness of Individual Information</i>	<i>Precision of Information</i>
	<i>Correctness of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Currency of Information</i>	<i>Precision of Shared Information</i>
	<i>Currency of Individual Information</i>	<i>Relevance of Shared Information</i>
	<i>Currency of Shared Information</i>	<i>Richness of Collaborative Environment</i>
	<i>Consistency of Information</i>	<i>Share Information</i>
	<i>Consistency of Individual Information</i>	<i>Timeliness of Information</i>
	<i>Consistency of Shared Information</i>	<i>Timeliness of Individual Information</i>
	<i>Data Interoperability</i>	<i>Timeliness of Shared Information</i>
	<i>Distribution of Information</i>	<i>Trust in Information</i>
	<i>Extent of Shared Information</i>	<i>Uncertainty</i>
<b>Awareness</b>	<i>Fusion</i>	<i>Uncertainty of Shared Information</i>
	<i>Information Quality</i>	
	<i>Accuracy of Individual Awareness</i>	<i>Collaboration about Intentions</i>
	<i>Accuracy of Shared Information</i>	<i>Command Approach</i>
	<i>Awareness about Environment</i>	<i>Experience of Personnel</i>
	<i>Awareness about Forces</i>	<i>Frequency of Command Interactions</i>
	<i>Awareness about Intentions</i>	<i>Frequency of Peer-to-Peer Interactions</i>
	<i>Awareness about Mission</i>	<i>History</i>
<b>Understanding</b>	<i>Collaboration about Environment</i>	<i>Quality of Interactions</i>
	<i>Collaboration about Forces</i>	<i>Quality of Peer-to-Peer Interactions</i>
	<i>Understanding about Environment</i>	<i>Understanding about Intentions</i>
<b>Decision or Action</b>		
	<i>Accuracy of Individual Decisions</i>	<i>Relevance of Individual Decisions</i>
	<i>Consistency of Individual Decisions</i>	<i>Speed of Command</i>
	<i>Completeness of Individual Decisions</i>	<i>Speed of Decision</i>
	<i>Correctness of Individual Decisions</i>	<i>Speed of Planning</i>
	<i>Currency of Individual Decisions</i>	<i>Synchronization of Actions</i>
	<i>Force Effectiveness</i>	<i>Task Speed</i>
	<i>Mode of Decision Making of Individual Decisions</i>	<i>Timeliness of Planning</i>
	<i>Responsiveness</i>	<i>Timeliness of Individual Decisions</i>
<i>Precision of Individual Decisions</i>	<i>Uncertainty of Individual Decisions</i>	
<i>Quality of Decisions</i>		

**Table A-1: “Anticipate” Event**

<b>Cognitive Pyramid</b>		<b>Conceptual Model Variable</b>
<b>Environment</b>	<i>Atmospheric Weather</i>	<i>Sensor Coverage (Spacial)</i>
	<i>Space Weather</i>	<i>Sensor Coverage (Medium)</i>
	<i>Sensor Persistence</i>	<i>Sensor Coverage (Spectrum)</i>
<b>Information</b>	<i>Accuracy</i>	<i>Information about Forces</i>
	<i>Completeness of Information</i>	<i>Information about Environment</i>
	<i>Completeness of Individual Information</i>	<i>Information about intentions</i>
	<i>Completeness of Shared Information</i>	<i>Information Uncertainty</i>
	<i>Consistency of Information</i>	<i>Network Reach</i>
	<i>Consistency of Individual Information</i>	<i>Precision of Information</i>
	<i>Consistency of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Correctness of Information</i>	<i>Precision of Shared Information</i>
	<i>Correctness of Individual Information</i>	
	<i>Correctness of Shared Information</i>	<i>Relevance of Shared Information</i>
	<i>Currency of Information</i>	<i>Richness of Collaborative Environment</i>
	<i>Currency of Individual Information</i>	<i>Share Information</i>
	<i>Currency of Shared Information</i>	<i>Timeliness of Information</i>
	<i>Data Interoperability</i>	<i>Timeliness of Individual Information</i>
	<i>Distribution of Information</i>	<i>Timeliness of Shared Information</i>
	<i>Extent of Shared Information</i>	<i>Trust in Information</i>
<b>Awareness</b>	<i>Fusion</i>	<i>Uncertainty</i>
	<i>Information Quality</i>	<i>Uncertainty of Shared Information</i>
	<i>Accuracy of Individual Awareness</i>	<i>Collaboration about Intentions</i>
	<i>Accuracy of Shared Information</i>	<i>Command Approach</i>
	<i>Awareness about Environment</i>	<i>Experience of Personnel</i>
	<i>Awareness about Forces</i>	<i>Frequency of Command Interactions</i>
	<i>Awareness about Intentions</i>	<i>Frequency of Peer-to-Peer Interactions</i>
	<i>Awareness about Mission</i>	<i>History</i>
<i>Collaboration about Environment</i>	<i>Quality of Interactions</i>	
<i>Collaboration about Forces</i>	<i>Quality of Peer-to-Peer Interactions</i>	
<b>Understanding</b>	<i>Understanding about Environment</i>	<i>Understanding about Intentions</i>
<b>Decision or Action</b>	<i>Accuracy of Individual Decisions</i>	<i>Speed of Decision</i>
	<i>Consistency of Individual Decisions</i>	<i>Force Effectiveness</i>
	<i>Completeness of Individual Decisions</i>	<i>Mode of Decision Making of Individual Decisions</i>
	<i>Correctness of Individual Decisions</i>	<i>Responsiveness</i>
	<i>Currency of Individual Decisions</i>	<i>Precision of Individual Decisions</i>
	<i>Quality of Decisions</i>	<i>Task Speed</i>
	<i>Relevance of Individual Decisions</i>	<i>Timeliness of Planning</i>
	<i>Speed of Planning</i>	<i>Timeliness of Individual Decisions</i>
	<i>Synchronization of Actions</i>	<i>Uncertainty of Individual Decisions</i>
	<i>Speed of Command</i>	

**Table A-2: “Find” Event**

<b>Cognitive Pyramid</b>	<b>Conceptual Model Variable</b>	
<b>Environment</b>	<i>Analyze</i>	<i>Quality of Computing Equipment</i>
	<i>Network Availability</i>	<i>Sensor Coverage (Spatial)</i>
	<i>Network Reach</i>	<i>Sensor Coverage (Medium)</i>
	<i>Network Reliability</i>	<i>Sensor Coverage (Spectrum)</i>
	<i>Quality of Communications Equipment</i>	<i>Sensor Persistence</i>
<b>Information</b>	<i>Accuracy</i>	<i>Information Ambiguity</i>
	<i>Authentication</i>	<i>Information Complexity</i>
	<i>Completeness of Information</i>	<i>Information Quality</i>
	<i>Consistency of Information</i>	<i>Information Uncertainty</i>
	<i>Consistency of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Correctness of Information</i>	<i>Precision of Information</i>
	<i>Correctness of Shared Information</i>	<i>Precision of Shared Information</i>
	<i>Currency of Shared Information</i>	<i>Relevance of Shared Information</i>
	<i>Distribution of Information</i>	<i>Share Information</i>
	<i>Extend of Shared Information</i>	<i>Timeliness of Shared Information</i>
	<i>Fusion</i>	<i>Timeliness of Individual Information</i>
	<i>Identification</i>	<i>Timeliness of Information</i>
	<i>Information About Capabilities</i>	<i>Uncertainty of Shared Information</i>
<b>Awareness</b>	<i>Accuracy of Individual Awareness</i>	<i>Identification</i>
	<i>Adaptiveness</i>	<i>Level of Confidence</i>
	<i>Awareness about Capabilities</i>	<i>Task Competence</i>
	<i>Awareness about Intentions</i>	
<b>Understanding</b>	<i>Accuracy of Collective understanding</i>	<i>Completeness of Collective Understanding</i>
	<i>Accuracy of Individual Understanding</i>	<i>Identification</i>
	<i>Collective Knowledge</i>	<i>Level of Confidence</i>
<b>Decision or Action</b>	<i>Command Approach</i>	<i>Mission Effectiveness</i>
	<i>Completeness of Individual Decisions</i>	<i>Task Competence</i>
	<i>Identification</i>	<i>Task Speed</i>
	<i>Level of Confidence</i>	

**Table A-3: “Fix” Event**

<b>Cognitive Pyramid</b>	<b>Conceptual Model Variable</b>	
<b>Environment</b>	<i>Accuracy</i>	<i>Network Reach</i>
	<i>Adaptiveness</i>	<i>Responsiveness</i>
	<i>Analyze</i>	<i>Robustness</i>
	<i>Atmospheric Weather</i>	<i>Sensor Coverage (Medium)</i>
	<i>Dynamics across Time</i>	<i>Sensor coverage (Spatial)</i>
	<i>History</i>	<i>Sensor Coverage (Spectrum)</i>
	<i>Indirect Sensing</i>	<i>Space Weather</i>
	<i>Mobility</i>	
<b>Information</b>	<i>Accuracy</i>	<i>Flexibility</i>
	<i>Accuracy of Shared Information</i>	<i>Fusion</i>
	<i>Completeness of Individual Information</i>	<i>Information about Environment</i>
	<i>Completeness of Information</i>	<i>Information about Forces</i>
	<i>Completeness of Shared Information</i>	<i>Information about Intentions</i>
	<i>Consistency of Individual Information</i>	<i>Information Quality</i>
	<i>Consistency of Information</i>	<i>Information Uncertainty</i>
	<i>Consistency of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Currency of Shared Information</i>	<i>Precision of Information</i>
	<i>Currency of Individual Information</i>	<i>Precision of Shared Information</i>
	<i>Currency of Information</i>	<i>Relevance of Shared Information</i>
	<i>Correctness of Individual Information</i>	<i>Shared Understanding</i>
	<i>Correctness of Shared Information</i>	<i>Timeliness of Shared Information</i>
	<i>Distribution of Information</i>	<i>Timeliness of Individual Information</i>
	<i>Dynamics across Time</i>	<i>Timeliness of Information</i>
	<i>Extend of Shared Information</i>	<i>Uncertainty of Shared Information</i>
<b>Awareness</b>	<i>Accuracy of collective Awareness</i>	<i>Correctness of Collective Awareness</i>
	<i>Accuracy of Individual Awareness</i>	<i>Correctness of Individual Awareness</i>
	<i>Accuracy of Intersection Awareness</i>	<i>Correctness of Partial Awareness</i>
	<i>Accuracy of Partial Awareness</i>	<i>Currency of Collective Awareness</i>
	<i>Awareness about Environment</i>	<i>Currency of Individual Awareness</i>
	<i>Awareness about Forces</i>	<i>Precision of Individual Awareness</i>
	<i>Awareness about Intentions</i>	<i>Timeliness of Collective Awareness</i>
	<i>Awareness about Mission</i>	<i>Timeliness of Individual Awareness</i>
	<i>Completeness of Individual Awareness</i>	<i>Uncertainty of Collective Awareness</i>
<i>Consistency of Individual Awareness</i>		
<b>Understanding</b>	<i>Accuracy of Collective Understanding</i>	<i>Correctness of Collective Understanding</i>
	<i>Accuracy of Individual Understanding</i>	<i>Correctness of Individual Understanding</i>
	<i>Accuracy of Intersection Understanding</i>	<i>Correctness of Partial Understanding</i>
	<i>Accuracy of Partial Understanding</i>	<i>Currency of Collective Understanding</i>
	<i>Completeness of Collective Understanding</i>	<i>Currency of Individual Understanding</i>
	<i>Completeness of Individual Understanding</i>	<i>Extent of collective Understanding</i>
	<i>Completeness of Intersection Understanding</i>	<i>Extent of Partial Understanding</i>
	<i>Completeness of Partial Understanding</i>	<i>Shared Understanding</i>
	<i>Consistency of Individual Understanding</i>	<i>Timeliness of Collective Understanding</i>
	<i>Consistency of Intersection Understanding</i>	<i>Timeliness of Individual Understanding</i>
<i>Consistency of Partial Understanding</i>	<i>Uncertainty of Collective Understanding</i>	
<b>Decision or Action</b>	<i>Adaptiveness</i>	<i>Responsiveness</i>
	<i>Analyze</i>	<i>Risk Propensity</i>
	<i>Collaboration about Environment</i>	<i>Robustness</i>
	<i>Collaboration about Forces</i>	<i>Speed of Command</i>
	<i>Collaboration about Intentions</i>	<i>Speed of Decision</i>
	<i>Collaboration about Mission</i>	<i>Speed of Planning</i>
	<i>Command Approach</i>	<i>Synchronization of Decisions</i>
	<i>Distribution of Information</i>	<i>Synchronization of Actions</i>
	<i>Dynamics across Time</i>	<i>Task Competency</i>
	<i>Experience of Personnel</i>	<i>Task Speed</i>
	<i>Flexibility</i>	<i>Timeliness of Individual Decisions</i>
	<i>History</i>	<i>Training</i>
	<i>Innovation</i>	<i>Trust in Information</i>
	<i>Level of Confidence</i>	<i>Understanding about Environment</i>
	<i>Perception of Cause and Effect</i>	<i>Understanding about Forces</i>
	<i>Quality of Decisions</i>	<i>Understanding about Intentions</i>
	<i>Quality of Plan</i>	<i>Understanding about Mission</i>

**Table A-4: “Track” Event**

<b>Cognitive Pyramid</b>	<b>Conceptual Model Variable</b>	
<b>Environment</b>	<i>Atmospheric Weather</i>	<i>Sensor Coverage (Spacial)</i>
	<i>Direct Sensing</i>	<i>Sensor Coverage (Spectrum)</i>
	<i>Indirect Sensing</i>	<i>Sensor Persistence</i>
	<i>Political Situation</i>	<i>Social Situation</i>
	<i>Sensor Coverage (Medium)</i>	<i>Space Weather</i>
<b>Information</b>	<i>Completeness of Information</i>	<i>Information about Mission</i>
	<i>Completeness of Shared Information</i>	<i>Information Quality</i>
	<i>Consistency of Information</i>	<i>Information Uncertainty</i>
	<i>Consistency of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Correctness of Individual Information</i>	<i>Precision of Information</i>
	<i>Correctness of Shared Information</i>	<i>Precision of Shared Information</i>
	<i>Currency of Individual Information</i>	<i>Relevance of Shared Information</i>
	<i>Currency of Information</i>	<i>Share Information</i>
	<i>Currency of Shared Information</i>	<i>Timeliness of Shared Information</i>
	<i>Data Interoperability</i>	<i>Timeliness of Individual Information</i>
	<i>Distribution of Information</i>	<i>Timeliness of Information</i>
	<i>Extent of Shared Information</i>	<i>Trust in Information</i>
	<i>Information about Environment</i>	<i>Uncertainty of Shared Information</i>
	<i>Information about Forces</i>	
<b>Awareness</b>	<i>Accuracy of Collective Awareness</i>	<i>Awareness about Forces</i>
	<i>Accuracy of Intersection Awareness</i>	<i>Awareness about Intentions</i>
	<i>Awareness about Capabilities</i>	<i>Awareness about Mission</i>
	<i>Awareness about Environment</i>	
<b>Understanding</b>	<i>Quality of Understanding</i>	
<b>Decision or Action</b>	<i>Accuracy of Individual Decisions</i>	<i>Political Situation</i>
	<i>Appropriateness of Individual Decisions</i>	<i>Quality of Decisions</i>
	<i>Authentication</i>	<i>Quality of Plan</i>
	<i>C2 Doctrine</i>	<i>Resource Allocation</i>
	<i>Command Approach</i>	<i>Resource Prioritization</i>
	<i>Communication of Intent</i>	<i>Responsiveness</i>
	<i>Constraint Enforcement</i>	<i>Risk Propensity</i>
	<i>Constraint Setting</i>	<i>Robustness</i>
	<i>Control Approach</i>	<i>Role of Authority</i>
	<i>Criticality</i>	<i>Skill</i>
	<i>Decision Participants</i>	<i>Task Speed</i>
	<i>Degree of Decision Concurrence</i>	<i>Social Situation</i>
	<i>Dynamics across time</i>	<i>Speed of Command</i>
	<i>Experience of Personnel</i>	<i>Synchronization</i>
	<i>Flexibility</i>	<i>Synchronization of Actions</i>
	<i>Force Effectiveness</i>	<i>Task Competence</i>
	<i>Identification</i>	<i>Task Efficiency</i>
	<i>Indirect Sensing</i>	<i>Task Knowledge</i>
	<i>Individual Task Efficiency</i>	<i>Timeliness of Individual Decisions</i>
	<i>Lethal Effectors</i>	<i>Training</i>
<i>Likelihood of Success</i>	<i>Trust in Information</i>	
<i>Mission Effectiveness</i>	<i>Uncertainty of Individual Decisions</i>	
<i>Nature of Rules</i>	<i>Willingness</i>	
<i>Non-Lethal Effectors</i>		

**Table A-5: “Target” Event**

<b>Cognitive Pyramid</b>	<b>Conceptual Model Variable</b>	
<b>Environment</b>	<i>Atmospheric Weather</i>	<i>Network Reliability</i>
	<i>Communications Interoperability</i>	<i>Network Richness</i>
	<i>Complicated-ness</i>	<i>Political situation</i>
	<i>Data Interoperability</i>	<i>Quality of communications Equipment</i>
	<i>Electivity</i>	<i>Quality of Computing Equipment</i>
	<i>Network Availability</i>	<i>Social Situation</i>
	<i>Network Reach</i>	
<b>Information</b>	<i>Completeness of Individual Information</i>	<i>Information about Intentions</i>
	<i>Completeness of Shared Information</i>	<i>Information about Mission</i>
	<i>Correctness of Information</i>	<i>Information Quality</i>
	<i>Correctness of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Currency of Individual Information</i>	<i>Precision of Information</i>
	<i>Currency of Information</i>	<i>Relevance of shared Information</i>
	<i>Currency of Shared Information</i>	<i>Timeliness of Shared Information</i>
	<i>Distribution of Information</i>	<i>Timeliness of Information</i>
	<i>Extent of Shared Information</i>	<i>Trust in Information</i>
	<i>Information about Environment</i>	<i>Uncertainty of Shared Information</i>
<b>Awareness</b>	<i>Awareness about Capabilities</i>	<i>Completeness of Individual Awareness</i>
	<i>Awareness about Environment</i>	<i>Correctness of Collective Awareness</i>
	<i>Awareness about Forces</i>	<i>Currency of Collective Awareness</i>
	<i>Awareness about Intentions</i>	<i>Currency of Individual Awareness</i>
	<i>Awareness about Mission</i>	<i>Shared Awareness (intersection)</i>
<b>Understanding</b>	<i>Completeness of Collective Understanding</i>	<i>Quality of Understanding</i>
	<i>Correctness of Collective Understanding</i>	<i>Uncertainty of Individual Understanding</i>
	<i>Currency of Collective Understanding</i>	
<b>Decision or Action</b>	<i>Accuracy</i>	<i>Resource Prioritization</i>
	<i>Adaptiveness</i>	<i>Responsiveness</i>
	<i>Authentication</i>	<i>Role of Authority</i>
	<i>C2 Doctrine</i>	<i>Risk Propensity</i>
	<i>Clarity about role</i>	<i>Robustness</i>
	<i>Command Approach</i>	<i>Role of Emotion</i>
	<i>Command Arrangements</i>	<i>Selectivity</i>
	<i>Communication of Intent</i>	<i>Skill</i>
	<i>Constraint Enforcement</i>	<i>Sleep Deprivation</i>
	<i>Constraint Setting</i>	<i>Social Situation</i>
	<i>Control Approach</i>	<i>Speed of Command</i>
	<i>Criticality</i>	<i>Speed of Decision</i>
	<i>Dynamics across Time</i>	<i>State of Mental Health</i>
	<i>Experience of Personnel</i>	<i>State of Physical Health</i>
	<i>Extent of Shared Information</i>	<i>Stress Level</i>
	<i>Force Will</i>	<i>Synchronization</i>
	<i>Identification</i>	<i>Synchronization of Actions</i>
	<i>Leadership</i>	<i>Task Competence</i>
	<i>Lethal effectors</i>	<i>Task Efficiency</i>
	<i>Level of Confidence</i>	<i>Task Knowledge</i>
	<i>Likelihood of Success</i>	<i>Task Speed</i>
	<i>Mission Effectiveness</i>	<i>Team Culture</i>
	<i>Mobility</i>	<i>Team Decisions</i>
	<i>Nature of Rules</i>	<i>Training</i>
	<i>Non-Lethal Effectors</i>	<i>Trust in Information</i>
	<i>Perception of Cause and Effect</i>	<i>Trust in People</i>
	<i>Political situation</i>	<i>Willingness</i>
	<i>Resource Allocation</i>	

**Table A-6: “Engage” Event**

<b>Cognitive Pyramid</b>	<b>Conceptual Model Variable</b>	
<b>Environment</b>	<i>Collective Knowledge</i>	<i>Number of Mental Models</i>
	<i>Constraint Enforcement</i>	<i>Policy Effectiveness</i>
	<i>Constraint Setting</i>	<i>Political Situation</i>
	<i>Experience of Personnel</i>	<i>Social Situation</i>
	<i>History</i>	<i>Stress Level</i>
	<i>Identification</i>	<i>Team Culture</i>
	<i>Lethal Effectors</i>	<i>Team Sensemaking Behavior</i>
	<i>Non-Lethal Effectors</i>	<i>Uncertainty</i>
<b>Information</b>	<i>Accuracy of Shared Information</i>	<i>Information about Mission</i>
	<i>Completeness of Individual Information</i>	<i>Information Ambiguity</i>
	<i>Completeness of Shared Information</i>	<i>Information Complexity</i>
	<i>Correctness of Individual Information</i>	<i>Information Quality</i>
	<i>Correctness of Information</i>	<i>Information Uncertainty</i>
	<i>Correctness of Shared Information</i>	<i>Precision of Individual Information</i>
	<i>Currency of Information</i>	<i>Precision of Information</i>
	<i>Currency of Shared Information</i>	<i>Precision of Shared Information</i>
	<i>Extent of Shared Information</i>	<i>Relevance of Shared Information</i>
	<i>Fusion</i>	<i>Timeliness of Shared Information</i>
	<i>Information About Capabilities</i>	<i>Timeliness of Information</i>
	<i>Information about Environment</i>	<i>Trust in Information</i>
	<i>Information about Forces</i>	<i>Uncertainty of Shared Information</i>
	<i>Information about Intentions</i>	
<b>Awareness</b>	<i>Accuracy of Collective Awareness</i>	<i>Awareness about Mission</i>
	<i>Accuracy of Individual Awareness</i>	<i>Completeness of Individual Awareness</i>
	<i>Accuracy of Intersection Awareness</i>	<i>Correctness of Collective Awareness</i>
	<i>Accuracy of Partial Awareness</i>	<i>Correctness of Individual Awareness</i>
	<i>Awareness about Capabilities</i>	<i>Correctness of Intersection Awareness</i>
	<i>Awareness about Environment</i>	<i>Correctness of Partial Awareness</i>
	<i>Awareness about Forces</i>	<i>Precision of Collective Awareness</i>
<i>Awareness about Intentions</i>	<i>Precision of Individual Awareness</i>	
<b>Understanding</b>	<i>Accuracy of Collective Understanding</i>	<i>Extent of Collective Understanding</i>
	<i>Accuracy of Individual Understanding</i>	<i>Extent of Intersection Understanding</i>
	<i>Accuracy of Intersection Understanding</i>	<i>Extent of Partial Understanding</i>
	<i>Accuracy of Partial Understanding</i>	<i>Precision of Collective Understanding</i>
	<i>Completeness of Collective Understanding</i>	<i>Precision of Individual Understanding</i>
	<i>Completeness of Individual Understanding</i>	<i>Understanding about Capabilities</i>
	<i>Completeness of Partial Understanding</i>	<i>Understanding about Environment</i>
	<i>Correctness of Collective Understanding</i>	<i>Understanding about Forces</i>
	<i>Correctness of Individual Understanding</i>	<i>Understanding about Intentions</i>
	<i>Correctness of Intersection Understanding</i>	<i>Understanding about Mission</i>
<i>Correctness of Partial Understanding</i>		
<b>Decision or Action</b>	<i>Analyze</i>	<i>Mission Effectiveness</i>
	<i>Assessment</i>	<i>Non-Lethal Effectors</i>
	<i>Constraint Enforcement</i>	<i>Persistence</i>
	<i>Constraint Setting</i>	<i>Stress Level</i>
	<i>Discovery</i>	<i>Task Competence</i>
	<i>Identification</i>	<i>Task Efficiency</i>
	<i>Innovation</i>	<i>Task Knowledge</i>
	<i>Level of Confidence</i>	<i>Task Speed</i>
<i>Likelihood of Success</i>		

**Table A-7: “Assess” Event**

## **APPENDIX B**

Determining the value of the Conceptual Model Variables within the AF2T2EA “Kill-Chain” process. 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.

“Anticipate” Event		
High Value	Medium Value	Low Value
<b>Ability to model, predict and display possible effects, warn, and report CBRNE and TIM threats</b>		
Understanding about Intentions		Atmospheric Weather
Understanding about Environment		Space Weather
		Sensor Persistence
		Sensor Coverage (Spacial)
		Sensor Coverage (Medium)
		Sensor Coverage (Spectrum)
<b>Predict how actions (Red, Blue, Gray) will cascade into direct and indirect effects in support of effects-based operations</b>		
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
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
<b>Anticipate adversary’s action(s) in order to streamline and shorten Find, Fix, Track, Target, Engage, and Assess (F2T2EA) cycle</b>		
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
		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
<b>Ability to model and predict CBRNE and TIM threats and events</b>		
Understanding about Intentions		Atmospheric Weather
Understanding about Environment		Space Weather
		Sensor Persistence
		Sensor Coverage (Spacial)
		Sensor Coverage (Medium)
		Sensor Coverage (Spectrum)

**Table B-1: “Anticipate” Value**

<b>“Find” Event</b>		
<b>High Value</b>	<b>Medium Value</b>	<b>Low Value</b>
<b>Fully merge and integrate sensor information to support battlespace situational awareness</b>		
<i>Sensor Coverage (Spacial)</i>		<i>Atmospheric Weather</i>
<i>Sensor Coverage (Medium)</i>		<i>Collaboration about Environment</i>
<i>Sensor Coverage (Spectrum)</i>		<i>Command Approach</i>
<i>Sensor Persistence</i>		<i>Frequency of Command Interactions</i>
		<i>Frequency of Peer-to-Peer Interactions</i>
		<i>History</i>
		<i>Quality of Interactions</i>
		<i>Quality of Peer-to-Peer Interactions</i>
		<i>Space Weather</i>
<b>Rapidly and accurately updated situational understanding as a result of changes in situational awareness</b>		
Correctness of Information	Currency of Information	Accuracy
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
<b>Accurate and real-time situational awareness of the battlespace to enable decision makers to correctly react to dynamic changes</b>		
<i>Awareness about Environment</i>	<i>Accuracy of Individual Awareness</i>	<i>Accuracy of Individual Decisions</i>
<i>Awareness about Forces</i>	<i>Accuracy of Shared Information</i>	<i>Collaboration about Forces</i>
<i>Awareness about Intentions</i>	<i>Force Effectiveness</i>	<i>Collaboration about Intentions</i>
<i>Awareness about Mission</i>	<i>Responsiveness</i>	<i>Command Approach</i>
<i>Speed of Command</i>	<i>Synchronization of Actions</i>	<i>Completeness of Individual Decisions</i>
<i>Speed of Decision</i>		<i>Control Approach</i>
<i>Speed of Planning</i>		<i>Consistency of Individual Decisions</i>
<i>Task Speed</i>		<i>Correctness of Individual Decisions</i>
		<i>Currency of Individual Decisions</i>
		<i>Experience of Personnel</i>
		<i>Mode of Decision Making of Individual Decisions</i>
		<i>Precision of Individual Decisions</i>
		<i>Quality of Decisions</i>
		<i>Relevance of Individual Decisions</i>
		<i>Timeliness of Planning</i>
		<i>Timeliness of Individual Decisions</i>
		<i>Uncertainty of Individual Decisions</i>

**Table B-2: “Find” Value**



"Track" Event		
High Value	Medium Value	Low Value
<b>Integration and display of operations information in a common operational picture available to entire network</b>		
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
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
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
		Uncertainty of Shared Information
<b>Improve, automate, and streamline monitoring of friendly air and space force location</b>		
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 (Spacial)	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
		Timeliness of Individual Decisions
		Training

**Table B-4: "Track" Value**

“Target” Event		
High Value	Medium Value	Low Value
<b>Improve Commander’s COA selection and dissemination process</b>		
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
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
		Task Efficiency
		Task Knowledge
		Timeliness of Individual Decisions
		Timeliness of Individual Information
		Timeliness of Information
		Timeliness of Shared Information
		Training
		Uncertainty of Individual Decisions

**Table B-5: “Target” 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
		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
Awareness about Mission		Shared Awareness (intersection)
<b>Capability to achieve self-synchronization of forces</b>		
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
		Social Situation
		State of Mental Health
		State of Physical Health
		Stress Level
		Uncertainty of Individual Understanding
		Willingness

**Table B-6: "Engage" Value**

"Assess" Event		
High Value	Medium Value	Low Value
<b>Real-time Red, Blue Gray force status assessment</b>		
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
	Uncertainty	Team Culture
		Team Sensemaking Behavior
<b>Ability to accurately assess air and space operational impacts of physical environmental conditions</b>		
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
<b>Improve COA evaluation and requirements process</b>		
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		
<b>Rapid assessment and selection of targets to maximize desired effects</b>		
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

**Table B-7: "Assess" Value**

## APPENDIX C

Table C-1 lists the top five values of the C2 Conceptual Model Variables within each of the seven “events” contained within the AF2T2EA “Kill-Chain” process.

AF2T2EA Event	Top Five Conceptual Model Variables
Anticipate	1) <i>Understanding</i> about Environment , Intentions
	2) <i>Uncertainty</i>
	3) <i>Information</i> about Forces, Environment, Intentions, Uncertainty
	4) <i>Awareness</i> about Forces, Environment, Intentions, Mission)
	5) <i>Correctness</i> of Information, Individual Information, Shared Information
Find	1) <i>Sensor Persistence, Coverage</i>
	2) <i>Correctness</i> of Information, Individual Information, Shared Information
	3) <i>Timeliness</i> of Information, Individual Information, Shared Information
	4) <i>Awareness</i> about Forces, Environment, Intentions, Mission
	5) <i>Speed</i> of Command, Decisions, Planning, Task
Fix	1) <i>Correctness</i> of Information, Shared Information
	2) <i>Precision</i> of Information, Individual Information, Shared Information
	3) <i>Timeliness</i> of Information, Individual Information, Shared Information
	4) <i>Accuracy</i> of Individual Awareness, Individual Understanding, Collective Understanding
	5) <i>Level</i> of Confidence
Track	1) <i>Correctness</i> of Individual information, Shared Information, Individual Awareness Collective Awareness, Partial Awareness, Individual Understanding, Partial Understanding, Collective Understanding
	2) <i>Accuracy</i> of Shared Information, Individual Awareness, Collective Awareness, Partial Awareness, Intersection Awareness, Individual Understanding, Partial Understanding, Collective Understanding, Intersection Understanding
	3) <i>Understanding</i> about Forces, Environment, Mission, Intentions
	4) <i>Sensor Persistence, Coverage</i>
	5) <i>Timeliness</i> of Information, Individual Information, Shared Information, Individual Awareness, Collective Awareness, Individual Understanding, Collective Understanding
Target	1) <i>Accuracy</i> of Collective Awareness, Intersection Awareness
	2) <i>Currency</i> of Information, Individual Information, Shared Information
	3) <i>Effectors: Lethal, Non-lethal</i>
	4) <i>Situation: Political, Social</i>
	5) <i>Awareness</i> about Forces, Environment, Intentions, Mission
Engage	1) <i>Awareness</i> about Capabilities, Forces, Environment, Intentions, Mission
	2) <i>Speed</i> of: Command, Decision
	3) <i>Task: Competence, Efficiency, Knowledge, Speed</i>
	4) <i>Mission Effectiveness</i>
	5) <i>Effectors: Lethal, Non-lethal</i>
Assess	1) <i>Understanding</i> about Capabilities, Forces, Environment, Mission, Intentions
	2) <i>Awareness</i> about Capabilities, Forces, Environment, Intentions, Mission
	3) <i>Correctness</i> of Information, Individual Information, Shared Information, Individual Awareness, Collective Awareness, Partial Awareness, Intersection Awareness, Individual Understanding, Collective Understanding, Partial Understanding, Intersection Understanding
	4) <i>Task: Competence, Efficiency, Knowledge, Speed</i>
	5) <i>Mission Effectiveness</i>

**Table C-1: Top Five Variables of the AF2T2EA Process**