

# **KA/KE HYBRID DOCUMENT - VERSATILITY FOR V & V AND SOFTWARE DEVELOPMENT**

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## **ABSTRACT**

Behavior modeling for Computer Generated Forces (CGF) requires knowledge acquisition and knowledge engineering. Traditionally, behavior modeling has been viewed as two distinct processes, a knowledge acquisition process being performed solely by military subject matter experts and a knowledge engineering process performed solely by software engineers. A need to combine these separated actions into a collective process has existed for many years and should be formally instituted in the interest of program efficiency. This paper presents a knowledge acquisition/knowledge engineering hybrid document designed to combine the doctrinally correct textual descriptions of military tactics, techniques and procedures written by subject matter experts and the engineering of this information into a software format called logic developed by a software engineer. To provide a perspective, this paper compares the knowledge acquisition document and software development process utilized by Close Combat Tactical Trainer (CCTT) with the knowledge acquisition/knowledge engineering hybrid document and software development process designed for use by the Army's next generation training simulation, OneSAF Objective System (OOS). The enabling construct for analysis of the two knowledge acquisition documents will be a study of like behaviors modeled in each training simulation. CCTT CIS ID# B1401, Engage Targets, Attack Helicopter Company is compared to OOS BKAD # 1BL0104BE0002B0, CO\_ATK\_HELO\_ENGAGE\_TARGETS. The knowledge acquisition/knowledge engineering document developed for OneSAF Objective System has applicability for any training simulation software development process. This document would serve equally well as a standardized re-use document for Department of Defense simulations.

## **ABOUT THE AUTHORS**

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## INTRODUCTION

Traditional behavior modeling has involved the gathering of expert information called knowledge acquisition followed by the analysis and data formatting of this information called knowledge engineering (Chorafas, 1990). These activities have been viewed as two separate and distinct steps in the software development process of military computer simulations with Knowledge Acquisition (KA) performed by military subject matter experts (SME) and Knowledge Engineering (KE) performed by software engineers (SWE).

Subject matter experts have experienced difficulties explaining to software engineers how "real world" behaviors should look using textual descriptions while software engineers have equally struggled with explaining data formatting requirements to subject matter experts. Knowledge acquisition efforts have been typically plagued with poor formatting of knowledge, including irrelevant or missed information. Additionally, knowledge acquisition descriptions have varied between authors due to individual writing styles and lack of controlling documents to ensure standardization (Tuttle, Lacy, Levine, O'Brien, Sheehan, 1999). The translation of textual data into code has consistently proven to be a labor intensive, time consuming and expensive part of simulation development.

The OneSAF Objective System (OOS) Behavior Knowledge Acquisition Document (BKAD) was developed to bridge this gap between knowledge acquisition and engineering using a revised data capture format designed to meet programmatic requirements. The BKAD is a product improvement over previous knowledge acquisition documents and remains under continuous review through the collaborative efforts of the OneSAF Knowledge Acquisition (KA) and Modeling Infrastructure (MI) Teams.

The BKAD format must be able to achieve three document requirements including knowledge acquisition/engineering capture, validation of data by U.S. Army service school experts and ease of use by software developers. Initial indications from experienced behavior modelers support the document's design with product improvement to continue throughout the program.

## OneSAF OBJECTIVE SYSTEM PROGRAM REQUIREMENTS

OneSAF Objective System will become the U.S. Army's primary training simulation for brigade-sized units and below. Program requirements for OneSAF Objective System include development of automated (no human-in-the-loop) behaviors for individual combatants through battalion-sized units and compliance with the operational requirements of three U.S. Army domains. The domains are Training Exercises and Military Operations (TEMO), Advanced Concepts and Requirements (ACR) and Research, Development and Acquisition (RDA).

Previous military simulations were not required to fulfill such a comprehensive modeling and simulation role. For example, Close Combat Tactical Trainer (CCTT) is an excellent training simulation for tactical units, but does not provide the analysis capability required of the research and development and advanced concepts domains. CCTT Semi Automated Forces behaviors are based on an accurate portrayal of military doctrine, but do not allow for automated, cognitive response by computer-generated entities (Pew and Mavor, 1998). Conversely, Modular Semi Automated Forces (ModSAF) is better suited to the study of advanced concepts and research and development based on the simulation's modular design. Platforms and attributes can be added or removed with minimal effort (Tolley et al., 1996).

OneSAF Objective System will use a sophisticated repository named Functional Description of the Mission Space (FDMS). The FDMS serves to collect and store formatted knowledge acquisition and engineering data for later export in Extensible Markup Language (XML) as the final OOS behavior format. FDMS data parsing and storage for behavior validation and code verification requires knowledge acquisition and engineering to be configured in an acceptable format (DaCosta, 2002).

These challenging program expectations and supporting technological advancements require a responsive approach to acquiring and engineering knowledge. Knowledge Acquisition Team members have had as their goal the development of an improved document, formatted and populated to meet the requirements of this advanced training simulation. OneSAF Objective System's evolving Behavior Knowledge Acquisition Document, Behavior Development Process and Validation and Verification Plan have been designed to meet all program requirements.

### **KNOWLEDGE ACQUISITION AND ENGINEERING**

Knowledge acquisition documents must satisfy the needs of subject matter experts, software engineers and validation officials. To achieve these three requirements, knowledge acquisition documents will likely provide information considered unnecessary by one or more of the users.

OneSAF Objective System's Behavior Knowledge Acquisition Document evolved over a four-month period through the collaborative efforts of knowledge acquisition subject matter experts, architecture and integration software engineers, modeling and simulation domain representatives and U.S. Army STRICOM integrators.

The main purpose of the BKAD is to achieve a better match of requirements earlier in the behavior development process. BKAD design strives to identify the specific information needed by modelers. Typically, modelers don't know what is needed from the domain to achieve behavior accuracy and subject matter experts don't know the modeler's needs for specific data.

The OOS Modeling Infrastructure Team has stated the ideal knowledge acquisition document should have "just enough" information, meaning only the information necessary for clear understanding of the behavior to be modeled. An ideal knowledge acquisition document would minimize or eliminate any inference of the military domain by a behavior modeler.

The OOS Behavior Knowledge Acquisition Document specifically formats knowledge capture for ease of engineering. Previous simulations provided knowledge acquisition in the form of textual descriptions requiring software engineers to expend many hours analyzing and engineering information into matrices for coding.

A legacy simulation knowledge acquisition document with similarities to OneSAF Objective System's BKAD is the Close Combat Tactical Trainer (CCTT) Combat Instruction Set (CIS). Combat Instruction Set sections include: Identifying and Administrative Data, Doctrinal Framework for CIS, Actions To Be Taken, Changes in CIS Actions and Battlefield Operating Systems (BOS) Coordination (Tolley, et al., 1996; Ourston et al., 1995). The OneSAF Objective System Behavior Knowledge Acquisition Document provides like information in a different format. Behavior Knowledge Acquisition Document sections include: Administrative Data, Overview, Actors, Input Table, Execution, Situational Interrupts, Exit Criteria and Appendices. (Figure 1 shows a graphical depiction of the full range of data elements composing each document.)

The BKAD section of prime importance to behavior development is Paragraph 4, Execution. The Execution paragraph contains a step-by-step index of actions to be modeled for a behavior followed by a brief textual description of the actions in each step. These concise descriptions specify what is to be modeled in code.

BKAD Paragraph 4 (Execution) and CIS Section C (Actions To Be Taken) are provided for comparison of format. Section C of the CIS is conceptually similar to Paragraph 4 of the BKAD; however, the BKAD provides required modeling information in a sequenced flow. (Fig. 2, BKAD Para 4 and Fig. 3, CIS Section C.)

CCTT CIS	OOS BKAD
<b>Section A. Identifying and Administrative Data</b>	<b>Administrative Data</b>
<b>Section B. Doctrinal Framework for CIS</b> 1. References 2. ARTEP Task and # 3. General Description of Task: 4. ARTEP Subtasks and Standards 5. Initial Conditions 6. Input Data 7. Notes	<b>1. Overview.</b> An abstract of the behavior to provide the software developer with an overall concept of the behavior.
<b>Section C. Actions To Be Taken</b> (Textual description of the tactics, techniques and procedures to be modeled in accordance with doctrinal sources) <ul style="list-style-type: none"> <li>- MOVE</li> <li>- SHOOT</li> <li>- SEARCH/OBSERVE</li> <li>- COMMUNICATE</li> </ul>	<b>2. Actors.</b> A list of specific subordinate actors/roles that may perform these tasks or subtasks. <ul style="list-style-type: none"> <li>- ECHELON (Company, etc.)</li> <li>- ACTORS (Platoons by type)</li> </ul>
<b>Section D. Changes In CIS Status</b> 1. Situational Interrupts 2. Terminating Conditions	<b>3. Input Table.</b> Inputs received from an entity's higher headquarters or a role player.
<b>Section E. Battlefield Operating Systems (BOS) Coordination</b> -Maneuver -Fire Support -Air Defense -Command and Control -Intelligent -Mobility/Counter mobility/Survivability -Combat Service Support	<b>4. Execution.</b> -Execution Step Table (Expected sequence of steps to complete the behavior, to include planning and selection of optional parameters. -Execution Text (Description of actions to be performed)
Section with <b>graphical images</b> of the behavior to assist the modeler with conceptualizing the military action.	<b>5. Situational Interrupts.</b> Unexpected events that cause a temporary or permanent termination of the task.
	<b>6. Exit Criteria.</b> Events or conditions that cause this behavior to end successfully or unsuccessfully.
	<b>7. Appendices.</b> Revision History, References/Sources, Terminology/Acronyms, Figures

Figure 1. CIS Sections and BKAD Paragraphs

Sequential steps of the BKAD Execution paragraph establish actions to be modeled for the actors identified in BKAD Paragraph 2, Actors. In the example BKAD, Attack Helicopter Company - Engage Targets, the actors are the Scout Platoon and Attack Platoon, subordinate military echelons of the Attack Helicopter Company.

The major difference between the two knowledge acquisition documents is the

formatting of information. BKAD design specifically configures data in a matrix approach for ease of analysis and engineering by software developers. The modularity attempts to provide the correct information in only the amount needed for modeling the behavior. (BKAD modularity is shown for Paragraph 2 (Actors), Paragraph 3 (Input Table) and Paragraph 5 (Situational Interrupts) at Figures 4, 5 and 6.)

**4. Execution.**

**Execution Step Table (Expected sequence of steps to complete the behavior, to include Planning and selection of optional parameters).**

Step #	Task Name	Actor	Cross-reference to other OneSAF BKADs
4.1.	<b>Scout and Attack Platoon</b>	Company	
4.2.	<b>Scout Platoon Actions</b>	Scout Platoon	
4.2a.	Scout Platoon Recon of BP and Observation of Engagement Area		
4.2b.	Occupation of BP by Attack Platoon		
4.2c.	Target ID by Scout Platoon with Target Engagement by Attack Platoon		
4.3.	<b>Attack Platoon Actions</b>	Attack Platoon	
4.3a.	Move into Battle Position		
4.3b.	Occupy Firing Positions		
4.3c.	Target Engagement		
4.4.	<b>Scout and Attack Platoon</b>	Company	

**Execution Text (Description of actions to be performed).**

**4.1. Scout and Attack Platoon.** Company Commander directs Scout Platoon to move into BP and report status. Scout Platoon Leader reports to Company Commander clear to move Attack Platoon into BP. Scout Platoon relocates to security positions and Attack Platoon moves into firing positions.

**4.2. Scout Platoon Actions.**

**4.2a. Recon of Battle Position.** Scout Platoon moves to BP confirming primary, alternate and supplementary firing positions.

**4.2b. Target Handover.** Scout Platoon observes Engagement Area, identifies targets and hands over targets to Attack Platoon.

**4.2c. Flank and Rear Security.** Scout Platoon relocates to observe and cover enemy avenues of approach into the area.

**4.3. Attack Platoon Actions.**

**4.3a. Move into Battle Position.** Attack Platoon aircraft move into battle position as Scout Platoon aircraft relocate.

**4.3b. Occupy Firing Positions.** Attack Platoon aircraft begin occupying firing positions to the right of the Company Commander in chalk order.

**4.3c. Target Engagement.** Attack Platoon receives handover target data from Scout Platoon and commences engagement of targets.

**4.4. Scout and Attack Platoon.** Company Commander directs ATKHC to move from BP following destruction of targets, handoff to another ATKHC or when low ammunition and fuel conditions require relocation to FARP.

Figure 2. BKAD Paragraph 4 (Execution)

**SOFTWARE DEVELOPMENT**

The OneSAF Objective System BKAD and CCTT CIS are each critical components of the software development processes for their respective training simulation programs. These two knowledge acquisition documents begin the process and are integral to the modeling effort. Each document plays a major role during the first two phases of their respective program's software development process.

OneSAF Objective System's BKAD formatting has aided the OneSAF KE process named Behavior Knowledge Engineering Conceptual Model (BKECM). The BKECM process decomposes the BKADs into a collection of Knowledge Engineering Documents (KED). Several KEDs are under development including a Master Behavior Matrix and Behavior Analysis Worksheet. Primitive behaviors and simple (non complex) behaviors are identified for commonality between BKADs while composite

**SECTION C. ACTIONS TO BE TAKEN**

**1. SEQUENCE OF ACTIONS:**

1. Scouts Hand Over the Targets:

a. Identify targets (I)

SEARCH/OBSERVE: Scout helicopters see the battlefield, find the enemy, coordinate its destruction, and provide security against ground and air threats. Scout helicopters identify and locate enemy targets and positions. Scouts reconnoiter firing positions to permit attack helicopters to fire from multiple positions into enemy flanks and rear areas. (FM 1-112, p. 3-8; FM 1-116, pp. E-2, F-1)

b. Hand over targets and release engagement authority to attack helicopter. (I)

2. Attack Platoons Engage Targets Using:

a. Engagement priority (V)

SHOOT: Engagement priority concerns the actions of the individual aircrew during the firing engagement. It encompasses immediate actions required for self-preservation and mission accomplishment. A general rule is for the aircrew to engage nearest target that first poses a threat. Engagement priorities in sequence are (default): immediate threat to self, immediate threat to platoon or company, immediate threat to other friendly forces, and preestablished target priorities. (FM 1-112, p. 3-18; *CPT Hennessy, USAAVNS*)

b. Target priority (V)

SHOOT: Target priorities are mission-dependent and refer to the types of targets that should receive first priority for destruction. Priority lists are designated in the OPORD or in the unit SOP. Target priority default condition is air defense artillery, command vehicles, tanks, engineer vehicles, and mechanized troop carriers. (FM 1-112, pp. 3-18, 3-19; *CPT Hennessy, USAAVNS*)

c. Maximum standoff range (depends on METT-T) and optimal direction of attack (V)

Figure 3. CIS Section C (Actions To Be Taken) [Excerpt]

**2. Actors (A list of specific subordinate actors/elements that may perform these tasks or subtasks).**

Echelon	Possible Organization, Configuration, or Composition	Required Starting Conditions:	Document Cross-Reference
Company	Company Commander, Platoon Leaders, and two Platoons: one (1) Aero Scout Platoon and one (1) Attack Platoon.	ORDER: Attack Helicopter Company occupy battle position; Destroy all targets within EA.  OPFOR formation moves into engagement area.	OneSAF UKAD: TBP (Attack Helicopter Company – Heavy Div, Light Div, Air Assault Div, Airborne Div) OneSAF EKAD: TBP
Actors	Possible Organization, Configuration, or Composition	Required Starting Conditions:	Document Cross-Reference
Scout Platoon	Lead/Wingman Team of two AH-64s w/Scout Platoon Leader in Lead A/C	All aircraft target identification equipment, communications and weapons systems are operational.	OneSAF UKAD: TBP OneSAF EKAD: TBP
Attack Platoon	(2) Lead/Wingman Teams of two AH64s w/Company Commander and Attack Platoon Leader as Lead for each team	All aircraft target identification equipment, communications and weapons systems are operational.	OneSAF UKAD: TBP OneSAF EKAD: TBP

Figure 4. BKAD Paragraph 2 (Actors)

**3. Input Table (Inputs received from an entity's higher headquarters, or a role player).**

Name	Value (Defines possible values of the input)	Required/Optional (Content from parent HQ's. Required has to be provided, Optional may be provided)	Description
Techniques of Fire Distribution and Control	Sectors of Fire	Required	Terrain specific or directionally prescribed sectors within a target area for the distribution of fires by attack aircraft.
	Target Reference Point (TRP)	Optional	A designated point used to centralize the firing effort or serve as a reference for distributing or converging fires on single or multiple targets.
	Quadrants	Optional	Division of an engagement area into quadrants for directing and shifting fires as enemy formations change.
	Fire Patterns	Optional	An enemy-oriented method for distributing fires based on the enemy's formations or location (near, far, right, left).
	Target Array	Optional	Focusing fires on specific portions of an enemy formation at the direction of the commander based on observation.
	Target Priority	Required	Target priorities are mission-dependent and refer to the types of targets to be engaged based on a priority list established in an operations order or unit SOP. Default: targets in priority for destruction are air defense artillery, command vehicles, tanks, engineer vehicles and mechanized infantry carriers.
Types of Engagements	Autonomous	Required	Target identification and engagement by a single aircraft.
	Remote	Optional	A target engagement involving remote identification (LRF/D) by one source and engagement (coded missile) from an attack helicopter.

Figure 5. BKAD Paragraph 3 (Input Table) [Excerpt]

**5. Situational Interrupts (Unexpected events that cause a temp or perm termination of the task).**

Action	Reaction	TERMINATION OF TASK	REFERENCE DOCUMENT
Receive Enemy Ground Fire	React to Ground Fire	No, RWA executes air drill and/or returns fire and continues mission.	B-KAD React to Direct Fire/Ground Fire (Aviation), # TBP (Platform #22)
Sustain Casualty	React to casualty care and evacuation	Yes, RWA with casualty returns to base.	B-KAD Return to Base, # TBP
Enemy Air Attack	React to Enemy Air Attack	Yes, if enemy jet aircraft are engaging. No, if enemy RWA and BLUFOR are capable of air-to-air engagements.	B-KAD React to Enemy Air Attack (Aviation) # TBP

Figure 6. BKAD Paragraph 5 (Situational Interrupts) [Excerpt]

(complex) behaviors are analyzed and formatted into more detailed engineering matrices.

The BKECM data engineering process continues to evolve and is being considered for transformation into a KE tool. Benefits of KE tools include their relative assurance of higher

degrees of standardization and improved efficiency of effort over human engineering techniques.

OneSAF Objective System uses a five-phase approach to modeling. The phases are: Domain Analysis, Domain Engineering, Behavior

Design, Behavior Implementation and Behavior Testing. BKADs are used in the first two phases of the behavior development process by describing the domain to be modeled in the Domain Analysis Phase and as the product for defining algorithms and data structures in the Domain Engineering Phase. The BKECM follows and transitions the process into the third

phase, Behavior Design. As discussed earlier, several types of Knowledge Engineering Documents are created during the BKECM analysis for the purpose of organizing and decomposing behaviors. (Figure 7 depicts the OneSAF Objective System Behavior Development Process.)

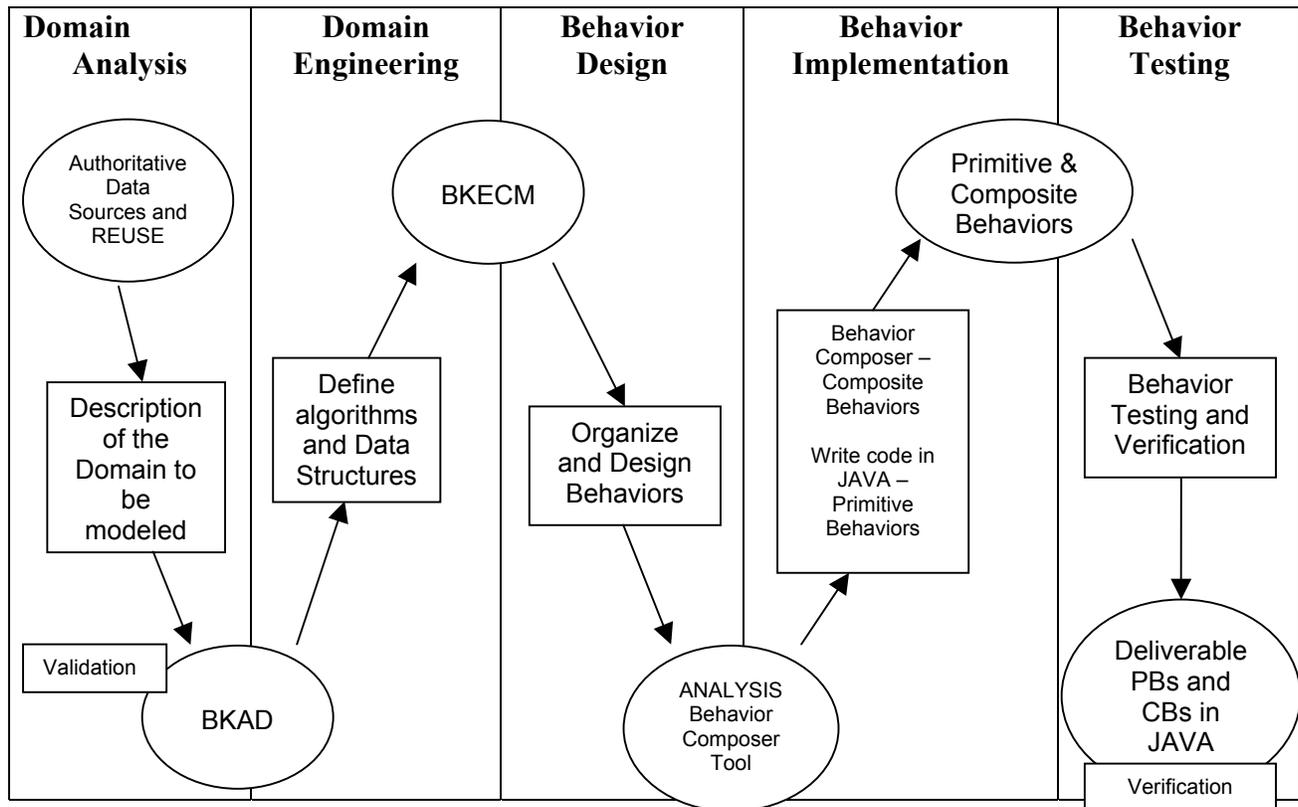


Figure 7. OOS Behavior Development Process

The behavior development process for OneSAF Objective System and CCTT are similar in design. CCTT has a five-phase approach to modeling behaviors. The phases are: CIS Development, CIS Software Analysis, Preliminary Design, Detailed Design and Code and Development Test. (Figure 8 provides a graphical depiction of the Close Combat Tactical Trainer CIS Software Development Process.)

Development Process. A knowledge engineering tool called Statemate CASE Tool was used to generate these five products for CCTT (Ourston et al, 1995). The products are: CIS to Activity Cross Reference, Common Activity Table, State Diagrams, Activity Charts and Data Dictionary. (Figure 9 depicts CIS Analysis and Implementation.)

During the 2<sup>nd</sup> phase of the CIS Software Development Process called CIS Software Analysis, CIS textual descriptions are translated into five software requirements documents. These software requirements (boxed in area, Fig. 9) are comparative to the BKECM knowledge engineering documents of the OneSAF Objective System Behavior

### VALIDATION AND VERIFICATION

Validation and verification procedures for the behaviors to be used in OneSAF Objective System are pending revision at the writing of this paper. At present, the procedures for validation include a doctrinal review and approval process accomplished by U.S. Army Training and Doctrine Command SMARTeam representatives

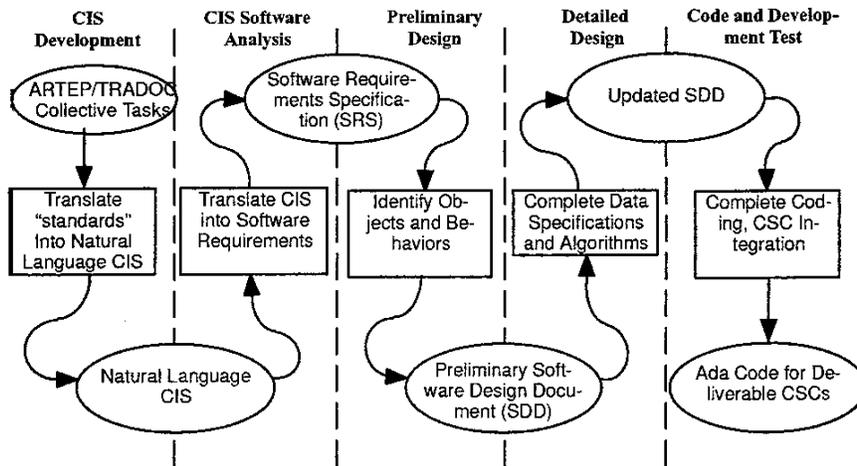


Figure 8. CIS Software Development Process

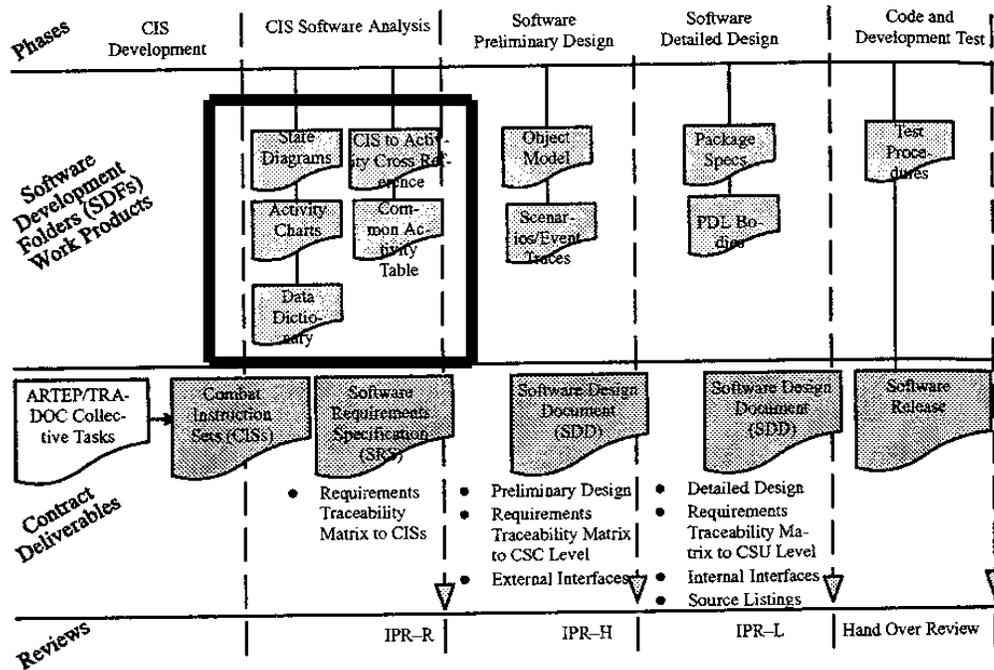


Figure 9. CIS Analysis and Implementation

located at U.S. Army branch schools (Hoffman, 2002). Approval is dependent upon an accurate, doctrinal portrayal of military tactics, techniques and procedures relating to the behavior and referenced by the most up to date authorized data sources. SMARTeam representatives must approve BKADs before continuing with the knowledge engineering process. BKADs are to be stored on the Functional Description of Mission Space for access, review and modification purposes by

SMARTeam representatives. Corrections are to be made to the matrices or textual descriptions of the document "on-line" with the name and date of the SMARTeam representative posted in the Revision Appendix of the BKAD (DaCosta, 2002).

Verification of the Java-coded behaviors is to be initially completed by the military subject matter expert responsible for writing the behavior document. Final verification of each behavior

involves joint observation, review and concurrence of the behavior's representation by military subject matter experts and TRADOC SMARTeam representatives during regularly scheduled 'on site' visits to the Integrated Development Environment (IDE) building in Orlando, FL.

CCTT's validation and verification procedures were highly defined with step-by-step reviews, database updates and doctrinal trace-ability requirements. CISs were consolidated in groups as completed and routed through the TRADOC System Manager (TSM) for review prior to release to the branch school experts for validation. Following approval, the Combat Instruction Sets were rerouted through the TSM for review and then returned to the military subject matter experts for modification and further processing. All documents were maintained on a database permitting review at any time by the TSM, subject matter experts or branch school representatives. No behavior code was entered into the CCTT baseline prior to validation of the CIS (McEnany et al., 1994).

#### **ANALYSIS OF BKAD AND CIS FOR KA/KE**

Four experienced modeling and simulation developers evaluated the BKAD for versatility in satisfying validation and verification requirements and improving knowledge engineering efforts. One respondent had modeled behaviors during the mid 1990s for the Combined Arms and Support Task Force Evaluation Model (CASTFOREM), a no "human-in-the-loop" simulation used by the Advanced Concepts and Requirements (ACR) domain. He is currently the ACR domain representative to the OneSAF Objective System and responsible for the V & V Plan. Two respondents had served several years as knowledge engineers for the Warfighter's Simulation (WARSIM) 2000 program. Both of these former WARSIM respondents are currently serving as knowledge engineers for the Modeling Infrastructure Team of OneSAF Objective System. Another respondent had been the Chief Scientist for Design (Software Architect) of the CCTT program from the mid to late 1990s. He is currently the Software Architect and Architectural Modeler for OneSAF Objective System.

A questionnaire was developed and distributed to these experts with the following three

questions: (1) Do you think the OOS BKAD will be able to satisfy the requirements of SMEs, SWEs and the Validation and Verification Plan? (2) Do you notice any product improvements between the CIS and BKAD that would aid the KE effort? If so, what specifically? (3) What improvements would you recommend to the present document?

In response to question #1, the former WARSIM respondents stated the BKAD would be able to satisfy the requirements of SMEs, SWEs, and the validation and verification plan. The respondent with CASTFOREM modeling experience did not believe the BKAD would be sufficient for streamlining knowledge engineering efforts due to writing differences between knowledge acquisition subject matter experts. The former CCTT Software Architect thought the BKAD would have to be expanded to meet validation and verification requirements based on his experience.

Question #2, product improvements between CIS and BKAD, resulted in all respondents supporting BKAD modularity as an aid to KE efforts. The CASTFOREM experienced modeler stated the matrix formatting would reduce interpretation and inference so common in the early stages of knowledge engineering. All respondents indicated a significant improvement with the execution paragraph of the BKAD over the CIS due to the logical, step-by-step progression of the Execution Matrix and concise textual description of each step in the Execution Text. All respondents thought time would be saved over the CIS by providing modelers with little or no military experience doctrinally correct behavior sequencing.

Responses to question #3 recommended use of the Execution paragraph (Execution Step Table and Execution Text) as the centerpiece of the BKAD. Generally, the respondents concurred all other paragraphs should serve to support the execution data through more detailed representation of the processes in each step. This would allow for faster decomposition of behaviors into primitives and simple behaviors critical to the success of knowledge engineering. CCTT's Software Architect recommended including actor echelons in the Execution Step Table and the inclusion of leader titles (e.g. Company Commander directs Scout Platoon...) as a part of the steps, when applicable. He also recommended the use of MOVE, SHOOT,

SEARCH/OBSERVE and COMMUNICATE elements for the BKAD as were used in the CIS.

### **FUTURE DIRECTIONS – SPRING 2002**

At the submission deadline for this paper, the OneSAF KA/KE Team had developed a more refined data engineering process for the writing of documents. The latest iteration is a series of documents for each military task to be modeled in OneSAF. An overarching document named Task Description Document (TDD) gives a general military description of the task, a subtask step-by-step index and a flow diagram of sequenced actions comprising the military task. Each subtask is analyzed and knowledge engineered through a comprehensive decomposition process. These knowledge-engineered, subtask documents are named Process Step Documents (PSD) and have been designed for speedy modeling of primitive and composite behaviors by software engineers.

This latest KA/KE initiative requires each military subject matter expert (SME) to attend instructional classes on the principles of logic writing. The Process Step Documents are based on production rule analytical concepts using textual explanations, tables and diagrams.

The progression from CCTT CIS to OneSAF BKAD to OneSAF PSD is an evolution reflecting higher degrees of knowledge-engineered data for use by SWEs. It is believed this heightened level of data engineering will reduce inference by modelers, improve modeling efficiency and ultimately save program development time.

### **SUMMARY/CONCLUSIONS**

The Behavior Knowledge Acquisition Document (BKAD) was developed through the collaborative efforts of military subject matter experts, software engineers, modeling and simulation domain representatives and U.S. Army STRICOM integrators. The BKAD was specifically designed as a product improvement over previous knowledge acquisition documents for the purpose of reducing KE man-hours.

Validation and Verification requirements must also be achieved with the BKAD. The document must provide for validation of doctrinal accuracy by branch school experts including trace-ability to authorized data sources. Java-coded behaviors must be verified by observing entities

on the synthetic battlefield while comparing against formatted data contained in the BKAD.

A comparison of the OneSAF Objective System Behavior Development Process and CCTT CIS Software Development Process showed many similarities. The OOS Behavior Development Process with BKAD and BKECM components appears to more acceptably satisfy the requirements for KA/KE through greater ease of data decomposition. The BKAD's modular approach to presenting knowledge capture appears to reduce the time previously expended by software modelers, with no military experience, in their analysis and engineering effort.

OneSAF Objective System BKAD is transforming the previously accepted practice of segregating KA and KE in two separate documents. The BKAD is not a fully encompassing KA/KE document at present, but serves as a first step in the evolution of a single knowledge acquisition/knowledge engineering hybrid document for U.S. Army STRICOM modeling and simulation programs.

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