2002 Command and Control Research and Technology Symposium

Paper's Title:

Development of a C2 Standard of Task Representation for C4ISR Systems, Simulations and Robotics: Battle Management Language

Topic(s) for which abstract is being submitted:

Primary Topic: Modeling and Simulation
Secondary Topic: C2 Decision Making and Cognitive Analysis

Authors:

Primary (POC): Scott Carey
Northrop Grumman Information Technology
1286 Eisenhower Road
Leavenworth, KS 66048
Tel: 913-250-0130
FAX: 913-250-0810
Email: scarey@northropgrumman.com

Additional: Martin Kleiner
Northrop Grumman Information Technology
2706 Longspur Way
Pleasanton, CA 94566
Tel: 925-600-7962
FAX: Same (call first)
Email: mkleiner@northropgrumman.com

Michael R. Hieb, Ph.D.
IITRI/AB Technologies Group
1901 N. Beauregard St.
Alexandria, VA 22311-1705
Tel: 703-933-3376
Fax: 703-933-3325
Email: mhieb@iitri.org

Richard Brown
TRADOC Program Integration Office – Army Battle Command Systems (TPIO-ABCS)
415 Sherman Ave.
Fort Leavenworth, KS 66027
Tel: 913-684-3137
FAX: 913-684-4538
BrownR@leavenworth.army.mil

Development of a C2 Standard of Task Representation for C4ISR Systems, Simulations and Robotics: Battle Management Language

Scott A. Carey
Martin S. Kleiner
Northrop Grumman Information Technology
1286 Eisenhower Road
Leavenworth, KS 66048
(913) 250-0130 Ext. 34
scarey@northropgrumman.com
mkleiner@northropgrumman.com

Michael R. Hieb, Ph.D.
IITRI
AB Technologies Group
1901 N. Beauregard St.
Alexandria, VA 22311
(703) 933-3376
mhieb@iitri.org

Richard Brown
TPIO-ABCS
415 Sherman Ave.
Fort Leavenworth, KS 66027
(913) 684-3137
BrownR@leavenworth.army.mil

Abstract

The science of Command and Control (C2) of military forces moves increasingly towards digital systems. As such, not only are humans consuming this information but also so are more automated systems. The need to use simulations to interact with Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) systems is becoming more acute. The interaction is becoming less interpersonal and focused more on data. Most critical of all the C2 information are the commander's intent, orders and directives, but these don't currently flow as data. They are typically transmitted as "free text" elements within messages or as stand-alone files. This is acceptable for interpersonal communication but it is inadequate for use with simulations, or for the future forces that have robotic components. Commanders demand to train as they fight. This means using their C4ISR devices to control simulations in addition to live forces. We need to fix the "free text" problem. Battle Management Language (BML) is a means to provide a completely unambiguous C2 specification for live forces, simulations and robotic forces.

Introduction

In May of 2000 the Department of the Army formally chartered the Simulation to C4I (SIMCI) Overarching Integrated Product Team (OIPT). Its mission is to provide recommendations on Army level policy to the Army Modelling and Simulation Executive Council (AMSEC) for improving interoperability between the Models and Simulations (M&S) and Command, Control, Communications, Computers, and Intelligence (C4I) domains. The SIMCI OIPT's specific objectives are to:

- Achieve seamless interoperability between M&S and C4I systems.
- Attain alignment of M&S and C4I standards, architectures, and common C4I components.
- Identify requirements for simulations and C4I to support interoperability.

Among the SIMCI OIPT's primary projects is the development of a Battle Management Language (BML) that will enable direct communications between standard Army Battle Command System (ABCS) components and supporting M&S applications. This paper will describe the background and concept for BML, discuss its required capabilities and its anticipated contributions to the SIMCI Objectives, the Army's transformation and the Objective Force. BML is absolutely essential to achieve the desired state of Simulations to C4I interoperability, and can contribute significantly to the Army Battle Command System in its own right.

Background

During the past several decades the use of models and simulations has increased exponentially in military affairs. Once primarily used in the research and development community and concept development and analysis agencies, these tools now reach across the breadth and depth of military organizations and functional areas. Of the domains, Training, Exercise and Military Operations (TEMO) is the most interactive with C4I systems. From the 1980's to the present the use of simulations to support training has expanded dramatically. Simulations such as Corps Battle Simulation (CBS), Brigade/Battalion Battle Simulation (BBS), JANUS, Close Combat Tactical Trainer (CATT), and Modular Semi-Automated Forces (ModSAF) have significantly improved both the quantity and quality of training opportunities. This is particularly true at the brigade, division and corps level, where the primary focus of training is on the command and staff processes. In the past, maneuver space, number of units, and logistic resources made it impractical and unaffordable to conduct effective, realistic command and staff training at the division and corps level. Now, using these supporting simulations, the highest echelons can conduct realistic training in a more frequent and cost effective manner. The major drawback of using computer-simulated training such as CBS, however, is the need for large contingents of support personnel to act as workstation controllers. The controllers provide the interface between the training unit and the simulation. The control group is often as large, or larger than, the training audience. While this enables training opportunities at the corps and division echelons, it is very expensive in terms of labor costs and lacks the degree of fidelity of actual combat operations.

Concurrent with the increased use of modeling and simulation in support of training has been the growth and development of automated Command and Control (C2) systems particularly at lower echelons of tactical forces. The first attempt to automate fire control was the Field Artillery Digital Automated Computer (FADAC). It was fielded in 1959. At the same time, a requirement for the Tactical Fire Direction System (TACFIRE) was emerging. TACFIRE arrived at the Field Artillery Board in 1972 for operational testing and was fielded to the 1st Cavalry Division Artillery in 1978. [2] The same materiel requirement for TACFIRE also envisioned development of automated systems in other areas of Combat, Combat Support and Combat Service Support operations. The program was called Army Tactical Data Systems (ARTADS). While the initial concept sought interoperability among the ARTADS component systems, the efforts became "stovepiped" as additional applications were developed outside the original unifying architecture. They had very specific battlefield functional area problems that they were being built to solve and interoperability with other systems was not a primary concern. Each system had its own hardware, operating systems, databases and software. As we moved through the 1980s and into the 1990s it became clear that there was a need for these systems not only to communicate with each other, but to also share common information. Efforts were initiated to fix the interoperability of these systems with the Common Hardware/Common Software Program in the 1980's. At the end of the last decade development began on the Joint Common Data Base (JCDB) [7], a shared, single repository of data common to more than one system. The result is today's Army Battle Command System (ABCS). The ABCS hosts a common picture of the battlefield by integrating information horizontally and vertically, i.e. within an echelon of command and from higher to lower echelons, respectively. ABCS consists of the following subsystems and is depicted in Figure 1. [13]:

- Global Command and Control System – Army (GCCS-A)
- Force XXI Battle Command Brigade and Below (FBCB2)
- Maneuver Control System (MCS)
- All Source Analysis System (ASAS)
- Advanced Field Artillery Tactical Data System (AFATDS)
- Forward Area Air Defense Command and Control (FAAD C2),
- Digital Topographical Support System (DTSS)
- Air/Missile Defense Planning and Control System (AMDPCS),
- Combat Service Support Control System (CSSCS),
- Army Airborne Command and Control System (A2C2S)
- Integrated Meteorological System (IMETS)

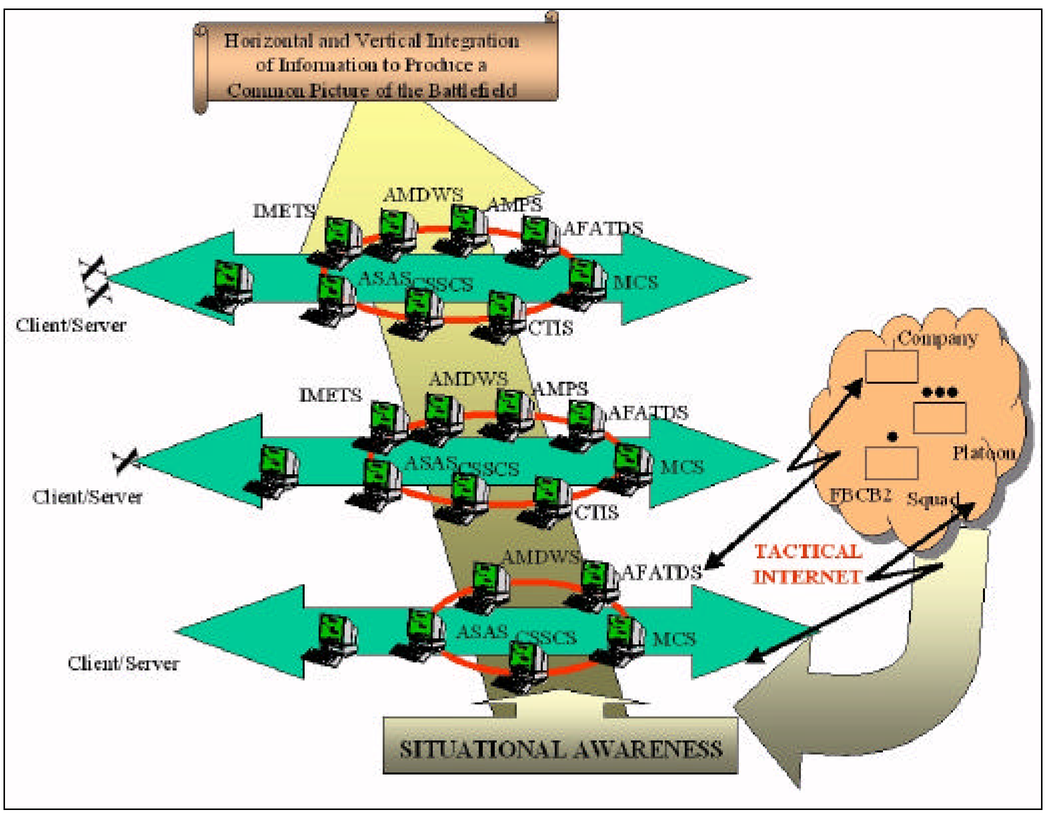

Figure 1. Army Battle Command System

During the 1990's the Army refocused its vision from the cold war to the tenets of Joint Vision XXI and Army Vision XXI. The tenets include Dominant Maneuver, Precision Engagement, Focused Logistics and Full Dimensional Protection. Critical to achieving these capabilities is the concept of using information superiority to provide vastly increased C2 capabilities. "The evolving doctrine keys on information-age technology. Digitization of the force will give our soldiers unprecedented tools to conduct battle in a manner never before seen. The power of the microprocessor is empowering the Army to move faster and more effectively -to compress time- and achieve an overwhelming competitive advantage in the information age." [10] The Army developed new organizations, doctrine, tactics, techniques and procedures. These were tested in a series of experiments focused on the "digitized" force. The experiments provided linked, automated C2 systems at each echelon of the participating units from the platoon through Corp level.

As the echelon of the participating units increased it became less practical to execute the experiments with a full compliment of live friendly and opposing forces. A greater level of modeling and simulation support was used to accomplish these exercises. Additionally, it became apparent that developing a suitable level of proficiency in the participating units required a focused training regimen with sufficient "battlefield loading" of the interactive information systems.

The Impetus for a Universal Battle Management Language

As stated, a major drawback of using computer-simulated training, such as CBS, is the need for large contingents of controllers at workstations providing the interface between the training unit and the simulation. One of the key issues in using M&S as a primary training adjunct to advanced C4I systems, and directly linked to the workstation controller topic, is the lack of an effective means of sharing information and directives among the simulations and the C4I systems. A method of enabling the C4I systems to both exchange information directly with the simulation and also provide for the direct control of and feedback from the simulated subordinates will significantly reduce workstation controller requirements and enhance the realism of the training.

The Army is making significant progress in sharing information through the development of the JCDB. However, relatively few advances have been made on controlling the simulation directly from the C4I systems. This is due largely to the reliance on unstructured, ambiguous "free text" within the operational C2 messages. "Free text" existing in USMTF, JVMF, and other message formats exists for the benefit of the human. The highly trained, professional soldier has little problem dealing with this "free text." Current automated systems that deal with "free text" handle it as a single data field and pass the <character string> on. Understanding the content of the <character string> does not exist within the current system, nor will computers be able to parse natural language for some time to come. Therefore, to resolve both of these issues, the concept of a BML was developed. Taking the widest possible interpretation, we offer the following definition:

BML is the unambiguous language used to command and control forces and equipment conducting military operations and to provide for situational awareness and a shared, common operational picture.

Along with this definition, we add four principles that guide BML development:

1. BML must be unambiguous;
2. BML must not constrain the full expression of a commander's intent;
3. BML must use the existing C4I data representations when possible; and
4. BML must allow all elements to communicate information pertaining to themselves, their mission and their environment in order to create situational awareness and a shared, common operational picture.

Additionally, in constructing BML we need to consider its flexibility versus its efficiency. Efficient BML takes the form of interactions that are highly structured, such as communications between pilots and air traffic controllers or between artillery observers and fire direction center. The efficiency accommodates the tension of dangerous, stressful situations and the potential for degraded communications media. Flexible BML, on the other hand, approaches the concept of "free text" where the users communicate in natural language. At the extreme, this may include vocal inflection and body language. Since our objective is to demonstrate a BML for use with current technology, we will focus more on the efficient end of the BML spectrum. Objectively, BML must interpret "free text," even to the degree that Arthur C. Clarke's "HAL9000," in the movie "2001 A Space Odyssey" could "sense" human intent as well as spoken language.

As emerging and future simulations develop, we face three options in meeting the BML requirement. First, we can create BMLs that are specific to each simulation. Second, we can develop a standard simulation BML and add interpreters between it and the C4I systems. Finally, we can develop a BML that is standard for both the simulation and C4I domains. To support the "train as we fight" maxim, we choose to develop a BML that will be standard for both domains.

Additionally, it is vitally important that BML contain no user noticeable distinction between live or simulated forces ensuring that commanders and staff can train as they fight. They will use the same BML whether they are dealing with live subordinates, a simulation, or a Future Combat System (FCS) robotic element, (Figure 2). For a detailed discussion of the principles of this universal BML, and its predecessors, see [3]

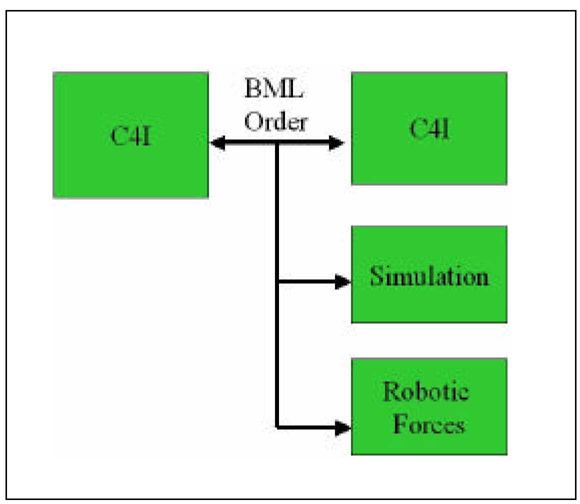

Figure 2: BML Scope

The Concept and Structures of BML

To achieve acceptance and also have utility for its primary ABCS users, BML needs to have a familiar, intuitive "look and feel." The "common look and feel" is manifest in the "operational battle management language," used by military professionals to interact with live forces. Doctrinal manuals such as FM 101-5-1 (future FM 1-02) define the vocabulary. The associated grammar is defined by other doctrinal manuals and from years of use. It is tailored to interpersonal communications. Doctrine provides the base line for common understanding amongst all users. Operational BML, however, lacks clearly delineated rules governing its use (semantics and syntax) and is riddled with ambiguity. It works because soldiers have grown up with it from the moment they enter the service. They learn its idiosyncrasies along with the idiosyncrasies of the individuals who use it. When a term is used, it has context based on the operation, unit type and echelon, and individual characteristics of the sender. Likewise, when a sender selects a term to use he does so with an understanding of these same factors of the intended audience. Any confusion is resolved through give and take between sender and receiver. Mentoring and coaching is a part of the process of learning the "informal" BML. While ease of use is this operational language's main strength, its main weakness relates to automated systems, specifically, lack of structure. As such, it is incapable of supporting the full range of automation that the Army is implementing. It demands further development and modification.

The Simulation Community has developed several languages that are similar to the BML we are developing. The highly structured EAGLE BML [9], the Command and Control Simulation Interface Language (CCSIL) [11], and the Army Modeling and Simulation Office (AMSO) BML-1 standard [1] were developed to support simulations. While successful in their application, they are not operational user friendly and do not adhere to C4I data representations. The Defense Modeling and Simulation Office has sponsored development of a Conceptual Model of the Mission Space [6] which defines terms traceable to service doctrine, but was also not oriented towards C4I Data Representations.

The primary vehicle in the Army for adding the required structure to BML is the JCDB. The JCDB focuses on two macro areas: first are the physical elements of the battlefield, which are referred to as objects; and second, the data for employment (actions) of the elements (objects) of the battlefield.

The physical elements of the battlefield fall into five general categories: Person, Organization, Materiel, Feature, and Facility. Each has subcategories and descriptive values that are capable of defining unique, individual entities. Using these descriptive values plus the series of standard (or unique) relationships defined among the elements we can describe a thorough "picture" of the battlefield. The picture can be shared among ABCS systems and, with some work, the supporting simulations as well. As mentioned earlier, this is significant progress in terms of sharing data and provides to a great degree for the Situational Awareness function of a BML.

The employment aspects within the JCDB are categorized as Situation, Plan, Action, Location and Capability. Each of these "items" also has sub-"items" and possesses descriptive values. Currently, however, these categories and their relationships do not provide sufficient structure to solve the "free text" issue, but they do provide a point of departure for further development. A significant portion of the BML project is to extend these areas and their relationships and the JCDB's categorization of the physical elements of the battlefield, to solve the "free text" problem in consonance with the four principles specified above. To address this disparity we specifically propose the following:

- Build in the vocabulary as contained in FM 101-5-1, Operational Terms and Graphics (future FM 1-02) and BML-1 as data tables.
- Incorporate the doctrinal base into the Joint Common Data Base (JCDB).
- Build in the syntax and semantics defined by the Army Universal Task List (AUTL) (future FM 3-15), the Army Training and Evaluation Program (ARTEP) Mission Training Plans (MTP) and the other related field manuals. Doing this allows specific items to be aligned with echelon and type unit as relationships in the data tables.

Building the Vocabulary

BML vocabulary derives from English but a more specific set of definitions exists for the military. The military definitions will be incorporated into the JCDB and, most importantly, will be linked to the specific uses that relate to other elements contained within the JCDB. This may seem straightforward but consider that the term "clear" has eight primary definitions and an additional 3 sub-definitions described in Joint Publication 1-02 and FM 101-5-1 plus three more "Army-only" definitions in FM 101-5-1. In each the specific meaning relates to one or more elements, such as a piece of equipment, a unit, a terrain feature, an enemy force or a combination as defined in the physical elements of the JCDB, see Table 1.

The specific meaning of a term is dependent on a number of other factors. In other words, it must be taken within an overall context. Normally these other factors consist of the "Who, What When, Where and Why." To add even more complexity to the situation, actions usually involve multiple parties, and the true context of the term only becomes apparent when all of these are taken into consideration. For example, the "Who" may consist of the element that is ordering and directing the action; the element that is carrying out the action(s); or the element that is the recipient of the action. These complex relationships and their specific meanings can only be understood if the BML has robust yet precise syntax and semantics. These are codified in the Army's doctrine; the AUTL and ARTEP-MTPs. Additionally, the organization and placement of these items within an operations order also contribute to their overall meaning.

In addition to defining terms, FM 101-5-1 also defines graphics and symbols related to the terms and their definitions. In fact an entire operations order can be created in graphical form using the BML. The functional BML will include this and represent these meanings and relationships appropriately.

Incorporating Doctrine

To fully understand the need to incorporate Doctrine into the BML it is important to understand first what Army Doctrine is … and is not. First of all "Army doctrine is

Definitions of the Term “Clear” from FM 101-5-1			
Joint Definitions also contained in JP 1-02			
Action	**To Whom/What**	**With Respect To**	**Why**
1.) Approve/Authorize	a.) A person or group of people	Action, duties, movements, etc.	Access to
	b.) An object or group of objects	Quality, quantity, disposition, purpose, etc.	Status of
	c.) A request	Correctness, validity, etc.	Execution of
2.) Approve/grant authorization	One or more aircraft	Flight, instrument flight, ground operations, etc.	Take off, land, etc.
3.) Grant	A person	A security clearance	Access to info
4.) Fly	An Aircraft	An obstacle	To avoid contact
5.) Pass	A designated point	One or more vehicles	Monitor movement
6.) Operate	a.) A gun	Ammunition	Unload or confirm empty
	b.) a Gun	Stoppages	Free
7.) Clear/free	An engine	Carbon	Maintenance of
8.) Clear/remove	Enemy aircraft	Designated airspace	Achieve air-superiority or control
Army Specific Definitions			
1.) Remove (Note: this is a tactical task)	Enemy forces/organized resistance	An assigned zone, area or location	Preclude interference with friendly operations
2.) Eliminate	Transmissions	A tactical radio network	Allow higher precedence transmissions
3.) Total elimination or neutralization	An obstacle	Follow on engineers	Provide mobility and protection
Note: This is an abridged version of the definitions intended to provide an insight into the broad range and scope of individual terms. Please see the source document for the full definition of the term “Clear”.			

Table 1. Definitions Of The Term “Clear”

authoritative but not prescriptive.” [4] Furthermore, “Doctrine touches all aspects of the Army. It facilitates communication among soldiers no matter where they serve, contributes to a shared professional culture, and serves as the basis for curricula in the Army Education System. Army doctrine provides a common language and a common understanding of how Army forces conduct operations. It is rooted in time-tested principles but is forward-looking and adaptable to changing technologies, threats, and missions. Army doctrine is detailed enough to guide operations, yet flexible enough to allow commanders to exercise initiative when dealing with specific tactical and operational situations. To be useful, doctrine must be well known and commonly understood.” [5]

At its highest levels Army Doctrine is rather philosophical and as such sets a generalized tone for the language, e.g. offensive operations constitute the decisive operations and the Army is offensively oriented. Additionally, it sets the high-level definitions for certain terms such as those that describe the types of operations that the Army will conduct (Offensive, Defensive, Stability and Support), the types of command relationships that can exist between units, forces, Services and nations, etc. From this point on, Army doctrine devolves down the echelons and organizations that constitute the Army field forces (those that are organized to perform Combat, Combat Support or Combat Service Support operations.) Moving from higher echelons to lower, the units themselves become more specialized and differentiated. Consequently, at each successively lower level the doctrinal characteristics while reflecting the aspects of the higher levels, become more specific and detailed in their definitions of terms and descriptions of actions. As this occurs the terms of the "language" become related to these particular types of units, their unique missions and individual equipment and capabilities. If we extract these relationships from the lexicon of doctrinal terms and enumerate them in the BML specification, then we can produce terms that have unambiguous meaning and are set in operationally specific context. For instance, if the term "clear" is used in an operations order where the performer of that action is a follow on Engineer unit and is associated with a given obstacle, the intent is obvious. On the other hand, if the same term "clear" is used in conjunction with a heavy maneuver company team and associated with an objective (hill 1234), the intent is also evident, yet significantly different from the engineer mission context.

A critical aspect of developing BML is not simply to specify the components and relationships that provide the context of the language, but to embed them, and dynamically link BML to the Training and Doctrine Command's organizations who develop and maintain doctrine. As with any modern language that is in widespread use BML must reflect the latest concepts, capabilities and representations of the objects and domain that it represents. Within the world of Military Affairs, it is said that the only constant is change itself, and the language itself must be fully capable of representing the current status of the domain, if it is to be useful and meet the conditions of Doctrine, as described above. In particular, as the Army "Transforms" and achieves the structure and capabilities of the Objective Force there will be much adaptation of doctrine, tactics, techniques and procedures. While the higher-level "philosophical" aspects of doctrine may remain stable, the lower-level, more specific aspects can be expected to change rapidly and often. A well-designed BML accommodates such change, and adds to doctrine distribution and understanding throughout the force.

Describing the devolution of Doctrine from higher to lower, and from the philosophical to the specific, depicts how the military conducts operations. The missions originate at the highest levels but are executed at the lowest levels. In a large-scale operation, such as Desert Storm, the overall mission and orders originate with the National Command Authority and pass to the Theater Commander, the Land Component Commander (if one is designated) and on to the Field Army. From the Field Army orders proceed to the multiple Corps, subordinate Divisions, and on to the Brigades, Battalions, down to the Companies and Platoons where the actual operations are executed. As the orders cascade from higher to lower they invoke the diverse units' specialties. While all Corps level organizations are very similar in structure and function, the difference in composition and function at the platoon level is extreme. These may range from airborne and armored combat forces through military intelligence and communications-electronics combat support elements to laundry and mortuary affairs combat service support platoons, all of which derive their specific missions and details from the one original Corps order. Decomposing complex high level missions into discrete, executable sets of action is one of the primary functions of operations orders. BML must enable and clearly communicate this function. As an example, one Corps level order will generate a minimum of 1,163 additional subordinate orders (see Table 2). BML has to clearly express the decomposition of missions and units with enough precision to cause correct behaviors in live units, and supporting simulations or, in the future, robotic forces.

Orders Cascading From One Corps Order					
Corps Order	**Div Level**	**Bde Level**	**Bn Level**	**Co Level**	**Total Orders**
1	**5**	**48**	**193**	**917**	**1164**

Table 2. Cascading of Orders

Building the Syntax and Semantics

As discussed above, the doctrinal base provides the philosophical underpinning for the BML, as well as a significant amount of the detail necessary to achieve the stated objectives of the language. As it stands, however, the base needs to tie directly to the AUTL and ARTEP-MTPs to be clear, concise and explicit. The AUTL is developed in conjunction with the Universal Joint Task List (UJTL) and attaches a number to various functions, missions, activities, and tasks that the Army, as a Service, can perform. The tasks are then supported by the ARTEP-MTPs, which describe the tasks in detail along with the conditions and standards for a given type unit at a given echelon. These in turn decompose all the way town through the platoon, squad and team level to individual soldiers, identified by Military Occupational Specialty (MOS) and skill level. When these tasks are associated with the specific vocabulary and unit data contained in the (objective) JCDB it provides us with the context required to give meaning to the particular use of the terms. BML now has a vocabulary as well as the required syntax and semantics.

Pulling It All Together

The preceding sections have described, in detail, all of the elements that are necessary to communicate clear and unambiguous mission orders from a human, supported by an automated C2 system, to a subordinate. This information could be directed to an experienced or novice human subordinate, a simple or cognitive agent simulation or a future robotic FCS component. What remains is to detail the specific relationships among these elements and present a common structure or format to convey them.

The standard format can be as simple as a matrix assigning the Who, What, When, Where and Why (the 5 Ws) for each subordinate element that is receiving a mission as well as the information needed to coordinate activities. Within the JCDB the ORGANIZATION table provides the “Who.” Its relationship to the ORGANIZATION-TYPE table associates the ORGANIZATION-TYPE function and echelon codes to specific organizations. The “What” is provided through the TASK table. TASKS, a directed activity, and EVENTS, a significant occurrence, are categories of ACTIONS, an activity. The ORGANIZATION-TASK table provides the association of tasks to specific organizations based on the organization’s function and echelon. Attributes of the TASK table provide the “When” and the “Why.” The ACTION-LOCATION table provides the “Where.” Numerous other tables exist within the JCDB that contain enumerations that portray information required to coordinate activities such as the WEAPONS-CONTROL-CODE table. This subset of JCDB tables reflects a capability within the JCDB to establish the data and relationships required for BML implementation

Presenting this using the concepts and notations of Set Theory we see that BML can take the attributes (Tasks, Units, etc) for all of the forces within a tactical organization as they would reside within a modified and expanded JCDB and can create a superset and appropriate subsets of the 5 Ws that are required to provide for the cascading operations orders. This is depicted below:

> What_Cd is the set of all possible tasks that can be assigned to military forces as defined by doctrinal manuals. A task, T, may be an operation as defined by the UJTL (attack, defend, etc.), a tactical task as defined by FM 101-5-1 (secure, clear, seize, etc.), or an ARTEP-MTP task (conduct tactical movement, conduct tactical road march, occupy an assembly area, etc.).
>
> $What\_Cd = \{T_1, T_2, \ldots .T_i\}$.
>
> $What\_Cd_{Unit\text{-}type\_echelon}$ is the set of all possible tasks that can be assigned to a Unit of a specific Unit-Type and Echelon as defined by unit-type and echelon specific doctrinal manuals. $What\_Cd_{Unit\text{-}type\_echelon} = \{T_{u1}, T_{u2}, \ldots T_{uj}\}$, where j is the total number of applicable tasks for echelon u and $\{T_{u1}, T_{u2}, \ldots T_{uj}\}$ is a subset of $\{T_1, T_2, \ldots .T_i\}$ (where T_{u1} is identical to one of the tasks in $\{T_1, T_2, \ldots .T_i\}$).
>
> As shown below a task (T_1) might be common to multiple Unit-Types and Echelons. For example the task attack might be common to a Tank/Mech brigade and battalion as well as to a field artillery battalion and an Air Force F-15 Squadron. Other tasks will be unique to a specific unit-type and echelon.
>
> $What\_Cd_{Tank/Mech\_BDE} = \{T_1, T_5, T_8, T_{19}, T_{24}, T_{30}\}$
> $What\_Cd_{Tank/Mech\_BN} = \{T_1, T_5, T_8, T_{32}, T_{40}, T_{41}\}$
> $What\_Cd_{FA\_BN} = \{T_1, T_5, T_{50}, T_{51}, T_{52}, T_{53}\}$
> $What\_Cd_{F15\_SQ} = \{T_1, T_5, T_{100}, T_{101}, T_{102}, T_{103}\}$
>
> Unit has properties of Unit-Type and Echelon: $Unit_{Unit\text{-}Type\_Echelon}$.
> $Unit_{Unit\text{-}Type\_Echelon}$ is associated with $What\_Cd_{Unit\text{-}type\_echelon}$.

Why_Cd is the set of all possible purposes for conducting the tasks that are elements of What_CD. The purposes, P, have been identified in the same doctrinal manuals used to identify the tasks, T. The terms selected convey a reason for conducting a task and in many cases the definition of the term defines an endstate condition.

$$\text{Why\_Cd} = \{P_1, P_2, \ldots.P_n\}.$$

For any given What_Cd element, T_x, where $1<=x<= i$; there is a corresponding subset of Why_Cd elements associated with it. Why_Cd(T_x) = $\{P_{x1}, P_{x2}, \ldots SP_{xm}\}$, where m is the total number of applicable purposes for Task x and $\{P_{x1}, P_{x2}, \ldots SP_{xm}\}$is a subset of $\{P_1, P_2, \ldots.P_n\}$ and P_{x1} is identical to one of the purposes in $\{P_1, P_2, \ldots.P_n\}$.

Therefore, a mission or tasking statement that is defined by the 5 Ws (Who, What, When, Where and Why) is structured to a finite set of possibilities by these set associations. Given a Who = Unit$_{\text{Unit-Type_Echelon}}$ (1 BN 40 AR is the name of a unit where Unit-type = Tank/Mech and Echelon = battalion.), which is associated to What_Cd$_{\text{Unit-type_echelon;}}$ then once a task, T_x is selected this is associated to Why_Cd(T_x) allowing us to now select a purpose, P, associated with why we want to do T_x for this specific instance.

Who	**What** What_Cd (T)	**When**		**Where**		**Why** Why_Cd (P)	
		Control	Parameter (DTG/Event)	Control (CM/LatLong)	Parameter		
1 BN 40 AR	ATTACKS	AT	D Day, H-Hour	CM	ZONE	SECURE	OBJ DOG
Note: DTG = Date-Time Group, CM = control measure, LatLong = Latitude/Longitude							

Table 3. Example of the 5 W's.

The Future

Current requirements and evolving operational concepts call for a wide variety of advanced capabilities to be embedded in future C4I systems. Among these will be Course of Action (COA) development and analysis tools, the capability to perform virtual mission rehearsals and the ability to command and control FCS robotic entities. In many instances such as COA analysis and virtual mission rehearsal, a logical method is to use either linked or embedded simulations to rapidly execute the considered or selected COA. This will enable the commander and his/her staff to rapidly visualize various outcomes of each COA and make adjustments in a rapid and responsive manner. The precursor for this capability occurred during operation Desert Shield/Desert Storm when both the VII Corps and XVIII Airborne Corps utilized the Army's Battle Command Training Program and its supporting CBS simulation to conduct virtual rehearsals of their operational plans. At the time this required the use of couriers to convey the plans and results between the theater of operations and the supporting simulation center at Ft. Leavenworth, KS for the XVIII ABC and the deployment of a large-scale simulation support group to the theater for the VII Corps. While the results of this effort were impressive the time and resources required make this current capability incompatible with the tenets of Army Vision XXI and the Objective Force capabilities. In these cases, as in normal operational training, a well-structured, user friendly BML will be critical to achieving this capability. Likewise, when directing future FCS robotic entities a commander can expect them to have some level of artificial intelligence, or at least expertise, but they will lack the ability of a well-trained human to parse, analyze and understand free text directives. Rather than develop a separate, additional capability to communicate with these entities BML can accomplish this task without requiring that commanders develop yet another unique yet narrowly focused skill set.

Conclusion

Current capabilities to link Tactical C4I systems to simulations in support of battle focused training are limited. In most cases the actual linkage occurs through support personnel acting as workstation controllers. While this method of operation is effective in supporting upper echelon battle command training it is extremely resource intensive in terms of both manpower and time consumption. Additionally, it provides little realistic concurrent training on the use of organic C4I systems and in some cases actually provides negative training due to the lack of stimulation and lifelike loading of these systems. The development of an operationally focused BML will significantly eliminate these problems and will act as a catalyst to stimulate multi-echelon simulation supported operational training with organic C4I systems. Also, an operationally focused BML that is embedded in the C4I systems can contribute significantly to the production, dissemination and "consumption" of automated operations orders. Both of these capabilities contribute significantly to achieving the Objective Force capabilities envisioned in the Army Transformation Plan.

Acknowledgment

The U.S. Army's Overarching Integrated Product Team for Simulation to C4I Interoperability (SIMCI OIPT) [12] supports Scott Carey and Martin Kleiner in the development of BML. Dr Hieb was supported by the Office of the Director for Information Systems for C4I (DISC4) of the Army, the Army Modeling and Simulation Office (AMSO), and the SIMCI OIPT while writing this paper. Mr. Carey, Mr. Kleiner and Dr. Hieb are Architects for the SIMCI OIPT. The authors gratefully acknowledge the encouragement and support given by the SIMCI OIPT and TRADOC to development of BML.

References

1. Argo, H., Brennan, E.J., Collins, M.W., Gipson, K., Lindstrom, C., and MacKinnon, S., "Level 1 Model for Battle Management Language (BML-1)," TEMO Simulation Laboratory (TSL), Fort Leavenworth, KS 23 March 1999.

2. Boutelle, S.W. and Filak, R., "AFATDS: The Fire Support Window to the 21st Century", Joint Force Quarterly, Spring 1996.

3. Carey, S.A, Kleiner, M.S., Hieb, M.R. and Brown, R., "Standardizing Battle Management Language - A Vital Move Towards the Army Transformation", 01F-SIW-067, Proceedings of the Fall Simulation interoperability Workshop, 2001.

4. FM 3-0 "Operations" Headquarters, Department of the Army, Washington, DC, June 2001, Par. 1-44.

5. FM 3-0 "Operations" Headquarters, Department of the Army, Washington, DC, June 2001, Par. 1-45.

6. Haddix, F., Sheehan, J., Loesekann, M. and Scrudder, R., "Semantics and Syntax of Mission Space Models", Paper 99F-SIW-152, Fall Simulation Interoperability Workshop, 1999.

7. Hieb, M.R., and Blalock, J., "Data Alignment Between Army C4I Databases and Army Simulations", Paper 99S-SIW-034, Spring Simulation Interoperability Workshop, 1999.

8. Kleiner, M.S., Carey, S.A., and Beach, J., "Communicating Mission-Type Orders to Virtual Commanders", Paper, Proceedings of the 1998 Winter Simulation Conference, December 1998.

9. Ogren, J., and Fraka, M., "EAGLE Combat Model Battle Management Language (BML)", Powerpoint presentation, BML Symposium at Fort Leavenworth, KS, 25 April 2001. (http://www.simci.org/html/librsry.html Public Folder/Meetings/Architect Meetings/Battle Management Language/BML Symposium/Eagle Presentation).

10. Pamphlet "Army Division XXI" US Army Training and Doctrine Command Deputy Chief of Staff for Combat Developments, undated.

11. Salisbury, M., "Command and Control Simulation Interface Language (CCSIL): Status Update" MITRE Informal Report, Twelfth Workshop on Standards for the Interoperability of Defense Simulations, March 1995 (http://ms.ie.org/cfor/diswg9503/diswg9503.pdf)

12. SIMCI WWW Site, Army Overarching Initial Product Team for Simulation to C4I Interoperability: https://simci.army.mil, 2002.

13. Weapon System Handbook, United States Army, 2001.

Author Biographies

SCOTT CAREY, a senior researcher/writer and program manager for Northrop Grumman Information Technology, is a retired Army Lieutenant Colonel. His last assignment before retirement was as the senior command and control operating system subject matter expert and observer/controller for the Battle Command Training Program at Fort Leavenworth, Kansas. Mr. Carey has eight years experience dealing with command decision modeling. Mr. Carey has a BS degree in Education from the University of Maine and a MS degree in Business Administration from Boston University, and is a graduate of the U.S. Army Command and General Staff College.

MARTIN KLEINER, a program manager and senior researcher/writer for Northrop Grumman Information Technology, retired from the U.S. Army with the rank of Colonel and has experience in the areas of maneuver warfare, intelligence, campaign planning, operational level targeting, and research and development. He has eight years experience dealing with command decision modeling. Mr. Kleiner received a BS degree in Organizational Behavior and Management from the University of Houston and is a graduate of the U.S. Army Command and General Staff College and the Army War College.

MICHAEL HIEB is a Vice President for C4I Programs of the IITRI/AB Technologies Group. Dr. Hieb is currently an Architect for the Army SIMCI OIPT. He received his Ph.D. in Information Technology at George Mason University in 1996 and performed his doctoral research at the GMU Center for Excellence in C3I. Dr. Hieb received his MS degree in Engineering Management from George Washington University and his BS degree in Nuclear Engineering from the University of California in Santa Barbara. He has published over 45 papers in the areas of M&S integration with C4I and Machine Learning. Previously, he worked as a Nuclear Engineer for General Electric.

RICHARD BROWN is a Senior Telecommunications Manager in the Army's Training and Doctrine Command's Integration Office for Battle Command Systems. His current focus is on simulations and C3 systems interoperability. Over the last 25 years he has worked on tactical fire control systems, and integrated equipment and processes that form command posts. Mr. Brown is a 1967 graduate of the University of Massachusetts with a BS in Experimental Psychology. He retired from the US Army Reserve as a lieutenant colonel in 1997.