Formalizing the Missions and Means Framework Specification

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ABSTRACT: As the Department of Defense (DoD) transforms itself from a forces-based, materiel-centric Cold War posture to a capabilities-based, mission-centric, asymmetric-warfare posture, it is increasingly vital that military planners, operators, and analysts concern themselves not only with “doing things right” (i.e., the technical architecture) but also with “doing the right things” (i.e., the operational architecture). Moreover, the historic “right thing” of winning the large-scale conventional engagements in Europe has given way to multiple and diverse “right things” of unconventional combat, homeland defense, peacekeeping missions, and various kinds of military operations other than war (MOOTW). To address these complex new objectives, the military Missions and Means Framework (MMF) has been developed within the DoD to comprehensively organize and rigorously specify operational purposes and goals and then explicitly relate, map, and allocate them to the proposed technical means for accomplishment. Recently, the MMF has increasingly been used to represent the synthesis of military operations and the employment of materiel/forces to accomplish these operations. This paper discusses an approach for providing a concise formal specification of the MMF, outlining a formal structure through which missions and means alternatives can be specified in such a way as to support machine parsability, ultimately enabling the modeling and simulation of wartime scenarios in a disciplined and structured manner. This approach to specifying the common semantics and syntax of the framework forms the basis for the complex process of decomposition of battlefield operations into atomic elements, specifying the relationships between those elements, and recomposing them into the basic components of simulation development. In describing this specification, this paper briefly summarizes the key MMF concepts, provides a proposed entity-relationship model which captures those concepts, and relates that model directly to the theoretical basis. Finally, it provides additional discussion regarding the complete specification requirements for each model element.

1. Introduction

The Missions and Means Framework (MMF) is a structure for explicitly specifying the military mission and for quantitatively evaluating the mission utility of alternative warfighting Doctrine, Organization, Training, Material, Leadership, Personnel, and Facilities (DOTMLPF) services and products. Its objective is to provide a framework to help the warfighter, engineer, and comptroller specify a common understanding of military operations, systems, and information, and to provide quantitative mission assessment of alternative solutions. It provides a disciplined process to explicitly specify the mission, allocate means, and assess mission accomplishment.

The specific objectives of developing this framework and associated procedures include the following [1]:

1. Unify the warfighter, engineer, and comptroller understanding of the missions and means.  
2. Account for the tangible, physical, objectively measurable factors (traditional testing and evaluation) and the intangible, cognitive.
subjective factors (traditional warfighting expertise) that constitute mission success.

3. Be sufficiently credible, timely, and affordable to make hard decisions – and have those decisions stay made.

4. Be sufficiently consistent, concise, repeatable, and scalable to compete effectively with alternative methodologies.

5. Provide a disciplined process to implement the transformation guidance provided by the Secretary of Defense and Chairman, Joint Chiefs of Staff.

6. Bridge the gap from warfighter concepts to more structured representations that can be implemented as modeling and simulation software, or in data as scenarios.

7. Satisfy the need for a formal conceptual model for the development of M&S tools.

The purpose of this paper is to present a product by which the semantics (meaning of terms) and syntax (relationships among those terms) for the MMF might be formalized. This specification has been derived from the current description of the MMF as articulated in the paper titled “The Missions and Means Framework” [1]. In developing a more complete specification, additional joint publications have been referenced, most notably “The Universal Joint Task List” [3]. In all cases, semantic definitions have been developed to be as consistent with current joint guidance as possible.

2. Concepts of the MMF

This section provides a very brief summary of the fundamental concepts that form the foundation for the Missions and Means Framework. A much more complete description is available in Reference 1, cited above.

2.1 Fundamental elements of the MMF

The Missions and Means Framework is based upon 11 fundamental elements to organize and specify military operations. As shown in Figure 1, MMF content is organized into seven groups, designated as Levels:

- Level – 7. Purpose, Mission
- Level – 6. Context, Environment
- Level – 5. Index, Location/Time
- Level – 4. Tasks, Operations
- Level – 3. Functions, Capabilities
- Level – 2. Components, Forces
- Level – 1. Interactions, Effects

Levels 5 through 7 characterize the mission portion of the MMF, while Levels 1 through 4 are considered the means portion of the framework. Note that, in this context, the word “means” takes on a slightly broader meaning than in its common application. MMF “means” include all resources and actions taken in pursuit of the missions and their objectives. For example, the units or components tasked; how they are organized; and the strategies, operations, or task decomposition decisions are all considered part of the means to achieve the ends associated with the mission. At each echelon in a task-organized chain of command, the commander at that echelon works with some factors that are externally imposed and others that are at the commander’s discretion. The initial version of the MMF specification that is presented in this paper represents the externally imposed factors (Level 7, Purpose and Mission; Level 6, Context and Environment; and Level 5, Index and Location/Time) as static and outside the span of control of the commander at that echelon. In this initial version, the own forces Levels 1 through 4 (and supporting operators) are considered dynamic and under the span of control of the own force commander at that echelon. The same is
true of the opposing force commander. Version 1 (and supporting data model) does not directly address the dynamics of a lower echelon commander negotiating changes in the operational concept with higher level echelon commanders that will eventually be required in the MMF specification.

2.2 Concept of transformational operators

In addition to the levels described above, the MMF includes the following four transformational operators, which capture the dynamic relationships that exist between levels.

- \(O_{12}x\) transforms Level-1 interaction specifications into Level-2 component states.
- \(O_{23}x\) transforms Level-2 component states into Level-3 functional performance.
- \(O_{34}x\) transforms Level-3 functional performance into Level-4 task effectiveness.
- \(O_{41}x\) transforms Level-4 task effectiveness into Level-1 interaction conditions.

2.3 Synthesis and employment processes

The “x” postscript in each of the designations above refers to the “S” or “E” operator. The MMF has two distinct versions of each transformational operator. Synthesis (S-suffix) is the top-down planning and decision-making process warfighters use to create, define, and design a military evolution to meet mission requirements. Employment (E-suffix) is the bottom-up execution and adjudication of actual outcomes when own and opposing missions/means collide in the battlespace. Synthesis and Employment operators are not mathematical inverses. Obviously, the processes and procedures used to design a course of action are not the same as those used to execute it [1].

2.4 Stocking and assembly perspectives

The MMF has two names for the mission content specified in each level—the “stocking” perspective and the “assembly” perspective. In the stocking perspective, when the MMF names, records, and references content, the organization within the level is an orthogonal decomposition into homogeneous collections of similar content, and uses the first term listed above in the listing of levels (e.g., Purpose, Context, Index, etc). In the assembly perspective, the MMF content description applies a decomposition of heterogeneous packages of diverse content, and uses the second term listed above (e.g., Mission, Environment, etc). For example, a combined arms team or an aviation strike package would each be specified as forces in the assembly perspective of Level 2. Each reflects the characteristics of an “assembled” package created by appropriately combining components selected with an eye toward accomplishing a specific mission or task. Using architectures, purpose parts are assembled into mission packages, context parts into environment packages, function parts into capability packages, and interaction parts into effects packages.[1]

3. A Missions and Means Framework Data Model

As the MMF conceptual basis matures, it is necessary to develop a more precise statement of common semantics and syntax, allowing for a consistent use of the framework and the implementation of tools. One of the primary purposes of this paper is to describe an approach for constructing an initial entity-relationship data model that captures the fundamental concepts, as well as the semantics and syntax of the MMF. In doing so, the authors have chosen the IDEF1X data modeling language, a common system for describing the key entities and their relationships in graphical form [2]. IDEF1X has been widely accepted as a language for describing and designing relational databases, and is very useful in providing a formal specification of the key relationships between database entities. IDEF1X is also useful for initially specifying concepts and their relationships in a logical or conceptual model, and has been used in this manner for the MMF analysis. An entity in IDEF1X refers to a collection or set of similar data instances that can be individually distinguished from one another. Individual members of the set are called instances of the entity. A box in IDEF1X represents a set of data items in the realm of the real world. An attribute is a descriptive property used to describe an individual member of the set. Thus, each entity in the model has associated with it a list of attributes that describe the characteristics of each instance of that entity in the database. This paper will not develop the attributes associated with individual entities, but will focus upon the higher level entities and their relationships. The relationship existing between individual members of these sets is given a name. Connection relationships denote how entities relate to one another.[2] An alternative representation for these concepts might include the use of Universal Modeling Language (UML) class diagrams, an effort that is left to another treatise.

The data model thus constructed has been developed by careful analysis of the seminal paper [1], which provides the conceptual description of the Missions and Means Framework. The textual description has been parsed and diagrammed so as to identify the key entities and describe the key relationships. Additionally, the paper has been scrutinized for key terms and definitions. In many cases, the terms are concisely defined in the text, although others
are not. The authors have collected key terms into a consolidated glossary for reference as Attachment 1 to this paper. This attachment serves as an initial version of a precise specification for key definitions in the MMF.

3.1 Key entities and relationships within levels

The MMF Data Model begins with the creation of two fundamental entities at each of the seven levels of the framework. Each entity captures the assembly and stocking perspective terms identified at each level.

Level – 7. PURPOSE, MISSION
Level – 6. CONTEXT, ENVIRONMENT
Level – 5. INDEX, LOCATION/TIME
Level – 4. TASK, OPERATION
Level – 3. FUNCTION, CAPABILITY
Level – 2. COMPONENT, FORCE
Level – 1. INTERACTION, EFFECT

The MMF definition for each of theses entities is discussed at some length in Section 4, and is provided as Attachment 1 to this paper. In creating the data model, it is critical to capture the appropriate relationships among these entities. The core entities and their fundamental relationships within Levels 5 through 7 are depicted in Figure 2.

The relationships depicted are those between stocking and assembly perspective entities within each level. No relationships between entities at different levels have been shown at this point. These relationships have been derived directly from the seminal paper through a parsing process that has evaluated the nouns and verbs of the descriptive text. They reflect the one-to-many parent-to-child relationships between the assembly and stocking entities at each level. Logically, the stocking entities reflect the “child’s” perspective in each of these relationships. The relationships are non-identifying because the stocking perspective entities are not dependent upon the assembly perspective entities for their full specification. For example, a COMPONENT can be fully specified prior to the creation of any FORCE with which it will be associated. The core entities and their fundamental relationships within Levels 1 through 4 are depicted in Figure 3.

In interpreting each of these relationships, it is helpful to consider each of the assembly perspective entities as a “package” that consists of a number (one or more) of the stocking perspective entities. In the case of Levels 5-7, the packages reflect the “givens” with which the warfighter must deal. The mission, the environment, and the location/time elements are not generally chosen by the warfighter, but are part of the constraints provided by the mission and the circumstances of the conflict. The packaging of purposes into missions, contextual conditions into an environment, and index locations and time constraints, is a method of accurately describing these in a concise and repeatable way.

In the case of Levels 1-4, however, the packaging of stocking perspective entities into assembly “packages” is very much done with deliberate intent by the operational warfighter. At Level 4, certain tasks are creatively chosen and packaged into a relatively small number of operations designed to contribute to the objectives outlined in the mission package in Level 7. At Level 3, the planner selects a number of functions performed by the various organizations available for participation in the effort, and crafts a capability package suitable for achieving the mission objectives. At Level 2, components are selectively chosen with an eye toward their complementary functions and assembled into a force package which has real-world capabilities to accomplish objectives in the mission environment. At Level 1, interactions with the opposing force and the environment occur which, when collectively assessed, create an effects package that leads directly to changes in the states of participating components.
In this way, the data model relationships at every level reflect the stocking and assembly relationships between the two core entities at that level. The assembly perspective entity generally serves as the parent in each relationship, and the stocking perspective entity serves as the child.

3.2 Key relationships between entities at different levels

The relationships in the data model between entities at different levels of the MMF are driven primarily by the concepts of transformational operators and the definitions of key terms used in the framework. Transformational operators have been defined and designed as a method for capturing the dynamic relationships between entities at different levels as the processes of synthesis and employment are implemented in the model.

3.3 Relationships from the synthesis process

As described above, synthesis in the context of the MMF is a top-down process that captures the key steps associated with the planning process in any large-scale mission. This process is modeled in the MMF through the concept of the transformational operators shown in Figure 4.

Figure 4 The Synthesis Process Among Levels 1-4

All plans involve choices and selections. The inverse-planning synthesis operators select choices and ripple forward the planned impact of selection changes. This initial version of the MMF data model does not address the select/selection-change representation that will eventually be required for all MMF levels.

O\textsubscript{3,4}S is the inverse planning process the warfighter uses to determine the Functions, Capabilities required to complete Tasks, Operations. The output is a collection of required Level-3 Capability package specifications, especially required performance. Recommended practice is to focus on performance required to enable Tasks to accomplish Missions and to state these required Capabilities as agnostically (without reference to specific service, unit, or weapons) as possible.[1] The logical relationships between levels 3, 4, and 7 arising from this description are shown in Figure 5.

Figure 5 O\textsubscript{3,4}S Relationships, Levels 3, 4, and 7

O\textsubscript{2,3}S is the inverse planning process used to select Components and define Forces to implement Functions and deliver Capabilities required in the Level-3 specifications. This is the essence of the warfighter’s Task-organization, strike package development, or Task force design; or the engineer’s functional allocation. The output is a table of organization and equipment stated as a collection of required Level-2 Force package specifications, including measures and standards for personnel and materiel readiness.[1]

Figure 6 depicts the primary data model relationships which capture the manner in which Forces and Components provide those Level-3 Capabilities.

Figure 6 O\textsubscript{2,3}S Relationships, Levels 2-3
O₁₂S is the inverse planning process used to select Interactions to achieve state changes in Level-2 Components that will have the intended Effects on Level-2 Force packages. This is the warfighter’s target-weapon pairing and Effects-based operations, and the engineer’s technology selection. The output is a prioritized list of targets stated as a collection of required Level-1 Effects package specifications.[1]

States as Descriptors. In order to implement these relationships in the MMF data model, we must introduce the concept of states and changes of state as descriptors. As an example, states are specified for Forces and Components (at Level 2), and the outcomes imposed by the Effects generated by Interactions (at Level 1); but all levels have the same type of state changes specifying the dynamics among all levels in a closed-loop construct. In order to capture these concepts, we must introduce another entity, STATE, to the model. A STATE in the MMF can be defined as the condition of a data model entity at a certain time, specified by the value of its attributes at that instant. All Components have states which can be accurately described and specified by the assignment of conditions and values to each of these main attributes. For a combat armored component, for example, the state would include the values assigned to attributes such as number of operational vehicles, fuel and armament status of each vehicle, manning percentages, etc. Each of these main attributes would be included in the STATE entity, and this entity would have a direct relationship to the COMPONENT as well as the FORCE entity. Note that the STATE entity has an identifying relationship with FORCE and COMPONENT. Logically, a single component may have a unique state configuration which may or may not need to be reflected in the main attributes of the force package to which it is assigned. Since force packages are created to accomplish mission objectives, the major attributes of the FORCE would logically be mission-oriented attributes. The major attributes associated with a COMPONENT would logically be more detailed and routine characteristics of a subordinate unit of the force package which might not be directly related to mission capabilities, as shown in Figure 7.

In reality, all MMF Levels have states. The time-forward execution and adjudication operators change the states in each of these levels. This initial version of the data model focuses attention on the states and state changes at Level 2, Components and Forces, that enable/constrain Level 3, Functions and Capabilities. Subsequent revisions will add this state/state-change representation to all MMF Levels.

O₄₁S is the inverse planning process used to identify Tasks that, if executed to standard, will generate Level-1 Effects that will lead to mission accomplishment. The output is a Level-4 specification of Tasks and Operations that are implied if a particular concept of operations is selected to accomplish the Mission by imposing the stated Effects.[1] The relationship that this implies is depicted in Figure 8.

Each of the relationships depicted in Figure 7 and Figure 8 can be traced to the description provided in the seminal paper for the Missions and Means Framework.[1]

3.4 Relationships from the employment process

The employment process in the MMF is a bottom-up process of execution and adjudication of actual outcomes when own and opposing missions/means collide in the battlespace.[1] This process is modeled in the MMF through the concept of the transformational operators shown in Figure 9.
**O₁₂E** is the forward execution and adjudication process that takes the actual Interaction conditions that Level-1 Effects packages deliver, and then determines Level-2 Component outcomes. Output includes Effect measures of effectiveness (MoEs) for use in a subsequent invocation of the **O₁₂S** inverse planning process. The output is a prioritized list of targets stated as a collection of required Effects package specifications.[1] Figure 10 shows that this transformational operator does not call for any additional relationships beyond those previously identified in the description of **O₁₂S** above.

**O₂₃E** is the forward execution and adjudication process that takes the actual performance delivered by the specified Level-3 Capability and determines Level-4 Task outcomes. Outputs include Capability MoEs for use in a subsequent invocation of the **O₂₃S** inverse planning process.

**Tasks, Functions, and Capabilities.** In order to implement these relationships in the MMF data model, we must introduce the concept of **measures of performance** as they relate to Functions and **standards of performance** of Capabilities. The MMF is consistent with the definitions provided for these terms in the Unified Joint Task List (CJCSM350004C, page B-B-1).[3] A **measure** is a basis for comparison—a reference point against which other things can be evaluated. In the UJTL, a **measure** provides the basis for describing various levels of task performance. For example, **measures of performance** for a task such as “Communicate Tactical Information” might include the speed of transmission and the accuracy of communications. A **criterion** defines acceptable levels of performance, often expressed as a minimum acceptable level. A **standard** for a task is the combination of the **measure** with the **criterion** for that task.[3] In order to capture these concepts, the MMF data model introduces three more entities, which are associated with the entities **TASK**, **FUNCTION**, and **CAPABILITY**. Consistent with the UJTL, the MMF has defined **task** as a specific, outcome-centric, definable activity intended to achieve a specific purpose with specific and measurable results. A **function** consists of a **task** associated with a specific set of **measures** that evaluate its level of performance. The concept of a **capability** adds upon the concept of measuring performance of the **task**, and thus the concept of the **function**, by incorporating the concept of **criteria** and **standards**. A **capability** provides the description of the external value provided by a **task** by associating it with **measures of performance** (MoPs) as compared to criteria and standards necessary for success. As an example, these definitions and the relationships described...
are modeled in Levels 3-4 of the MMF data model as shown in Figure 12.

Figure 12 O_{3,4}E Relationships, Levels 3-4

All MMF operators will determine performance delivered by a generating Level to a consuming Level. This initial version of the data model focuses attention on the criteria, measures, and standards that evaluate the performance generated by Level 3, Functions and Capabilities, for consumption by Level 4, Tasks and Operations. Subsequent revisions will add this representation of criteria, measures, and standards for all MMF Levels and Operators.

O_{4,1}E is the forward execution and adjudication that takes the actual Level-4 Operations package specifications and determines which Interactions will actually occur at which Location/Time under what Environment. In this way, O_{4,1}E identifies the break down of an Operation into a time/event ordered list that gets executed as Interactions. The output is a Level-1 Effects package specification, as well as operation MoEs for use in subsequent invocation of the O_{1,2}S inverse planning processes.[1] The relationships the O_{4,1}E operator calls for are shown in Figure 13.

The aggregated view of all major relationships for the Missions and Means Framework is provided for reference as Attachment 2 to this paper. This attachment includes all relationships previously discussed as well as others arising from key definitions of terms.

Figure 13 O_{4,1}E Relationships, Levels 1, 4, 5, and 6

4. Formal Specification Requirements for Key Data Model Entities

In order to more completely formalize the MMF specification process, it is necessary to more completely define the requirements for the complete specification of the key entities. These will be done in sequence from Level 7 through Level 1. In the following discussion, any term that appears in all capital letters is intended to refer to the data model entity of the same name in the data model.

4.1 PURPOSE and MISSION

A purpose in the Missions and Means Framework is “an anticipated outcome that is intended for or guides a planned action.”[1] An important aspect of a purpose is its outcome-centric orientation, unrelated to its means of accomplishment. The complete specification for a PURPOSE requires a concise statement of the intended outcome, any association with a specific level of war (strategic national, strategic theater, operational, tactical-joint, or tactical-service), the realm (e.g. diplomatic, economic, or cultural realms at the strategic level of war), and any relationships with other purposes (e.g. subordinate or compositional relationships with overarching purposes).

A mission in the MMF is “an assignment with a purpose that clearly indicates the action to be taken and the reason therefore.”[5] From an assembly perspective, the mission represents the creative aggregation of chosen purposes into a complementary blend or framework, and marries them with the fundamental actions to be taken in their
pursuit. The complete specification for a MISSION in the MMF would include an identification of each of these purposes, the identification of the tasks or activities to be undertaken in their pursuit, the association of the mission with the appropriate level of war, and the relationships it has with other missions.

4.2 CONTEXT and ENVIRONMENT

In the MMF, context refers to the individual conditions or circumstances under which a mission is to be accomplished. Conditions are used to express variables that affect task performance, and are applied to specific actions or tasks, not to overall missions. The Universal Joint Task List (CJCSM 3500.04C) provides detailed guidance as to the characteristics and organization of conditions as they apply to the context, and identifies three broad categories—physical, military, and civil—of conditions.[3] The MMF approach to conditions remains consistent with this guidance. CONTEXT in the MMF should be properly specified through the identification of all applicable conditions.

Context becomes an environment in the MMF when a collection of context conditions is assembled into a consistent whole. This implies that the environment is an all-encompassing concept which includes all applicable conditions as they relate to the accomplishment of the mission, not only those that relate directly to the accomplishment of a single task. The complete specification requirements for the ENVIRONMENT in the framework is done through the complete identification of all applicable conditions related to the accomplishment of the overall operation, in the pursuit of the overarching goals of the mission.

4.3 INDEX and LOCATION/TIME

The index specification provides the “where” and “when” details of mission accomplishment. It is a list of individual items which provide that precise specification. The standard location indexing system recommended for use is the Global Command and Control System (GCCS) GEOfiLe System, which provides codes for specific locations, each selected as a significant global location for reference.[1] Examples of time-indexing systems are relative time offsets or sequencing rules. The complete specification of the INDEX calls for the list of all appropriate locations and times used for reference.

The location/time element is a package specification which combines the elements of “where” and “when” an operation is to be executed. The data specification of LOCATION/TIME includes the complete identification of all relevant locations and associated standard data points.

4.4 TASK and OPERATION

The task is the “do-what” named-with-a-verb model element, which is a specific, discrete, and definable activity intended to achieve a relatively narrowly defined purpose with specific and measurable results.[1] In the mission analysis and decomposition process, the task is the most elemental entity. The MMF is entirely consistent with the Universal Joint Task List approach to task and task analysis, and calls for the use of the UJTL framework for mission decomposition using the comprehensive, integrated menu of functional tasks, conditions, measure, and criteria supporting the DoD. Tasks in the MMF (and the UJTL) are organized into four separate areas by level of war, each task individually indexed to reflect its placement in the structure. For example, Strategic-National tasks are prefixed with SN, Strategic-Theater tasks are prefixed ST, Operational tasks are prefixed OP, and Tactical tasks are prefixed TA. MMF tasks have a direct relationship to specific levels of war, and also have vertical and horizontal linkages to other tasks.[3] The complete specification of a TASK in the MMF data model should include a concise statement of the activity, its relationships to specific level of war, its relationship to a specific MISSION, and its relationships with other TASKS.

The MMF operation is a military action involving the carrying out of a military mission. It is the process of carrying on combat, including movement, supply, attack, defense, and maneuvers needed to gain the objective of any battle or campaign.[1] An operation involves a number of components or forces performing many tasks in a coordinated fashion in pursuit of mission objectives. The operation is designed and specified through the process of the selection of tasks and their assignment to individual components or forces, and the design of sequence and timing to achieve synchronous and synergistic outcomes. The specification process for an OPERATION requires the complete hierarchical list of all TASKs to be performed, any vertical or horizontal linkages between TASKs, and all temporal and spatial relationships between TASKs. Note that the formal specification of the OPERATION in the MMF does not require the association of a TASK with any specific COMPONENT or FORCE.

4.5 FUNCTION and CAPABILITY

An MMF function specifies the internal necessities required to deliver capabilities.[1] The reader is referred to the paragraph subheading “Tasks, Functions, and Capabilities” in Section 3.3 above. The complete MMF specification for a FUNCTION requires the association of a specific TASK with a specific MEASURE OF PERFORMANCE. The example cited above is the
association of the task “Communicate Operational Information” with the measures speed of transmission and accuracy of transmission. This association has created the complete specification of this function.

A capability in the framework reflects the performance-centric “how well” specification necessary to conduct successful operations.[1] The important aspect of this definition is the direct relationship between the capability and success in the execution of an operation, a relationship that does not exist for a function. The reader is once again referred to the discussion of Tasks, Functions, and Capabilities included in Section 3.3 above. The appropriate specification for a CAPABILITY in the MMF requires the identification of a specific FUNCTION and associates it with specific STANDARDS. Each STANDARD, of course, is specified via the association of a MEASURE OF PERFORMANCE with a CRITERION defining an acceptable level.

4.6 COMPONENTS and FORCES

A component in the MMF is a subordinate organization serving as one of the compositional elements comprising a larger force.[1] A component is a piece or combination of pieces of the force which has been selected because it has been designed and resourced to perform a specific function in the context of overall mission objectives. A component has therefore been associated directly with one or more functions which reflect its unique potential for contributing to the mission. As described in Section 3.3 above, the current condition or status of a component is described by the conditions and values assigned to its associated state. The complete specification of the MMF model element COMPONENT calls for the identification of its name or unit designation (or the name/designation of all of its compositional elements), an itemization of personnel/materiel inventories, an association with the set of FUNCTIONs it is designed and resourced to perform as an organized entity, and all of the attributes of the STATEs which describe its condition or status. Furthermore, each COMPONENT must be associated with a STATE entity which includes all applicable conditions and values associated with its key descriptive attributes.

The concept of force in the MMF is closely associated with the accomplishment of a specific aspect of the mission. The force is a package entity created as an aggregation of selected components chosen for the complementary blend of functions each brings to the fight.[1] Typically, the force package exists only in the context of an existing mission requirement, while its compositional components typically exist prior to the conflict, after the conflict has arisen, and long after it has been resolved. The force is designed and built for the specific purpose of achieving the mission objectives. It relies upon existing components to bring their respective resources and functions to the fight. In the aggregate, these functions provide a true battlefield capability to accomplish those objectives. The complete specification for the model element FORCE in the MMF requires the association of a specific set of COMPONENTS with a specific set of CAPABILITIES in the context of a specific OPERATION being executed in pursuit of the goals and objectives of a specific MISSION. Additionally, this specification requires the identification of those attributes of STATE which are the key descriptors as to the status and viability of the FORCE as a warfighting unit pursuing MISSION objectives.

4.7 INTERACTIONS and EFFECTS

An interaction in the MMF is designed to provide a mechanism for describing how task execution changes the states of forces and components. Interactions are organized by the phenomena (e.g., physics, chemistry, biology, psychology, sociology) that generate them, and serve to generate and organize effects packages.[1] The proper specification of an INTERACTION in the MMF requires the identification of the FORCE entities involved, the comprehensive specification of all EFFECTs which are generated by the INTERACTION, an organization of those EFFECTs into packages of related results, and an identification of all model entities which are affected by these EFFECTs (e.g., the engaging parties, third parties, the environment, etc).

Effects in the MMF capture the outcomes resulting from specific interactions as they occur and progress.[1] They are the aggregated and organized results of all interactions that occur, and they provide an accurate description of all changes that occur in the affected entities (engaging parties, third parties, environment, etc.) as a direct result. The complete specification of an EFFECT requires the identification of all entities that experience a change as a result of the EFFECT, and the specific STATE change that occurs (nature and magnitude of change) as a result.

5. Conclusions and Recommendations

This paper has presented an approach for providing a concise formal specification of the Missions and Means Framework. This approach to specifying the common semantics and syntax of the framework forms the basis for the complex process of decomposition of battlefield operations into atomic elements, specifying the relationships between those elements, and recomposing them into the basic components of simulation development. In describing this specification, this paper has briefly summarized the key MMF concepts, proposed
an initial entity-relationship model that captures those concepts, and related that model directly to the theoretical basis outlined in the seminal paper for the framework.[1] Finally, it has provided additional discussion regarding the formal definitions and complete specification requirements for each model element. In doing so, the authors have initiated the next step in making this framework the valuable structure for mission analysis, modeling, and simulation that it is intended to be.

The next steps in maturing the Missions and Means Framework development include fully specifying the proposed “generic” data model to include appropriate attributes for each entity, documenting the model common semantics and syntax more completely, and developing recommended practices guidance for future application of the framework. Furthermore, additional development efforts should begin to construct the necessary overlays to the “generic” data model that would tailor it for fully capturing the requirements associated with real-world military operations, systems engineering, and training. In sum, this would involve the more complete systems engineering specification necessary to make the MMF a more useful and widely accepted approach to mission analysis and modeling and simulation alike.

6. References


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Author Biographies

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CAROLYN HARE is a systems analyst at the Signal and Information Sciences Laboratory, Applied Research Laboratories, The University of Texas at Austin. She currently works as a key analyst in the development of a formal data model for the MMF. Ms. Hare has 18 years of experience working in support of various projects in the defense community.

ROY SCRUDDER is a program manager at the Signal and Information Science Laboratory, Applied Research Laboratories, The University of Texas at Austin. He holds a BS Degree in Mathematics from the University of Tennessee. Mr. Scrudder has over 25 years’ experience in systems analysis and design, with the last 15 years working in support of various data engineering and data management projects in the defense community. He currently provides data engineering expertise to the Joint Strike Fighter, Multi-mission Maritime Aircraft, and Army and Joint command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) and simulation initialization efforts.

JACK SHEEHAN is the Chief Engineer, Future Combat Systems Program Office, Combined Test Organization, Department of the Army. He has over 25 years’ experience in systems analysis and design, with particular emphasis on the application of modeling and simulation to real-world conflicts, planning, and analysis. He holds undergraduate degrees in nuclear and electrical engineering from Texas A&M University and a graduate degree in Electrical and Computer Engineering from The University of Texas at Austin.
### Attachment 1 Definition of Key Terms

(Terms appearing in all capital letters are entities in the MMF Data Model)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>CAPABILITY</td>
<td>The ability to execute a specified course of action under a specified set of circumstances or conditions</td>
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<tr>
<td>COMPONENT</td>
<td>One of the subordinate organizations that constitute a FORCE package, or one of the subordinate elements that constitute a materiel system</td>
</tr>
<tr>
<td>CONTEXT</td>
<td>The individual conditions/circumstances under which a mission is to be accomplished</td>
</tr>
<tr>
<td>CRITERION</td>
<td>The acceptable level of performance to accomplish the mission</td>
</tr>
<tr>
<td>EFFECT</td>
<td>The phenomena-centric specification of the changes of state for components and forces resulting from mission space interactions</td>
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<tr>
<td>Employment</td>
<td>The bottom-up execution and adjudication of actual outcomes when opposing forces collide in the mission space</td>
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<tr>
<td>ENVIRONMENT</td>
<td>The collection of context conditions that are assembled into a consistent whole</td>
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<tr>
<td>FORCE</td>
<td>The “by whom” network of physical and virtually integrated units, personnel, and equipment that are the “players” in military evolutions.</td>
</tr>
<tr>
<td>FUNCTION</td>
<td>A key contribution made by a FORCE in the mission space. Specified by associating a TASK with a MEASURE OF PERFORMANCE</td>
</tr>
<tr>
<td>INDEX</td>
<td>A list of individual locations and times of interest in the mission space</td>
</tr>
<tr>
<td>INTERACTIONS</td>
<td>The phenomena-centric specification of the EFFECTs generated by the collision of opposing entities in the mission space</td>
</tr>
<tr>
<td>LOCATION</td>
<td>“Where” in terms of geo-spatial/military geometry</td>
</tr>
<tr>
<td>LOCATION/TIME</td>
<td>The data package specifying both the “where” and the “when” in terms of geo-spatial/military geometry and chronology</td>
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<td>MEASURE OF PERFORMANCE</td>
<td>The objective metrics of the “outcomes’ of tactical actions, the level achieved by a FORCE as it implements a function</td>
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<tr>
<td>MISSION</td>
<td>The essential activities assigned to a unit or individual, containing the elements of who, what, when, where, and why.</td>
</tr>
<tr>
<td>PURPOSE</td>
<td>The anticipated outcome that is intended for or guides a planned action</td>
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<td>STANDARD</td>
<td>The metric against which the outputs of a process are compared and declared acceptable/unacceptable. Specified by associating a MEASURE with a CRITERION.</td>
</tr>
<tr>
<td>STATE</td>
<td>The condition of a data model entity at a given time, specified by the value of its attributes at that instant.</td>
</tr>
<tr>
<td>Synthesis</td>
<td>The top-down planning and decision-making process used to create, define, and design a military evolution to meet mission requirements</td>
</tr>
<tr>
<td>TASK</td>
<td>A specific, definable activity that is intended to achieve a specific purpose with specific and measurable results</td>
</tr>
</tbody>
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