

Task Based Approach to Planning

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ABSTRACT: The Task Based Approach to Planning utilizes doctrinal tasks (AUTL, MTP, etc) in context to the planning cycle represented by the Army's Military Decision Making Process (MDMP).

- Receipt of Mission
- Mission Analysis
- COA Development
- COA Analysis (Wargaming)
- COA Comparison
- COA Approval
- Orders Production

This paper explores the feasibility of enabling a semi-automated military decision making process across all steps of the Military Decision Making Process (MDMP). Automation of these steps depends on successful integration of CGF systems, JC3IEDM, battle management language represented by collective tasks and their associated measures of performance and effectiveness.

The approach to automation of the MDMP is to focus on associating command and control aspects of the MDMP to the measures and decision points of collective tasks. Decision points represent potential branches for future courses of action. Measures of collective tasks provide a common means for comparing the future value of each COA branch. Common criteria or measures of effectiveness (MOE), for comparing COA branches at a decision point, are derived through backwards planning. These MOEs represent measures for mission success. The COA (branch) specific measures of performance (MOP) are used to evaluate each COA by the common set of MOEs. The decision points are identified by backwards planning from the final objective to the start of the mission. The decisions to be made are in specific context to the current situation (METT-TC) and means of accomplishing each COA branch. The measures of the decision point's (DP) objective situation are represented by a METT-TC estimate derived through backwards planning. These DP measures are criteria for evaluating the effectiveness of COA options (candidate branches). The METT-TC measures of performance resulting from COA analysis (wargaming) are used to generate each COA's value or MOE. The DP criteria are used to evaluate and compare the COA options by their respective MOE values. The commander is responsible for identifying decision points, the criteria, and weights for assessing MOEs of the options. The COA generation, analysis, and comparison are the focus of the automated MDMP.

1 Introduction

The analog steps of COA Analysis and Comparison are currently as subjective as they are quantitative. If we assume the Army's MTP tasks can be modeled computationally, those tasks could be used to analyze and assess options just as they are used to analyze and assess the proficiency of combat elements. If MTP tasks can be

used to assess SAF-CGF performance, it must be assumed that CGF combat elements are proficient in task performance. This assumption appears to hold true for SAF-CGF systems developed from task based doctrine, such as OneSAF. What is missing from the SAF-CGF behaviors is the cognitive ability to perform effective command and control (balance resource means with constraints of the mission).

1.1 Operational View

The Task Based Approach to Planning utilizes Army tasks (AUTL, MTP, etc) in context to the planning cycle represented by the Army’s Military Decision Making Process (MDMP). Figure 1: Operational Planning and the MDMP below depict the relationship of the MDMP to data representations of task based planning.

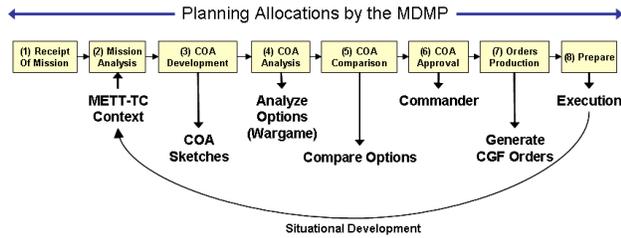


Figure 1: Operational Planning and the MDMP

The steps of COA Analysis and Comparison are both subjective as well as quantitative. If we assume the Army’s MTP tasks can be modeled computationally, those tasks could be used to analyze and assess options just as they are used to analyze and assess the proficiency of combat elements.

1.2 Operational to System View Matrix

The Task Based Planning components align very well with the steps of the MDMP as shown in Figure 2: Task Based Planning and the MDMP.

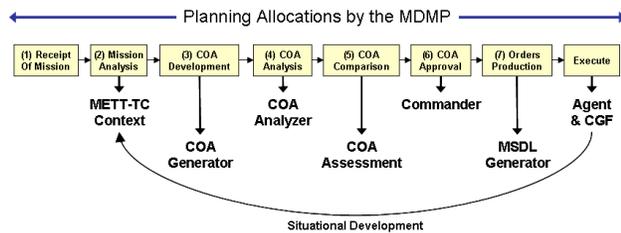


Figure 2: Task Based Planning and the MDMP

Knowing how components of Task Based Planning relate to the MDMP enables the developer to integrate Army tasks within this context. These tasks are used to computationally assess the proficiency of units in the conduct of the tasks. The assumption is that these same tasks can be used to computationally assess the feasibility of a task’s performance being effective in context to a mission or COA.

1.3 Operational Task Based Planning

The Task Based concept is an innovative approach to using the Army’s Universal Task List (AUTL) to support the assessment and decision making of ongoing military operations while they are being conducted. The approach is to maintain a state space graph of possible future states related to the potential effectiveness of tasks as they relate

to mission objectives. Software agents use tasks and assessments of tasks on the trajectory of the ongoing operation, to estimate future value (effectiveness) of available options. For example, Lanchester equations and Bayesian networks can be used to determine the likelihood of each option’s success. Options are generated automatically or semi-automatically by placing a set of Mission Training Plan (MTP) tasks into a specific situational METT-TC context. The METT-TC context provides for measures of effectiveness which constrain acceptable (effective) performance. The measurements of performance (MOPs) are achieved using a Lancaster and Bayesian based simulation driven by the current situational factors of METT-TC. Each task is evaluated by the MTP tasks which form templates for assessment of an option’s effectiveness. Specific MTP tasks are selected as templates given the AUTL and the unit/element performing the task; Infantry Company for example. Task steps flagged in the MTP as leader tasks equate to decision points. Task steps and performance measures flagged as critical drive commander’s critical information requirements (CCIR) that must be measured or estimated before an option can be selected as a viable (feasible) branch of execution. The COA Generator evaluates the MTP task to place the performance measures into the proper METT-TC context. That context represents the measures of performance for each performance measure. The COA Analyzer evaluates these MOPs based on boundary conditions of the tasks represented as resource constraints to include time in order to determine a TPU evaluation. Tasks which are evaluated to Uneffective are eliminated as possible steps for any option. Tasks evaluated to Partially effective are refined by modifying performance criteria (measures designated in the order). Tasks evaluated as Totally effective are adopted as part of the option. If a complete set of tasks cannot be identified as effective for an option that option is trimmed from the tree.

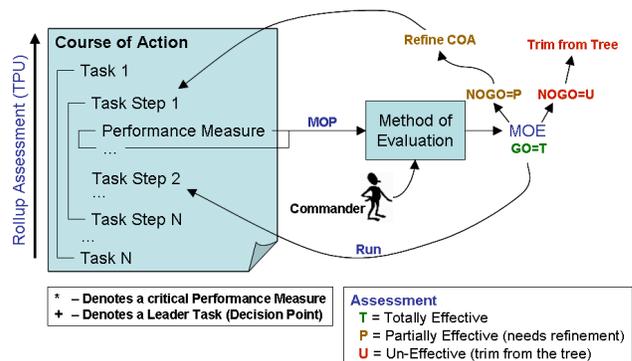


Figure 3: Computational Task Based Planning & Analysis

1.4 Operational Task Based Planning and the MDMP

Given the task based approach to planning can be used to generate options and assess the feasibility of those options, an assumption, this approach can be put into the common context of the MDMP as depicted in Figure 4: Task Based Planning and Automation of the MDMP.

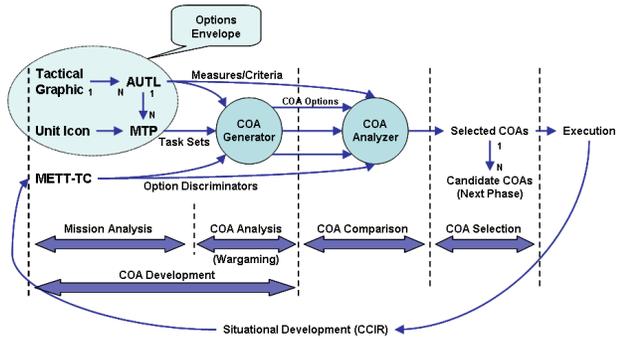


Figure 4: Task Based Planning and Automation of the MDMP

The tactical graphics represented by the sketch apply to one or more AUTL tasks. Each AUTL task represents a universal standard set of measures across MTPs. This means one or more MTP mission task sets are related to each AUTL task. The appropriate MTPs are selected based on the functional type of unit as specified by the unit icon (type and echelon) on the sketch.

The selection of AUTL tasks based on the tactical graphic enables the identification of options at the mission level. Each AUTL task then maps to one or more mission task sets by unit type and echelon. The set of options are further scoped by the identification of the tactical graphic. Individual options are generated by identifying the AUTL task(s), unit type & echelon, and then the MTP mission task sets. The total set of options encompasses the “Options Envelop” for planning. This envelop expands upon an N^2 paradigm of options. Candidate options are selected based on the criteria (designated measures) and constraints which are the factors of mission, enemy, troops, terrain, and time constraints (METT-TC). These discriminators are used to differentiate measures into groups of MOPs and MOEs for use by COA Generator and COA Analyzer.

1.5 Sketch the Plan

Graphics entered in a COA sketch represent higher headquarters (HHQ) inputs to the task based approach to planning. This means the task based approach to planning is used to evaluate options for the subordinate elements to achieve their HHQ objectives as represented by the sketch (commander’s intent).

In this phase of planning the commander’s sketch is translated into 2525B graphics. These graphics are then used to identify the applicable AUTL tasks.

1.6 Army Universal Task List

The AUTL tasks provide a common framework of measures used to first assess the feasibility of a COA, and second to compare COA options leading to the selection of the COA that best answers the higher headquarters (HHQ) objectives (risks, resource utilization, synchronization, etc). However, the AUTL does not provide sufficient detail to enable these processes to succeed. The AUTL does not place the task in context of the steps to be performed, the type of unit that will conduct the task, nor does it place the measures into context of the task’s performance. These requirements are provided for by Mission Training Plans that are specific to the unit type/size conducting the task. The AUTL can be used to identify the MTP missions/tasks which apply as well as the AUTL task(s) which proceed and follow each any AUTL task (horizontal planning). Therefore the AUTL is used in conjunction with the COA sketch to identify options in terms of the types of units to be used for a COA, and the mission task sets those units will perform.

1.7 COA Generator, the MTP Tasks and COA Analysis

MTP tasks place AUTL tasks into context of the element (unit) that is being tasked. The AUTL tasks are used in conjunction with MTP tasks to:

- Identify which MTPs apply to the AUTL, representing options of which types of units can accomplish the COA (mission) represented by the sketch.
- Identify options which are a list of MTP missions (task sets), specific to each type of unit, representing the combination of one or more MTP tasks.
- Specify the effective measures (criteria) that apply to each MTP task, in specific context to the situation related to the graphics (sketch).

These criteria are then placed in specific context of the METT-TC situation that is provided for in the COA sketch using a method of evaluation to generate a value or measure of effectiveness. The combination of these factors provides the MOE values for each MTP task in a COA specific context.

$$MOE = MethodofEvaluation(METT-TC, Criteria, MOPs)$$

Those performance measures of the MTP task designated as critical (*) represent the basis for identifying the commander’s critical information requirements (CCIR).

Those measures designated as leader (+) represent potential decision points (DP) for the COA.

The COA Generator then estimates the measures of performance for each performance measure. These MOP estimates are then used by methods of evaluation to estimate the MOE. Given these MOPs and MOEs for each option, the COA Analyzer can assess the tasks, steps, and performance measures based on the measures of effectiveness and task criticality.

1.8 COA Analyzer and COA Selection

Because an AUTL task has a single set of measures, these measures can be used as common criteria (selection criteria), and task specific MOP values which represent the inputs to the weighting scheme used to compare the relative values of COA options. The weighting scheme is represented by the doctrinal rollup of Go-NoGo measures of performance for each MTP task resulting in a TPU rating, where T=Totally Effective, P=Partially Effective, and U=Un-effective.

1.9 Situational Development

As a COA executes (develops), the METT-TC situation changes. These changes enable a more informed selection or development of a COA for the next phase of execution given the previously identified set of Candidate COAs.

1.10 Task Hierarchy and Backwards Planning

Tasks are by nature hierarchical. Each step of a task is representative of a task (sub-task) in and of itself. This sub-task may be defined in the same task document (MTP), or in another collective task document. A battalion task consisted of commander/leader tasks (decision points) as well as aggregations of subordinate tasks. The top of the hierarchy is the AUTL. The AUTL specifies the measures that apply to all lower MTP tasks. These MTP tasks place each AUTL task in specific context to the type and size of the element (unit) performing the task. The MTP also places the measures in specific context to the performance (steps) of the task.

Consider a battalion level task as representing a mission or phase of a mission to the battalion's subordinate elements. The objective and designate measures (criteria) of the battalion task constrains the options for how subordinate elements will perform their tasks. It specifies the criteria for evaluating MOE values of the tasks. These criteria of a HHQ task's objectives represent the effective future for a subordinate's performance. The top-down decomposition of tasks is the basis for backwards, or top-down planning.

Each MTP task identifies the unit's element to which it applies. So, an Infantry Battalion MTP will identify which

tasks apply to each class/type of subordinate element (HHC, Infantry Company, FA Battery, etc). So the MTP tasks decompose vertically down to the subordinate elements of the unit.

1.11 Task Sequence

The AUTL does more than identify measures of universal Army tasks. It also identifies the situational context for when the task is to be performed, and the tasks to follow. The identification of the tasks to follow provides the knowledge of why a task is to be performed. For example conduct tactical road march is performed to relocate a unit to an area of operations. If the unit is already in the correct area, that task can be eliminated (dropped) from consideration for an option or branch. So, AUTL can be used to propose follow on tasks as subsequent courses of action.

2 Systems View

The systems view identifies connectivity and information flow between components of a system. Here we investigate this view from two contexts. First we examine the inter-connections between the task based planner and other components of the system. Second, we examine the intra-connections within the task based planner.

2.1 Inter-Connectivity

The Inter-Connectivity system view identifies the logical connections between the task based planner and other system components.

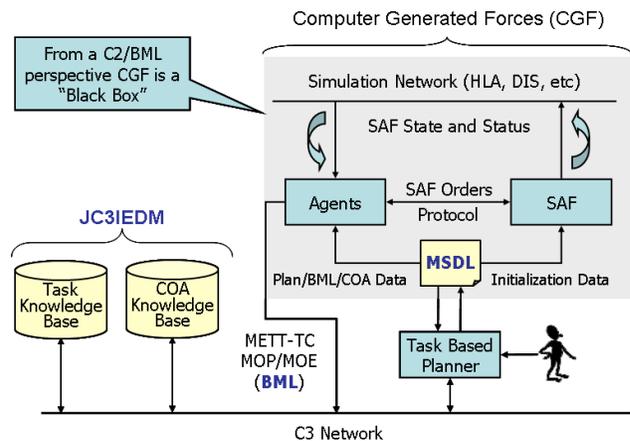


Figure 5: Systems Inter-Connectivity View

- Computer Generated Forces (CGF) – In this context, CGF is used to indicate a near-fully automated SAF that includes intelligent Agents that provide for automated command and control over a SAF. These agents effectively model/simulate a military role player.

- Agents – Intelligent C2 Agents are used to command and control the SAF. These agents interpret measures (criteria) from the orders (MSDL/BML) to compute MOP values as inputs to SAF orders. As the situation develops these agents re-compute the inputs as necessary to ensure the SAF performs effectively. When C2 over SAF performance is not effective, the Agent then raises alerts as situational reports to the operator so the COA (task/order) can be re-planned accordingly. For example, if a unit is unable to reach a coordination point in time, the plan will need to be resynchronized.
- Semi-Automated Forces (SAF) – SAF systems are performance based. They execute tasks based on variables that don't cross-correlate in context to measures of an order. SAF systems don't perform tradeoffs between measures; trade off speed for security for example. So a for a traveling order, a SAF would take inputs of a route, and traveling speed, rather than a start point, end point, level of security, and times to begin and end the travel. Stated in another way, SAF orders require the operator to specify the specific means for accomplishing the mission. By constraining the means we constrain flexibility of the SAF which mitigates cross-correlation between measures of the task. The flexibility of C2 is applied to Agents, not the SAF. Just as a driver provides for C2 over the performance of a vehicle.
- Military Scenario Definition Language (MSDL) – MSDL is used to capture the plan coming out of the Task Based Planner as input to the CGF and other operational components of command and control.
- BML – BML is used to publish and subscribe to situational and COA developments/updates.
- JC3IEDM – JC3IEDM provides the logical data model for persisting MSDL and BML details during simulation/execution.

2.2 Intra-Connectivity

The Intra-Connectivity system view identifies the logical connections between internal components of the task based planner. This systems connectivity view focuses on data flow and the inter-dependencies of the data that drive use case dependencies. This view does not reflect an actual use case. In particular the feedback loop of re-planning as the situation develops is not represented.

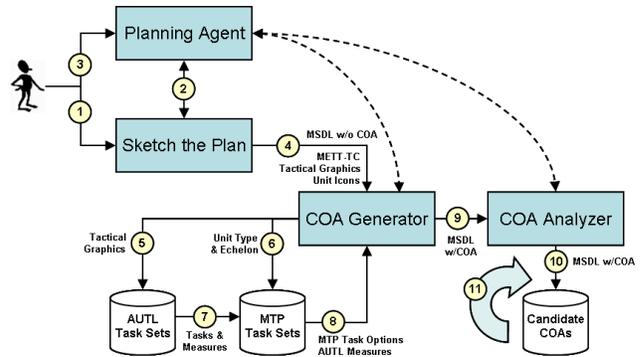


Figure 6: Systems Intra-Connectivity View

- Sketched tactical graphics representing control measures and unit icons (disposition) are entered by the commander.
- MIL STD 2525B symbology are derived by the planning agent based on the commander's sketch.
- The commander constrains the selection/derivation of 2525B tactical symbology.
- The resulting tactical graphics and unit icons are produced in a known METT-TC context. The METT-TC context is represented by time frame, disposition of troops, and disposition of threats.
- The COA Generator uses the tactical graphics (verbs) to identify candidate AUTL tasks. The AUTL tasks provide common criteria (measures) that apply across unit doctrine (MTP tasks).
- The COA Generator uses the unit icons to scope candidate MTP task sets. These represent the complete set of MTP tasks that apply to the unit type/size.
- AUTL tasks and measures are used to select candidate MTP tasks (options) from the candidate MTP task sets.
- Selected candidate MTP tasks and AUTL measures are used by the COA Generator to generate proposed COA options in the specified METT-TC context.
- Proposed COA options are output in MSDL for analysis. These COA options represent the Options Envelop to be trimmed through computational analysis as the METT-TC situation develops. The tasks are captured in MSDL using constructs of C-BML grammar.
- Candidate COAs, those that are feasible in the current context, are output in MSDL.
- As the situation develops (current context), candidate COAs are trimmed from the options. This re-planning loop is not limited to the COA Analyzer. The loop involves additional iterations over all ten steps of the process.

2.3 Sketch the Plan

Sketch the Plan takes the commander's inputs as a sketch and outputs 2525B graphics and task organization elements (unit icons). The results are output to the COA Generator in MSDL format. This MSDL scenario would initially include aggregate units, tactical graphics and overlays, and other METT-TC situational details. In a re-planning mode, the MSDL scenario may include candidate COAs in addition to the situational scope.

2.4 COA Generator

The COA Generator identifies candidate AUTL tasks that apply to each tactical graphic. The COA Generator interacts with the Planning Agent to further constrain options by trimming the set of AUTL tasks, and candidate MTP task sets (units to perform the task). As the plan develops, specific units are allocated to the array of unit icons. The designation of these units includes identification of their METL. The identification of the METL further constrains COA options provided within the MTP task sets.

2.5 COA Analyzer

COA analyzer auto-evaluates estimates of task performance given resources and probabilities of success. The probability of success for each task is derived from the estimates of the developing situational context or conditions under which the task will be executed. The standard of deviation of these probabilities decreases as the currency of information of the situational context develops. This situational context includes threat disposition, environment (weather, obstacles, etc), unit designations and disposition, available time, etc.

2.6 SAF/CGF

Semi-automated forces are initialized by instancing the MSDL scenario as simulation models. The COA within the MSDL scenario cannot be imported directly by a SAF. The problem is that SAF systems don't generally take performance criteria as inputs. SAF systems do generally take measures of performance as inputs. For example, speed or rate of travel is a common input for any traveling order. However speed relates to measures of arrival time, security, concealment, etc. If a SAF accepted arrival time, level of security, and level of concealment as inputs, these three would decompose to different objective rates of travel. This is a classic case of a cross-correlation between correlated sets of variables being the measures. Cross correlations exist when variables are shared across correlated sets of variables used to estimate the values for measures of effectiveness. A primary responsibility of a SAF role player is to automate the de-confliction of these measures through trade offs and re-planning.

2.7 Agents

Automated role players are used to keep SAF performance effective (synchronized). These agents are also used to initiate re-planning efforts of the COA as the situation develops. Note, the Agents applied to the inter-connectivity and intra-connectivity view perform different activities. However, both require the ability to determine COA effectiveness. The SAF Agent evaluates effectiveness of execution in progress. The Planning Agent evaluates the effectiveness of a COA by the estimation of each COA's future value. What is important to understand is that a common representation of effectiveness (measures and methods of evaluation) must be shared across all planning components (CGF, COA Generator, COA Analyzer, Commander, etc).

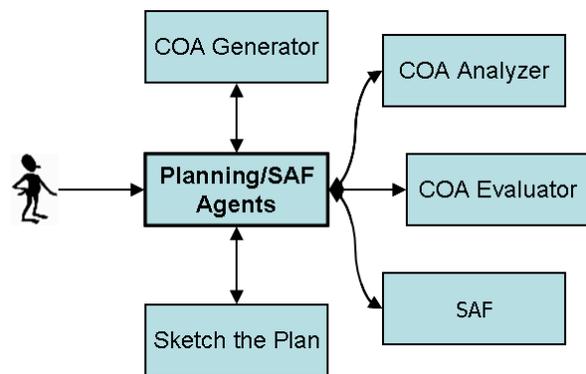


Figure 7: Agents as a Common Effectiveness Engine

This concept of effectiveness represents a thread of common understanding or standard that binds the planning system together end-to-end. For example, a SAF importing an MSDL COA would depend on an agent or role player to de-conflict the order's criteria, otherwise an import of MSDL COA would ignore the planned intent of how the task is to be effective in affecting the current situation. This paper has allocated the understanding of effectiveness to the agents as a common component which integrates to all other components of the planning system. In this context the Agents represent an effectiveness engine that relies on the commander's inputs to clarify intent and de-conflict the plan.

3 Technical Standards View

The technical standards view brings the planning effort into context of existing standards used across the Army today. This view is critical to bridging a common understanding between military subject matter experts and the engineers/scientist who develop automated planning systems. This view places planning into a technical standards context, a military training context, and a context of C2 data exchange.

3.1 AUTL

The AUTL tasks provide a standard set of measures that can be applied across the Army's Mission Training Plans. These measures can be used to develop common criteria and methods of evaluation for assessing measures of performance (MOP). The result is the estimation of measures of effectiveness (MOE) for a task in a specific context. The difference between a MOP and criteria of effectiveness is the context of that measure in an order. Measures designated in the order are evaluation (effectiveness) criteria for evaluating performance through a method of evaluation. The output of the method of evaluation is the measure of effectiveness of a task's performance. Measures that are prescribed (guidance) or otherwise left to the task unit to select/determine are measures of performance. The smaller the number of evaluation criterion specified in the order, the greater flexibility a unit has in performing the task. It is this flexibility that leads to the "Options Envelop" encompassing the various means available to accomplish the mission.

$$MOE = MethodofEvaluation(Constraints_{c=1 to C}, MOP_{p=1 to P}, Criterion_{n=1 to N})$$

Equation 1: Method of Evaluation

Where the constraints are METT-TC based, the MOPs and Criteria are the measures of the AUTL task. Criteria are those measures that are specified in the order (tasking). MOPs are those measures the unit is free to select/determine to provide for effective performance (MOE). In the mission and means framework the method of evaluation is equivalent to the $O_{4,1x}$ operator [5].

3.2 Mission Training Plans

The MTPs provide methods of evaluating performance of collective tasks. Each MTP is specific to a type of unit (proponent school) as well as size (echelon). The task identifies conditions for execution, standard/object of the task, and the steps & performance measures used to evaluate the task performance. Each MTP task places an AUTL task into specific context of the means, or type of unit, to execute the task. The GO-NOGO steps and performance measures of the MTP task are used as a method of evaluation in specific context of the type of unit performing the task. This enables evaluation of the feasibility of a planned task as well as assessment of ongoing task performance in specific context of a unit or type of unit.

3.3 MSDL

The MSDL based scenarios capture the initial synchronized plan as a basis of common C2 across components. MSDL is used to initialize the Agents, SAF and JC3IEDM data with an initial course of action and

situational context. During execution, as the situation develops the COA is developed accordingly, but the MSDL is retained in its original context. When a COA deviates sufficiently (the threshold of success has passed), re-planning produces an updated or new MSDL COA as a FRAGO. This is then used to redirect execution by replacing part or all of the COA in progress.

3.4 C-BML

C-BML data is used to share the developing situation as well as planned courses of action (orders and tasks) which will serve to change that situation. C-BML is used as a language of command and control for all forces, human, robotic and simulated (SAF). C-BML is defined based on JC3IEDM schema subsets plus other meta data. C-BML is developed from doctrinal tasks. These tasks are decomposed to their atomic JC3IEDM representations. This decomposition provides a common computational representation of tasks that can be interpreted across doctrines (nations and services). C-BML is not intended to be directly interpretable by a SAF. A role player or software agent is required to interpret C-BML in context to a SAF order. This is a natural consequence resulting from the intentional C2 flexibility provided for in orders.

3.5 JC3IEDM

The JC3IEDM represents the logical data model of command and control information to be shared. It is assumed the JC3IEDM includes the complete scope of C2 data. Under that assumption, the JC3IEDM represents the world (ontology) that is described by any language of C2. Such languages include C-BML and MSDL. All C2 objects, actions, and relationships can be described using subsets of the JC3IEDM schema. This does not mean that languages such as C-BML and MSDL include only JC3IEDM data constructs. Terms making up MSDL and C-BML are fully not constrained by their ontology. Descriptive terms (abstractions) are necessary above and beyond the ontology itself to describe the intent of C2 in context to the ontology (how C2 is intended to change the world). Task measures represent a good example of this concept. For example a measure of "% Fratricide" represents an abstract description of how the world is altered in context to a task and the METT-TC situation of that task.

4 Conclusions

The challenges of providing for automated planning based on military universal and collective tasks requires a level of interoperability for command and control. Given a task based representation of courses of action is feasible; a common standard for C2 needs to exist to make the COA representation interoperable across systems and system components. This interoperability requires a common

understanding (standard) for interpreting the effectiveness of task performance. The concept of using standards as a means for interoperability is hardly new. Reference the Mission and Means Framework [5]. However, the concept that training standards apply to C2 interoperability between systems is often overlooked. This concept/approach indicates that solutions to technical standards can be found in other disciplines and areas of study. In this case measures of AUTL tasks and the associated methods of evaluating effectiveness can provide for 'effective' C2 interoperability. This is of course why the AUTL and MTP tasks were developed. These standards ensure actual military units can interoperate in the performance of their missions. While the concept holds promise for the modeling and simulation community, there remains much work in standardizing measures and associated methods of evaluation across doctrines. Without such standards for C2, other standards such as MSDL and C-BML will be limited in the degree of interoperability that can be achieved.

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