Towards a Maritime Domain Extension to Coalition Battle Management Language: Initial Findings and Way Forward

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ABSTRACT: *This paper describes initial findings of a multi-national research effort within the NATO Modeling and Simulation Group Technical Activity 085 (MSG-085) Standardization for C2-Simulation Interoperation, to investigate the use of Coalition Battle Management Language (C-BML) in the maritime domain. The purpose of the effort is to develop a maritime extension to C-BML that will be used for expressing and exchanging plans, orders and reports specific to the maritime domain. The current research and experimentation described in this paper cover the exchange of selected parts of two naval operational messages: Operational General Matters (OPGEN) and Operational Tasking of Anti-Surface Warfare (OPTASK ASUW). A set of information exchange requirements has been developed based on an operational scenario including a Naval Coalition Task Force (CTF) conducting naval operations. Initial findings and lessons learned presented in this paper will be used to create a more comprehensive maritime C-BML extension to be tested during the final experimentation event of MSG-085.*

1. Introduction

Simulation systems are an integral part of many military enterprise activities such as training, planning and experimentation. To support these activities, it is necessary that command and control (C2) and simulation systems share information. To facilitate the seamless exchange of military information such as orders, reports and requests one can define a C2-Simulation (C2-SIM) federation of systems. The end goal is not only to share information, but rather to specify a common, standardized approach that also supports the acquisition and evolution of the systems comprising the C2-SIM federation and to do so in a repeatable, cost-effective manner. Therefore, standardization is critical to ensure the key benefits of C2-SIM interoperability can be achieved and repeated.

The NATO Modeling and Simulation Group commissioned the start of Technical Activity (TA) MSG-085 "Standardization for C2-Simulation Interoperation" in 2010, as a successor to MSG-048 "C-BML" [1], [2]. The objective of MSG-048 was to investigate the potential employment of the Coalition Battle Management Language (C-BML) for multinational and NATO C2 to simulation interoperability. As a follow on TA to MSG-048, MSG-085 was tasked to assess the operational relevance of C-BML and assist in increasing the Technical Readiness Level of C-BML technology to a level consistent with operational employment by stakeholders. To accomplish its mission, MSG-085 is focusing on operational and technical requirements of C2 to simulation interoperability for each service (Maritime, Land and Air) to ensure the operational relevance of C-BML for multinational and multi-service use.

The purpose of this paper is to report recent work that has been conducted concerning the application of MSDL and C-BML for use in the maritime domain. In particular, this paper describes required extensions to C-BML that are needed to support maritime operations and some of the initial findings and lessons learned from preliminary use of C-BML for supporting operational tasking of Anti-Surface Warfare (ASUW).

The paper is organized as follows: Section 2 gives an overview of the research effort including objectives, focus, and methodology. Section 3 provides the maritime operational context that has been used for this research. Section 4 discusses findings of C-BML modeling for maritime domain. Section 5 presents the way ahead and Section 6 presents the conclusions.

2. Overview

2.1. C-BML in Multi-Domain

The concept for a Battle Management Language (BML) as a means to automate the execution of military operations by simulated forces in the conduct of military enterprise activities (e.g. command post training, mission planning and experimentation) was introduced over a decade ago [3]. The original work defined a model as the basis for standardized machine to machine language for use by intelligent software agents to execute military functions and also to interface with the human controller. This work also defined the five key factors: *Who, What, When, Where* and *Why* (*aka* the five W's) that allow simulated units to: analyze their situation; project the end state of an operation; determine a course of action; and execute a course of action [3].

C-BML is a variant of BML that is being developed by the Simulation Interoperability Standards Organization (SISO) as an unambiguous formal language for the exchange of digitized representations of military information such as orders, requests and reports during the execution of military scenarios [4]. For the initialization of simulation systems, SISO has developed the Military Scenario Definition Language (MSDL), released as a standard in 2008 [5]. Combined use of MSDL and C-BML together can provide a capability for defining, initializing and executing military scenarios.

The initial concept of a Battle Management Language (BML), standardizing the interfaces between Command, Control, Communications, Computers, and Intelligence (C4I) systems and simulations, was mainly built on Army requirements. Although the problems related to C4I to simulation inter-operation are not unique to land forces, most of the initial work on BML was based on Army concepts, doctrines and procedures [6], [7].

With the increasing employment of coalition forces within the NATO operations, an emerging requirement for a multi-service and multinational BML encompassing Joint Coalition Forces was addressed and formulated in [8]. The first successful attempt to prove the feasibility of multi-service use of BML was conducted in a prototype system demonstration at the Interservice Industry Training, Simulation and Education Conference (I/ITSEC) 2004 event. In this demonstration, air operations were added to existing ground operations within BML using a common representation [9].

Although some work already has been conducted in the maritime domain [10], much of the research in C2-to-simulation interoperability has dealt with the land and air domains. The use of C-BML for autonomous unmanned surface vehicle patrol tasking within an anti-piracy mission is described in [11]. This preliminary work identified several areas where the preliminary SISO Phase 1 C-BML product required extensions, and potential areas of improvement. Despite the continuous efforts of SISO and NATO in relation to the multi-service operational employment and standardization of C-BML, there remains a gap regarding the use of C-BML in the maritime domain.

2.2. MSG-085 Technical Activity Objectives

The combined used of C-BML and MSDL standards has been the focus of recent experimentation activities within MSG-085 [12]. Main objectives of the overall MSG-085 Technical Activity are to:

1. Clarify and complement existing C-BML and MSDL requirements;
2. Propose a set of C-BML orders and reports to serve as a common reference set;
3. Assess and leverage available C-BML implementations;
4. Address C2 and simulation initialization requirements; and
5. Demonstrate the operational relevance and benefits of the approaches considered.

2.3. Research Objectives and Methodology

MSG-085 Programme of Work (POW) mandates the following objectives to ensure the operational relevance of C-BML: (1) Investigation of multi-level and multi-service use of C-BML. (2) Identification of operational/technical requirements to ensure that CBML supports multinational and multi-service use. Based on these objectives, the research effort described in this paper focuses on investigating the use of C-BML in the maritime domain. It aims to develop and test a preliminary maritime extension to C-BML in order to express and exchange plans, orders and reports specific to the maritime domain.

One of the primary goals of this research is to establish a set of requirements for a maritime BML extension. A requirements driven approach has several advantages, including ensuring that the resulting C-BML product is grounded in military operational procedures and is consistent with the associated operational message flows. Figure 1 depicts a mission-focused, requirements-based approach to define information requirements (IR) and information exchange requirements (IER) for the C-BML information products. Shown in green are the elements taken from actual operations procedures, while depicted in gray are the derived elements that are used to construct the maritime C-BML.

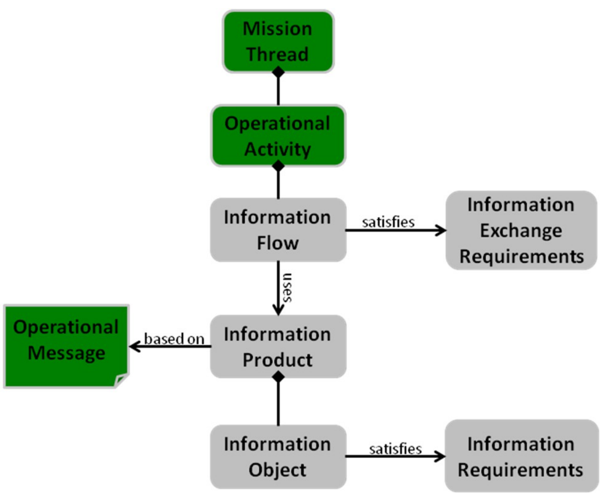

Figure 1. Operational Procedures based Requirements Approach for C-BML

The methodology applied in this research can be summarized as follows:

1. Preparation of example operational messages in accordance with a naval operational scenario.
2. Development of an initial set of prioritized IERs based on message templates in APP-11(C).
3. Mapping of the prioritized IERs to C-BML expression/ elements using a scenario based modeling approach.
4. Development of maritime tasking grammar using Command and Control Lexical Grammar (C2LG).

The following paragraphs outline the tasks that were executed to achieve the expected results.

Identify and document an initial set of C-BML Information Exchange Requirements (IERs) for the maritime domain. The information requirements allow for the specification of information objects (i.e. C-BML expressions) that comprise information products (i.e. C-BML messages). Vocabulary or *lexicon* and grammar or *syntax* are necessary but not sufficient to support the required information flows. For example, metadata also is needed such that messages can reference expressions contained in other messages, as in operations. As part of the maritime C-BML requirements activity, both information requirements and information exchange requirements were identified and documented.

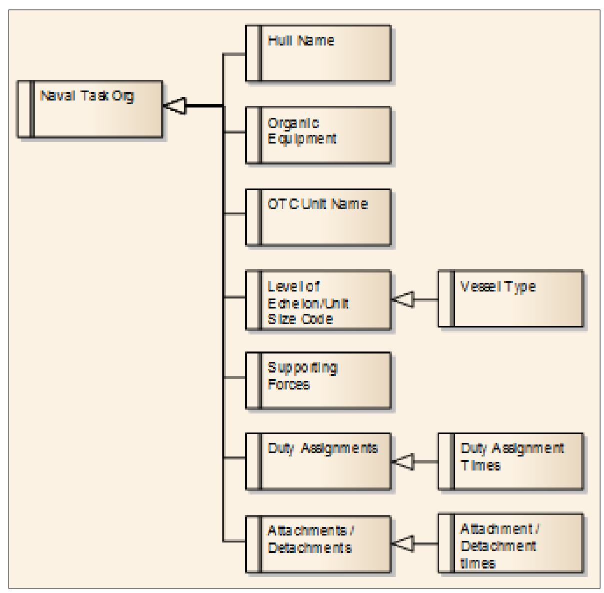

Figure 2. Example Requirements for Naval Task Organization

As an example, Figure 2 shows a partial view of the requirements for expressing a Naval Task Organization. This figure also illustrates the use of the SysML requirements profile for the Unified Modeling Language (UML) to capture and organize requirements using graphical means. Once captured as part of a Maritime C-BML requirements model, the requirements then were transformed into a requirements specification using automated document generation capabilities.

Conduct basic C-BML/MSDL modeling based on the IERs. The concepts used for C-BML and MSDL models are depicted in Figure 3. These concepts are consistent with the Joint Consultation Command and Control Information Exchange Data Model (JC3IEDM) [13], developed by the Multilateral Interoperability Programme (MIP) and the NATO Joint Symbology Standard, NATO APP-6 (C) [14]. Generally, the elements found in the upper part of the figure (entities and events) are objects that are being modeled, and those elements in the lower part of the figure (location, time, place and symbology) are properties or alternate representations of these objects.

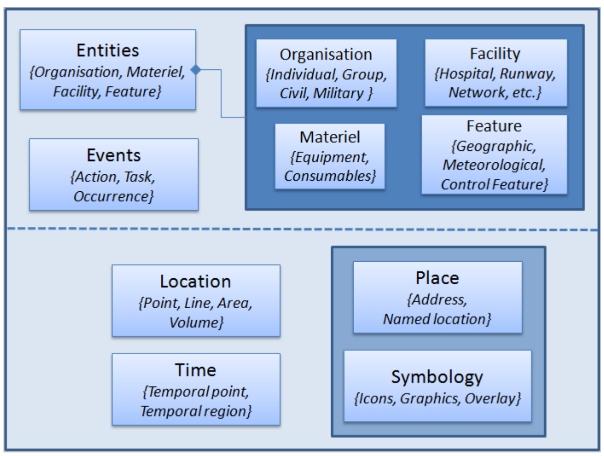

Figure 3. MSDL/C-BML Modeled Concepts

Construct C2 Lexical Grammar for maritime domain. The insights and results from the scenario based modeling can be collected, and generalized in a formal way in order to formulate a grammar. Such a grammar helps to formalize and standardize C-BML in general and the maritime extension of C-BML in particular. In section 4, it will be argued that the specific demands on a maritime C-BML extension advocate for a "lexical" grammar insofar as at least the rules for task assigning expressions should be task specific. In other words, a given task comes with specific restrictions about how to express it. Thus, it makes sense to provide a specific rule for each task by which the assignment of that task has to be expressed. Such a rule depends on its particular task denoted by a specific task verb. Since those task verbs are lexical items of the grammar and the grammar's rules depend on these lexical items, the grammar is a "lexical" one.

Identify C2-Sim initialization requirements for Maritime domain. Military enterprise activities such as training and experimentation require the definition of operational scenarios that are executed across a set of interconnected C2 and simulation systems that can be considered as a C2-SIM federation. As with simulation federations such as the High Level Architecture (HLA), when developing a C2-SIM federation it is necessary to consider all aspects of the scenario life-cycle: scenario definition, scenario refinement, scenario initialization, scenario execution, post-scenario analysis, consistent with the DSEEP [16] The current work considers C2-SIM initialization requirements that are intended to guide the development of future versions of standards, such as MSDL, for scenario definition, refinement and initialization. This initial set of requirements forms a core that is extended with additional requirements that support scenario execution, i.e. for defining the C-BML Maritime domain extension.

Experiment/demonstrate the initial Maritime C-BML capability in a relevant environment. An experimentation event for the practical observation of the deliverables of the research effort is being planned within the MSG-085 Final Experimentation event. The experimentation environment will consist of naval C2 systems (or surrogates), C-BML servers and naval simulations. Figure 4 illustrates the conceptual experimentation environment. Naval scenario for the experimentation event was extracted from a joint scenario and will be discussed in greater detail in the next section.

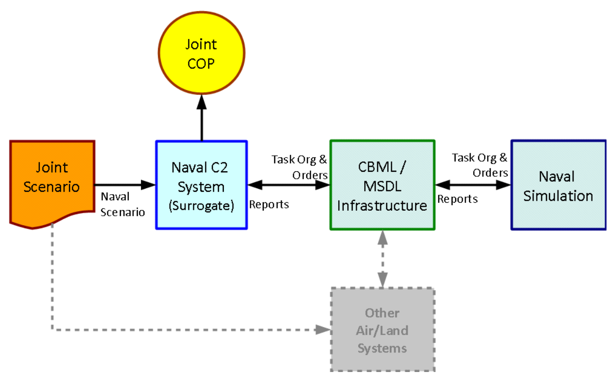

Figure 4. Conceptual Experimentation Architecture.

3. Maritime Operational Context

This chapter gives an introduction to maritime operations and describes the scenario that has been used as a basis for the modeling.

3.1. Overview of Naval Warfare

Naval operations involve the conduct of all or some types of naval warfare such as: Anti-Surface Warfare (ASUW), Anti-Air Warfare (AAW), Anti-Submarine Warfare (ASW), Submarine Warfare (SW), Naval Mine Warfare (NMW) and Electronic Warfare (EW). Depending on the situation and the threat in the operational area, some of these types of warfare can be omitted. Since ASUW is one of the commonly used types of warfare in a naval operation, the scenario used in this research focuses primarily on ASUW related operations.

In order to meet the requirements of an operation, a fleet commander allocates units to specific task forces (TF). A task force is subdivided into task groups (TG), each task group into task units (TU) and each task unit into task elements (TE), depending on the force structure and operational requirements [17].

3.2. Operational Scenario

Following subsequent paragraphs describe details of the operational scenario used in this research.

3.2.1. Task Organization and Area of Operation

The maritime operational scenario is derived from the scenario of VIKING 2011 exercise, which uses the real-life geography of central and southern Sweden, renamed to a fictional country called BOGALAND and surrounding neighboring countries [18]. The task organization of blue forces illustrated in Figure 5 is designated as TF 401 and is comprised of three task groups.

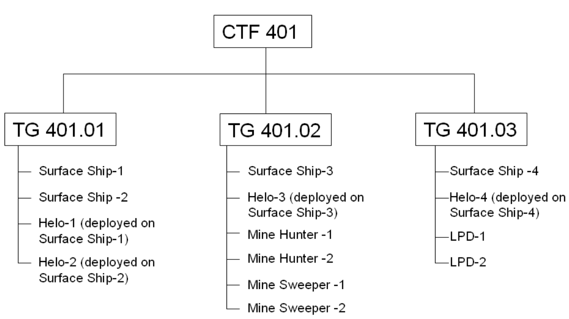

Figure 5. Coalition Task Force Organization

The battlespace or area of operation (AOO) is illustrated in Figure 6. The units of TG 401.01 are patrolling in the areas of A1 and A3; TG 401.02 is waiting in the area of A3; and TG 401.03 is in the vicinity of the reference point BB at the beginning of the scenario.

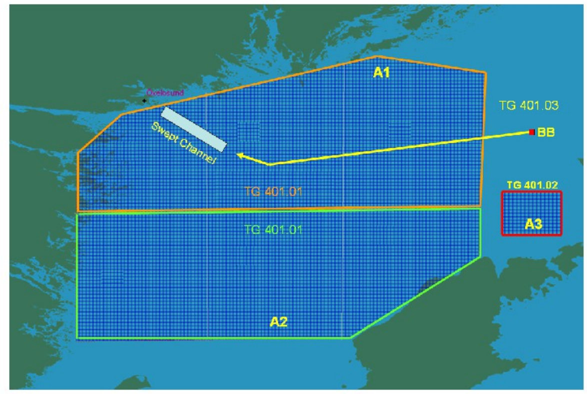

Figure 6. Area of Operation

3.2.2. Conduct of Operations/Tasking

There are three different types of operations in the scenario. The first one is the Maritime Interdiction Operations (MIO) that are conducted by TG 401.01 at ashore of main land and areas of A1 and A2. Main objectives are to detect, locate, identify, monitor and inspect all surface units in order to control maritime traffic in the Area Of Responsibility (AOR). Possible other tasks that might be ordered to the units during operation are as follows:

1. Demonstration of forward presence.
2. Carry out scouting operations (surveillance operations, reconnaissance operations, pre-hostilities tasks, hostilities tasks) in order to establish and maintain tactical picture.
3. Monitoring military activities and movements in all three operational environments (air, surface and land).
4. Monitoring all civilian and military traffic in order to enforce embargo orders on specified goods, persons and services.
5. Boarding operations.
6. Providing protection of specified commercial shipping.

The second one is the Mine Sweeping/ Hunting Operations for safe entrance/ashore of main land. It is assumed that TG 401.02 had already conducted these operations. The task group is now waiting in its assigned waiting area (A3).

The third one is the movement of a convoy in naval formation and conduct of ASUW operations. TG 401.03 is responsible for moving a convoy of amphibious forces safely to the harbor where it disembarks its load. Surface threats are expected in the passage way of the convoy. Therefore, the Commander of TG 401.02 orders the conduct a sector screen where: the first Landing Platform Dock (LPD) is the guiding ship; the second LPD is located in the first sector; and the surface ship with its organic helicopter is located in the second sector. The surface ship conducts patrolling in its assigned sector and may perform ASUW tasks, as required. Not all types of ASUW tasking are included in the scenario. Currently, only third party targeting and ASUW operations supported by the organic helicopters are covered.

3.2.3. Naval Operational Messages Used

The research covers the exchange of selected parts of the two naval operational messages, Operational General Matters (OPGEN) and Operational Tasking of Anti-surface Warfare (OPTASK ASUW). OPGEN is used to promulgate general matters of policy, instructions and expectations to all types of warfare. OPTASK ASUW is used to promulgate detailed plans, tasking and instructions to conduct ASUW [19]. Both of these messages are issued by the Officer-in-Tactical Command (OTC) to the subordinate commanders. Messages issued from subordinate commanders to higher level commanders are not covered yet.

3.2.4. Simplifications to the Scenario

Due to the complexity and variety of naval warfare, the current research is limited to ASUW related operations. ASUW can be conducted with many different types of units such as: ships, submarines, coastal batteries. The scenario covers only surface ships and helicopters as operating units of ASUW tasks. The operational scenario includes only blue forces and omits opposing and neutral forces for the sake of simplicity.

4. C-BML/MSDL Modeling Results

This section presents and discusses the initial results of C-BML modeling of maritime operations. The goal of the modeling is two-fold:

1. Create examples and guidelines on how to represent maritime tasks in C-BML; and
2. Identify potential maritime extensions to C-BML where no apparent mappings exist.

The C-BML Phase 1 Full Schema is used as the target BML schema [4]. A scenario based modeling approach is utilized, where example surface warfare orders including selected parts of OPGEN and OPTASK ASUW are used. The OPGEN and OPTASK ASUW examples define a maritime task organization and basic task assignments to units including corresponding control features. The main results are discussed in subsequent paragraphs.

4.1. Naval Task Organization

The task organization described in Section 3 has been successfully mapped to C-BML, using the size codes 'Task Force, Naval', 'Task Group, Naval' and 'Task Element, Naval'. The level 'Task Unit, Naval' has not been used for modeling the example orders. The task organization was modeled using C-BML only. The corresponding MSDL representation will be derived from it in future work.

In the JC3IEDM [13], which forms the C-BML's basis, there is a clear distinction between an organization and the equipment (in our case the naval platform or vessel) that is being manned. This means that a task organization is made up purely of organizations, and the vessels then are associated to these organizations. Along the same lines, an organization may have another *organic* organization. The actual equipment is associated with the organizations.

This distinction is not quite as clear in the maritime domain, where a ship name just as well refers to the hull as to crew itself. However, this does not cause any problems as long as care is taken to use the different concepts correctly.

In C-BML, all instances of objects are associated with a generic type which may be reused by several instances. This means that all objects that are created also must have a corresponding type. In our example, the ship and naval helicopter types were created on the basis of generic JC3IEDM types (namely "VesselType" and "AircraftType").

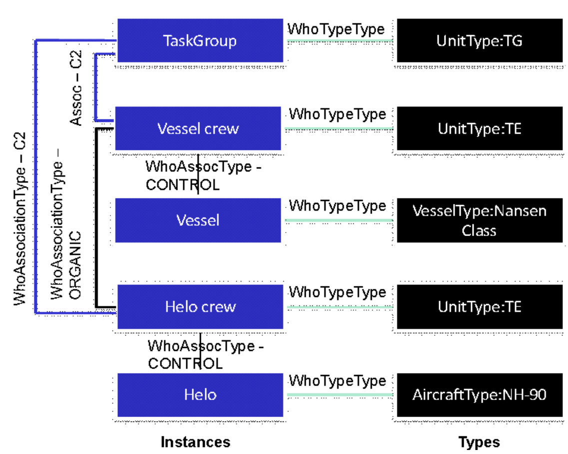

Figure 7. Representation of Task Organization

From Figure 7, the "WhoAssociationType" with the value ORGANIC specifies an organic helicopter and the value CONTROL specifies the organization (vessel crew) manning a vessel. Figure 7 does not show the association between the OTC and the warship where he/she is located (i.e. the flagship). This association and the respective post were also modeled.

C-BML contains all ship types listed in STANAG 1166 [20]. When looking for flag ships, two values were found: "Amphibious Force Flagship or Amphibious Command Ship" and "Auxiliary Flag or Command Ship". None of these fit our case very well, however the modeling required using one of them (or an additional new value).

A further assumption is that flag ship is a role that may be assigned to another ship type. Since the concept of role is not very explicit in JC3IEDM, the way to model this may seem complicated. Figure 8 illustrates the structure. Two instance vessels are created: one for the frigate, one for the flagship. Then these are associated with the phrase '*serves as*' which is defined as: *The subject is used for a role that is characterized by the object*'.

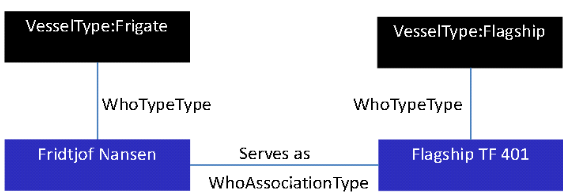

Figure 8. Representing a Flagship

Something similar is used to represent the OTC. The OTC is represented as a "MilitaryPostType", which is in command of the task force. The actual person acting as the OTC then is represented as a person that commands the "MilitaryPostType".

4.2 Naval Tasking

The task statements in C-BML are based on the principle of 5Ws (Who, What, When, Where, Why). Employing the 5Ws is not always straightforward when attempting to map a maritime operation plan found in OPGEN and OPTASK ASUW to C-BML statements. One reason for this is that maritime vessels have many simultaneous tasks and roles in several warfare areas during an operation. A second reason arises from the fact that the maritime plans are less specific than the land equivalent that typically is found in an Army OPORD.

Even though maritime operations have standardized tactics, techniques and procedures (TTPs) [21], tactical graphics and standardized task verbs for the maritime domain are less common than those that are defined for ground operations in NATO Joint Military Symbology standard, APP-6 [14]. Due to these challenges employing an approach of a maritime tasking grammar using C2LG proved to be very beneficial as a guide for mapping to C-BML.

For maritime surface warfare, there are many different tasks related to surveillance and collection of information about the tactical situation. The type of task used depends on the level of conflict, and thus is not always known at the beginning of the operation. *Patrol* and *search* are examples of surveillance tasks.

There are more than 400 different task values in the current version of C-BML, with more than 25 % coming from the maritime domain; however, most of them are related to mine countermeasures. When performing a detailed mapping of our operation using C-BML, in order to assign a specific task to a unit one of the following three situations occurred:

1. There is a direct mapping for the task in question to an existing value (1/3)
2. An existing value is identified, but the definition does not reflect the domain (1/3). An example is the task "screen" where the current definition from JC3IEDM and AAP-6 is not appropriate for the maritime domain. However, there is a second definition from AAP-6 that looks promising.
3. No mapping suggestion is found (1/3).

Thus, the list of task values in C-BML (and JC3IEDM) needs to be extended. The task values themselves and their respective definitions (from JC3IEDM and AAP-6) are, in some cases, not fully appropriate as the maritime domain does not fit well with the 5W paradigm. As a consequence, some of the task values and definitions must be established or adjusted based on authoritative documents (e.g. AAP-6 [15]).

Many tasks include movement or displacement of vessels and thus form one of the focuses of the modeling. In principle, vessel position and intended movement can be defined through a set of route segments defining a passage (cf .http://en.wikipedia.org/wiki/Passage_planning) or by referring to areas in which ships should reside. Routes as well as areas should be defined as C-BML control features.

Movement tasks includes timing and there are several ways to define timing:

1. Start and end time;
2. Time at a specific waypoint;
3. Average speed for a route; and
4. Speed at each leg

Option 4 is currently only available by using C-BML's "AirRouteSegment".

Another important aspect of naval force movement is force dispositions. A screen can be specified by sectors relative to a High Value Unit (HVU). Vessels can have different tasks within the formation. After considering several approaches to model such a formation, the preferred way of representing a formation is to define the formation as a control feature, and then assign (task) vessels into the formation.

In section 4.4, more details will be presented about the modeling of task assignments in C-BML with grammar aspects.

4.3 Control Features

Control feature are areas, lines and points directed by a commander to establish responsibilities and coordinate the actions of tasked units. Normally, control features are established in advance and they hold for a certain time span.

Since C-BML has a close connection to the JC3IEDM, it is worthwhile to take a look at the JC3IEDM when modeling the definition and the establishing of control features in C-BML. In the JC3IEDM, control features (control measures) refer to geometric specifications. The geometric specifications themselves do not contain any semantics regarding their meaning, not even a name. The semantics are captured in objects (typically control measures) having a geometry. For instance, a control measure may be of type "phase line", with name "Rover", while the underlying geometry assigned to this phase line is just a sequence of coordinates representing a line. The further semantics of the phase line will be implied by the task to which it is assigned.

As a consequence, in C-BML, the use of control features consists of two steps: definition and assignment. In the definition phase, which also could have been handled by MSDL, a control feature is defined by a name, assigned to a geometric type (point, line, area) and to a corresponding sequence of coordinates (only one coordinate in the case of a point). In the second step, the name is used to establish the control feature together with its type (e.g., "area of responsibility" or "control point" or "line of advance"), its owner (the one who establish it), its user (the one to whom it concerns), and its temporal specifics (when its validity starts and when it ends). More details are provided in the following section taking grammar issues into account.

4.4 C2 Lexical Grammar

The construction of a grammar, especially the construction of a maritime extension of the C2LG, starts with collecting the task verb specific rules by which tasks can be assigned to units; since in order to command units in a simulation system, tasks have to be assigned to those units. This simple truth holds for ground units as well as for maritime units. Thus, in general, tasking maritime units follows the guidelines for tasking ground units formulated in [22] and successfully applied in the experiments of MSG-048 [23] and in further associated trials [24]. In particular, however, the details of how to formulate the tasks to be assigned clearly depends on the tasks in question so that maritime tasking differs from ground tasking with respect to these details. This, we will illustrate in the following. In general, an expression for task assignment respects from (1) [22]:

(1) TaskAssignment → TaskingVerb TaskerWho TaskeeWho (Affected|Action) Where Start-When (End-When) (Mod) (Why) Label

In (1), "TaskingVerb" refers to the task in question. For ground tasks as well as for some maritime tasks, JC3IEDM's attribute "action-task-activity-code" provides values like "move," "patrol" or "escort" for "TaskingVerb". "TaskerWho" as well as "TaskeeWho" refer to units. "TaskeeWho" denotes the one who has to execute the task in question. "Affected" normally also denotes a unit, the one that is affected by the task. This might be a friendly unit, e.g., in the case of "escort", or a hostile units, e.g., in the case of "attack". In some cases, however, "Affected" might refer to a facility or a feature. Obviously, the expression of this argument highly depends on the task in question and is therefore to be examined carefully in the maritime context. This also is true for "Where" that refers to the spatial specifics of the task. "Start-When" as well as the optional "End-When" denote the temporal specifics of the task. The optional "Mod" is used for listing the task modifiers, e.g., ordered formations. The optional "Why" is used to provide an explanation about aims and about goals. In expressions for commanding simulated units, it normally is not specified. The general form to assign tasks ends with "Label" to provide a label by which the task assignment can be referred to in other BML expressions.

As mentioned above, some of the tasks important in the maritime domain are listed as values for JC3IEDM's attribute "action-task-activity-code." In this case, definition of the task is available and can be used for determining the specifics of the respective BML rule to assign that kind of task. For an example, let's consider the "escort" task. The JC3IEDM definition of "escort" is "to accompany and protect another force or convoy". Obviously, "another force or convoy" is a friendly unit that is affected by the task. Thus, the "escort" rule has an affected, or to be more precise an "AffectedWho":

(2) TaskAssignment → escort TaskerWho TaskeeWho AffectedWho At-Where Start-When (End-When) (Mod) (Why) Label

So, a BML-expression to assign an escort task might look like the following:

(3) **escort** TF401.02 FFGH3 MH1 **at** escort_area **start** aft 20130401150000 escort-387;

In (3), "TF401.02" orders the frigate "FFGH3" to escort the mine hunter "MH1" through "escort_area" beginning after the 1st of April, 2013, 3 p.m.

Applying the method illustrated by the "escort" example, we found JC3IEDM definitions for "advance", "attack", "embark", "mine hunting, maritime", mine sweeping, maritime", "move", "patrol", and "surveillance". Out of those definitions, we developed BML rules like the "escort" rule given in (2). In addition we added or adjusted (for maritime use) definitions and rules for "disembark", "search" and "reconnaissance".

The grammar to be constructed not only includes rules for task assignment but also rules for assigning control features and rules that determine how to build constituents, in particular those used in the task assignment rules, e.g., TaskerWho, TaskeeWho, AffectedWho, Where, Start-When, End-When, and Mod. The latter kind of rules has already been introduced into the SISO standard [4], so they are largely known. On the other hand, maritime specific aspects have to be taken into account to express maritime formations (as part of "Mod") and it should be noted that, maritime units are normally identified by the naval platform type (e.g. Frigate, Fast Patrol Boat, Mine Sweeper etc. See section 4.1 for more details).

With respect to those rules by which control features are assigned, an example can help to illustrate the principles which are based on the discussion presented in section 4.3. Example (4) shows the BML expression that establishes a control feature of name "alpha" and of type "area of responsibility".

(4) area of responsibility alpha TG401.01 FFGH1 start at TP0 end at TP7 label-aor-011;

In the example, control feature "alpha" is established by the task group "TG401.01" and holds for the frigate "FFGH1" from point in time "TP0" to point in time "TP7".

To sum up the grammar related aspects of modeling, it can be said that currently, the maritime extension of the "Command and Control Lexical Grammar (C2LG)" is under construction. After completion, it will be made available for discussion in order to support the efforts of SISO "C-BML" Product Development Group.

4.5. Modeling Issues

In JC3IEDM, there is a restriction, for implementation reasons, that a report ("ReportingData") may only refer to one type of data (table). However, several entries in the same table may still use the same "ReportingData". In C-BML, the exception also is ruled out, which implies more verbose XML-code, especially during initialization. For instance, when assigning types to the instances, 60% of the code in a report is typically repeated from another report. The relevance of this restriction in C-BML should be discussed.

5. Way Forward

5.1. Experiences, Challenges and Findings

The naval warfare domain is very large, and includes inherent complexity due to the size and properties of the operational area, the diversity of threats and the requirement to conduct different types of warfare simultaneously within a task force. The current research covers only a limited part of ASUW. To cover all types of naval warfare within a maritime C-BML study, substantial resources are required. To mitigate risks and optimize resource allocation, an iterative development methodology is advised [26].

There are more than 20 naval operational messages that can be conveyed for different types of naval warfare during maritime operations [19]. For C-BML modeling, each operational message is to be analyzed carefully. It should be noted that, not all messages/message fields are relevant or applicable for C-BML modeling.

Identification of correct operational requirements is essential for the successful operational deployment of C-BML. An operational scenario and relevant operational message samples based on that scenario are very useful for the validation of the operational requirements. Also, operational requirements are to be refined in collaboration with technical people in order to identify technical requirements for C-BML modeling.

5.2 Future Work

Current research includes only task organizations, tasking and orders to the units. Status updates and reports of the units are not included. OPSTAT messages are used to convey information about the operational status of the units and other pertinent information. So, these messages that are essential to establishing a recognized maritime picture and providing shared awareness will be analyzed for C-BML modeling in the next phase of this research.

Adding information exchange mechanism to C-BML for the interaction of maritime forces with land and air forces is also essential in a joint operational context. For this reason, it is being planned to include Naval Gunfire Support (NGS) to existing operational scenario and perform basic C-BML modeling for the related operational message (OPTASK AMPHIBIOUS) as a future work.

6. Conclusions

MSG-085 is investigating the use of C-BML in the maritime domain and a preliminary maritime extension to C-BML has been developed. This extension is based on a set of IERs, which have been established by using an operational scenario. The IERs have been mapped to the SISO C-BML Phase 1 Full Schema. C2-Sim initialization Requirements have been reverse-engineered from the existing enriched MSDL schema. Initial findings and lessons learned of this research will be used to create a more comprehensive Maritime C-BML extension to be tested during the MSG-085 Final Experimentation event, which is being planned to occur in late 2013.

7. Disclaimer

The views and conclusions contained herein are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of any affiliated organization or government.

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