Investigating Contributions of the C2Core to Battle Management Language

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Abstract

The US military continues to explore alternatives for communication of command and control (C2) information. A recently developed alternative is the C2Core, which seeks to define a standard vocabulary for XML messaging in support of military C2, and works with the much smaller Universal Core (UCore) that is intended to play the same role across many governmental domains. Because of its intended scope, C2Core has potential as a basis for communicating information that the Battle Management Language (BML) community has been considering as necessary for interoperation of C2 systems and simulations. This paper reports some results of a project sponsored by the US Army to investigate the feasibility of representing BML information by prototyping an operations order capability. We describe the experimental architecture and the functions developed in an operational prototype, along with lessons learned about the potential of contributions of the C2Core to BML.

1. Introduction

SISO has an ongoing standards development effort, Coalition Battle Management Language (C-BML), to enable Command and Control (C2) systems to interoperate with simulation systems. The US Army has sponsored a project to investigate representing BML with the C2Core representation that has been developed to represent the same sort of informatio
This paper describes some of the experience
lessons learned in that project.

2. BML Background

Battle Management Language (BML) and its v
proposed extensions are intended to fa
interoperation among command and control (C2
modeling and simulation (M&S) systems by provi
common, agreed-to format for the exchang
information such as orders and reports. In
implementations, this has been accomplishe
providing a repository service that the partici
systems can use to post and retrieve messages exp
in BML. As shown in Figure 1, the supporting ser
implemented as middleware that is essential to the operation of BML and can be either centralized or distributed. Recent implementations have focused on use of the Extensible Markup Language (XML) along with Web service (WS) technology, a choice that is consistent with the Network Centric Operations strategy currently being adopted by the US Department of Defense and its coalition allies [1]. In our work to date, representation of BML for storage has used the Joint Consultation, Command and Control Data Interchange Model (JC3IEDM) [2]. The only version of BML that has seen extensive practical use is the Integrated BML (IBML) that was developed by the authors and use by NATO MSG-048 for BML experimentation [3].

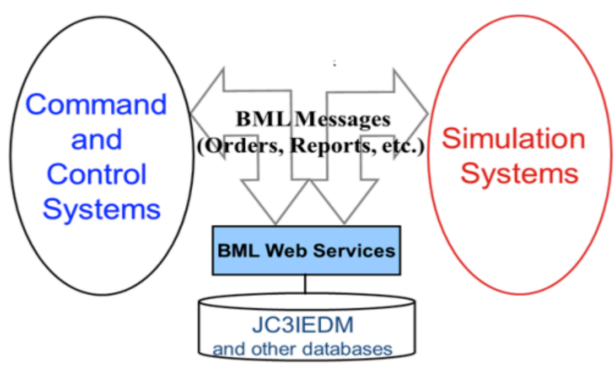

Figure 1. Overview Architecture of BML

3. C2Core Background

3.1 Universal Lexical Exchange

Universal Lexical Exchange, or ULEX, provides the foundation of the C2Core architecture [4]. This abstract messaging framework provides an extensible data-packaging format for the purposes of information sharing [5]. The ULEX framework is based on a plug-in architecture, which enables different systems to exchange standard concepts. ULEX defines major message exchange objects, hierarchy, and structures of all elements [6]. Additionally, all data elements are organized into components that support the underlying actions required to accomplish the operations that are essential to information sharing [7]. The main advantage of using the plug-in architecture is that communities may develop an application only once in order to share information based on the ULEX specification. Further, if additional information is needed for a specific community, modules can be written in a structure payload, rather than rewriting an implementation for a different exchange [4]. For more information, see [8].

ULEX supports combined Universal Core (UCore), Command and Control Core (C2Core), and C2 Community of Interest (COI) content for data exchanges via pointers that connect data elements in the UCore digest to the structured payload(s) [9]. ULEX places no restrictions on the semantics of data exchanges.

3.2 Universal Core

UCore is an implementation of the ULEX. UCore is built on an extensible framework that allows users to build more detailed exchanges that are tailored to their mission requirements. UCore's framework describes key concepts common in every domain. It consists of a limited but flexible data model structure with a semantic context that focuses on Who, What, When, and Where [5]. It is extensible, which in turn allows communities of interest (COIs) to extend UCore elements to meet their own needs. Moreover, this framework permits COI users to wrap metadata standards into a structured payload. The general approach is to provide a structure payload where data from other schemas are incorporated [5].

3.3 Command and Control Core

In order to support the specific goals of a particular C2 community, a command and control framework (or C2Core) that extends from the UCore has been devised. C2Core messages use ULEX containers to create separation from UCore. All C2Core components conform to the C2Core nomenclature and design rules specifications, which detail how to create components and build structure payloads. As a design requirement, C2Core builds on the UCore foundation. The C2Core-UCore binding specification describes the necessary connections needed for connecting C2Core formats to the UCore digest [9]. The C2Core namespace provides the necessary components that combine with UCore components. C2Core Version 1.0 supports two different implementations. One implementation is the *UCore Full*, and the other is the *Payload Only*. Both implementations contain a structural payload of reusable C2Core data components (along with COI extensions) [4]. UCore Full utilizes the structure payload extension offered by UCore and is used when consumers want to make use of the UCore digest. For the work described below, only the *Payload Only* implementation was used. For more details, see [4] and [9].

3.4 Command and Control Community of Interest (COI)

A C2Core COI extension also uses ULEX containers to create separation from C2Core. Specifically, COIs extend C2Core portions for data requirements that are specific to a Program of Record (POR). Based on scenarios, information exchanges, and data requirements, a high-level COI/POR data model is constructed and extended from C2Core components [9]. This model primarily provides a communication device among a specific work group as a whole. A work group designs a COI/POR data model to represent, in a domain-neutral way, a data exchange that meets their COI specific requirements [9]. For the current experimentation, our C2Core COI extension extends C2Core data components and represents a very detailed understanding of a particular scenario.

4. C2Core/IBML Project Description

The Integrated Battle Management Language (IBML) [3] is a collection of shared and integrated products and specifications that serve as a common foundation for the development and production of advanced command and control processes including orders, reports, and geospatial capabilities across BML stakeholders. The purpose of the IBML architecture effort was to provide an effective enterprise-wide infrastructure for the integration of the many BML activities developing Army, Joint, or Coalition capabilities for significantly improved processing of Orders, Plans, and Reports. The products of this effort were intended to help command and control forces and equipment conducting military operations and training and to provide for improved situational awareness and a shared, common operational understanding of these operations. The specific focus was the integration of Battle Command (BC) with Modeling and Simulation (M&S) information in support of BC and M&S systems (Army, Joint, and Coalition). IBML also will support the strategic goal of providing a comprehensive set of architectures. The specific thrust of the IBML effort was to integration of geospatial, Intel, and C2 information in support of Operations and Training. In addition, the project was intended to result in inputs to the US-JC3IEDM process, coordinated US input to the Coalition BML Standard (C-BML), and an integrated NATO demonstration. It also was intended to support Army evaluation and integration of C2Core and UCore products. The scope of this effort was focused on Army WMA needs and will include defined Joint and Coalition capabilities. The focus started with Ground Operations tasking-based formats for Orders, Plans, and Reports (including integrated geospatial information). Infrastructure developed is extensible to support non-WMA needs and requirements.

This task reused and leveraged US Army SIMCI funded efforts and products from FY08, FY09, and FY10. It also fed into and supported SIMCI, NATO, and SISO efforts in FY11/12, including work to develop a NATO OPORD schema compatible with SISO C-BML. This paper describes results of experimental development of a C2Core Information Exchange Specification (IES) for BML that has been demonstrated to interoperate with IBML. Figure 2 shows the architecture of the configuration developed.

4.1 Common Ground Digital OPORD

The input to the C2Core OPORD was derived from a digitized implementation of the US Army Operations Order (OPORD) developed by the Common Ground Joint Concept Technology Demonstration (JCTD) [14][15]. Common Ground has developed a powerful, geospatially-enabled user interface capability for generating the OPORD, which was successfully demonstrated in August 2010 [8].

The Common Ground digital OPORD produces order information represented in the Joint Consultation, Command, and Control Information Exchange Data Model (JC3IEDM). By way of contrast, the BML NATO OPORD described in [13] is intended for communicating order information among systems that are SISO Coalition BML (C-BML) enabled. Thus, the information produced by the user interface in the Common Ground digital OPORD could be conveyed to other C-BML capable systems using the NATO OPORD schema described here, if translated in the sort of mediating interface module used by other BML-capable national systems.

5. C2Core Digital OPORD Specification Development

The development of the C2Core Digital OPORD specification focused on the development of the C2Core Digital OPORD Ontology and Information Exchange Specification (IES) through the extension of the Army C2Core Ontology v1.1 and the C2Core XML Schema v1.0. The methodologies and purpose of these extensions are described in the following sections.

5.1 C2Core Digital OPORD Ontology Development

The C2Core Digital OPORD Ontology v1.0 was developed as a Community of Interest (COI) extension of the Army C2Core Ontology version 1.1 standard. The Army C2Core Ontology v1.1 uses doctrinally defined terminology to establish a systematic way of organizing the terms, entities, and events that occur within and to accurately describe the C2 Domain. The Army C2Core Ontology v1.1 itself is defined with categories that extend from UCore 2.0. Through this extension the C2Core Digital OPORD Ontology v1.0 provided a mechanism to capture the terms that describe the US Army OPORD as well as defining a relationship between the terms. The majority of the extensions were the defining of sub-types of the terms that already existed in the Army C2Core Ontology v1.1.

The extensions focused in the following areas:

- Task Organization
- OPORD Paragraphs
- Header
- Situation
- Mission
- Service Support
- Command Signal
- Execution
- Five Ws
- Tactical Spatial Objects

Task Organization and OPORD Paragraphs are standard portions of the US Army OPORD. We will focus here on discussing the last two areas of the Five

Ws and the Tactical Spatial Objects. The Five Ws define the Who, What, When, Where and Why of a statement. These statements can be found contained in most portions of the paragraphs that make up the Digital OPORD, and most evidently they define the actions or tasks to be undertaken.

Each portion of the Five Ws defines a specific aspect of a statement. *Who* represents the unit or organization that is to perform the task and that task is described by the *What*. *When* and *Where* give detailed information that relates to the location at which the task (*What*) is to be performed or upon what location the task is to be performed. Lastly, the *Why* gives the purpose or desired result of the assigned task.

Tactical Spatial Objects (TSOs) are essentially automated staff estimates or geospatial decision support tools. They are extracted from vector terrain feature data like the US Army Theater Geospatial Database (TGD), and from Digital Elevation Models (DEM) such as Digital Terrain Elevation Data (DTED). The terrain features are grouped, optimized, and analyzed to provide both commander and staff with responsive terrain information expressed in war fighter terms tailored to the mission and tasks. While TSOs may be produced by a variety of means, the general idea is to develop automated algorithms and request processes. These algorithms are capable of processing large amounts of terrain data in a rapid, consistent, and standardized manner. TSOs manifest themselves as Overlays, Graphic Control Measures, or Tactical Decision Aids. TSOs support the military planning and intelligence processes by providing a toolkit to visualize the battle space, conduct mission analysis, and develop Courses of Action. Example TSOs include Maneuver Network, Cross Country Mobility (CCM), Obstacles, Cover and Concealment, Mobility Corridors, UAS Operations Sites, Direct Fire Planning, and Helicopter Landing Zones (HLZs).

The information required to properly define a reference to a TSO was not available within the current Army C2Core Ontology v1.1 release; therefore extensions were necessary to capture this information. Examples of the required information include: Version, Creation and Expiration Timestamps, Description, Stored Location (for accessing the full TSO data), Point Of Contact information and Keywords associated with the TSO.

Once this extension was created, it provided a guide for understanding the best method for extending the C2Core v1.0 XML Schema and the creation of the C2Core Digital OPORD Information Exchange Specification (IES).

5.2 C2Core Digital OPORD Information Exchange Specification Development

The C2Core Digital OPORD is an XML schema representation of the US Army OPORD developed as a Community of Interest (COI) subset of the C2Core Data Model and Information Exchange version 1.0 standard. The following subsections describe the development of the IES of the C2Core Digital OPORD schema through subset generation, creating extensions to the subset, message development, and validation.

The desired result of the development of the C2Core Digital OPORD XML schema is the ability to share US Army OPORD data and to have a defined, common and unambiguous understanding of the meaning and intent of the data. To obtain this goal, and to be considered C2Core compliant, the development of an IES is vital to the sharing of this knowledge. An IES is an organized set of artifacts that define and document the implementable, recurring data exchange intended by an associated COI. The content of an IES is defined in [10].

The IES artifacts defined by C2Core as mandatory and that were developed for the C2Core Digital OPORD are:

- Manifest
- Metadata
- Change log
- Exchange Schema
- Subset Schema

The IES artifacts defined by C2Core as optional and that were developed for the C2Core Digital OPORD are:

- Extension Schema
- Sample XML Instance
- Wantlist

The following sections define the creation of these artifacts for the purposes of the C2Core Digital OPORD COI 2011 Battle Management Language C2Core Demonstration.

5.3 C2Core Subset Generation

The C2Core website (https://c2core.ittl.gtri.org/c2core) provides a Schema Subset Generation Tool (SSGT) that allows the user to do a keyword search on the data model where the keyword represents a Property, Type, Namespace, or Facet that is part of the current C2Core release. Utilizing this tool, we were able to select only the portions of the C2Core that pertained to the Digital OPORD as well as determining if the portions of the C2Core that already existed met the needs of the Digital OPORD.

The artifacts generated from the SSGT include the XML schema that includes the selected components as well as the referenced schemas that make up the C2Core v1.0 specification. Another artifact generated is the *Wantlist* which is an optional component of an IES. Once the proper selections were made to form the Schema Subset and the artifacts were generated, the next step was to determine what extensions were necessary.

5.4 Development of Extension Schema

An extension schema contains components that use or are derived from the components in reference schemas, in this case the C2Core v1.0. This was necessary because it was not possible to correctly capture and represent the data needed to describe a Digital OPORD using only the existing types and elements from C2Core. After analysis of the C2Core model it was determined that there was a need for extensions to be added to the C2Core v1.0 release. Some of these extensions were additions to existing C2Core components; others required creation of new components (types and elements). In some cases, components that were created were substitutions or replacements of C2Core components due to the fact that no existing component would represent the data in a way that was suitable for the Digital OPORD.

As with the extension of the Ontology, the extensions focused in the following areas:

- Task Organization
- OPORD Paragraphs
- Header
- Situation
- Mission
- Service Support
- Command Signal
- Execution
- Five Ws
- Tactical Spatial Objects

5.5 Development of Exchange Schema

An *exchange schema* is a schema in an IES that defines a root element for an Information Exchange Package (IEP), which is the actual instance document that is prepared and transmitted when an IES is implemented. Though an IES allows for the creation of multiple exchange schemas, we concluded that it would be most useful for our purposes to create a single exchange schema that would represent the Digital OPORD.

Development of the exchange schema for the C2Core Digital OPORD included multiple levels of schema. We created of a schema that references the Extension schema, which references the C2Core subset schema. The exchange schema is restricted to defining a single root element to be considered part of a valid C2Core IES. The exchange schema is then is used to build the instance messages, or IEP.

When the exchange schema met all our qualifications to capture the data needed for a Digital OPORD, the IES was then submitted to the conformance tool, The Conformance Testing Assistant (ConTesA), which validates XML instances and schemas against the business rules of the specification. The IES passed 100% of the automated rule checks. This completed the development of the C2Core Digital OPORD IES.

6. Generation of the Information Exchange Package

The generation of the IEP (the instance document of the exchange schema) was achieved through the development of a Web service which extracted the data pertaining to the 16 PM 3 SBCT Base OPORD from a Common Ground node, which is a JC3IEDM based data store. The data was then translated into the C2Core Digital OPORD XML message.

The required web service was created using the Common Data Services Framework (CDSF) which is a set of tools and libraries for facilitating the design and implementation of data services that comply with the Data Services Layer - Army (DSL-A) service interface specifications and the UCore XML specifications. The DSL-A is a framework that contains a set of data service interface specifications developed for the Army Enterprise. The DSL-A enables the Army and supporting organizations to develop data services that expose data sources, authoritative and otherwise, to consumers across the Army. This is a platform-independent service interface specification.

CDSF makes use of standard implementation frameworks (such as SCA, WCF, JAX-WS, etc) though it is not strictly bound to these frameworks. While some developers may only need CDSF to generate standards-compliant schemas and WSDLs for their service the development of the C2Core Digital OPORD web service made maximal use of the CDSF to generate the initial source code for the service.

The completed web service transformed the data from the Common Ground objects to a C2Core compliant C2Core Digital OPORD XML message.

7. Converting C2Core OPORD to IBML

We used the Scripted BML Server (SBMLServer) [11] to provide the C2Core OPORD service. SBMLServer has the capability to push and pull an IBML order with components compliant to the SISO C-BML Phase 1 Trial Use Light schema. We used this capability to convert the incoming C2Core Digital OPORD to an equivalent IBML order. To do this we created an XSLT stylesheet that is applied to the incoming C2Core Digital OPORD. External interface to invoke this capability in the SBMLServer is the same as any other type of push such as IBML and C-BML. The SBMLserver was modified so that when a C2Core push is requested, there is an extra preprocessing step of applying the XSLT stylesheet to convert the OPORD to an IBML order. The server then proceeds to push the IBML order.

Mapping between a C2Core Digital OPORD and an IBML order with C-BML components was not straightforward with one-to-one mappings. Several assumptions had to be made within the XSLT stylesheet.

- Several free text fields within the C2Core Digital OPORD had to be mapped to existing JC3IEDM codes.
- Only one C2Core Digital OpOrd <MissionTask> element is processed. We assumed that situation and execution tasks were in support of the one mission task processed. To process multiple <MissionTask> elements, we would require that the C2Core Digital OpOrds specify which mission task each situation and execution task supports.
- Any referenced units within a C2Core Digital OPORD must already exist within the SBMLServer database. For the demonstration, we had to pre-populate the JC3IEDM formatted database with the units referenced within the C2Core Digital OPORD pushed.
- A C2Core Digital OPORD can specify a location with a reference. These references are assumed to be already defined within the SBMLServer database.
- A C2Core Digital OpOrd has a larger set of valid location types than C-BML. Within the XSLT stylesheet, we mapped a subset of C2Core Digital OpOrd location types; only those which had corresponding types within C-BML.
- A C2Core Digital OPORD can specify altitude measurements in reference to many different types of coordinate systems. We assumed that all altitude measurements are in reference to 'ground level'.
- A C2Core Digital OPORD can specify several task organization trees. Within an IBML order, we support only one task organization tree with C-BML components. We chose to map only the first root organization and its children from C2Core to IBML.

8. Converting IBML OPORD back to C2Core

In order to pull out a C2Core Digital OPORD that was previously pushed, we created another XSLT stylesheet that maps an IBML order with C-BML components to a C2Core Digital OPORD. When a client makes a request to pull a C2Core Digital OPORD that was pushed into the database as an IBML order, the server pulls out the information in the format of an IBML order. There is an extra post-processing step where the pulled IBML order is converted back to a C2Core Digital OPORD. Since the mapping between C2Core to IBML was not one-to-one, the extracted C2Core Digital OPORD is a valid subset of the original C2Core that was pushed.

9. Lessons Learned

The project described above was focused on a CBML standard compliant implementation using a C2Core basis. The lessons learned were primarily related to that focus.

9.1 C2Core Implementation

1. C2Core Digital OPORD elements needed to be created because C2Core either didn't capture data in the desired format or desired data structures did not exist in current C2Core v1.0 release.

2. The C2Core Ontology provided a good way to understand relationship between data structures.

3. The C2Core Ontology does not provide documentation to facilitate creation of C2Core compliant XML schema.

4. C2Core representation of OPORD information is at a level similar to that of IBML. Translation

between the two is not difficult.

5. C2Core OPORD as represented in XML is readily displayed on the GMU BMLC2GUI [12].

9.2 C-BML Implementation

SISO C-BML Light proved to be reasonably compatible with previous CIO/G6 sponsored IBML architecture and SIMCI sponsored NATO OPORD.

The JC3IEDM mappings for the Phase 1 Draft Composites Light are different from those developed for IBML and so required a new script implementation; however, the changes were not challenging.

9.3 General Conclusions and Recommendations

The possibility of using C2Core directly as a BML dialect should be investigated. This would require implementing a C2Core Data Store to use as BML repository. Both native C2Core data store and C2Core encoded in JC3IEDM should be considered. A benefit of the JC3IEDM version could be interoperability with other coalition implementations including, Common Ground.

9.4 C2Core Digital OPORD Implementation

While the Data Services Layer – Army (DSL-A) Common Data Service Framework (CDSF) generated web service based on C2Core Digital OPORD XML schema for C# did save considerable time and effort in the creation of the web service, it did not create all classes defined in C2Core Digital OPORD XML schema. Hand generation was required for some classes and others needed to be edited for completeness or corrections.

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Author Biographies

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WILLIAM DEMASI is a Senior Software Architect with Atlantic Consulting Services, Inc. In this role he has developed an ontology and XML schema derived from the C2Core v1.0 standard to represent the Digital Operations Order (Digital OpOrd), as well as the alignment of various Army data models and data schemas for the facilitation of interoperability between various systems. William has also been the co-author of: Lessons Learned from C2IEDM Mappings within XBML and Implementing Battle Management Language: A Case Study Using the Command and Control Information Exchange Data Model and C4I-M&S Reference Object Model.

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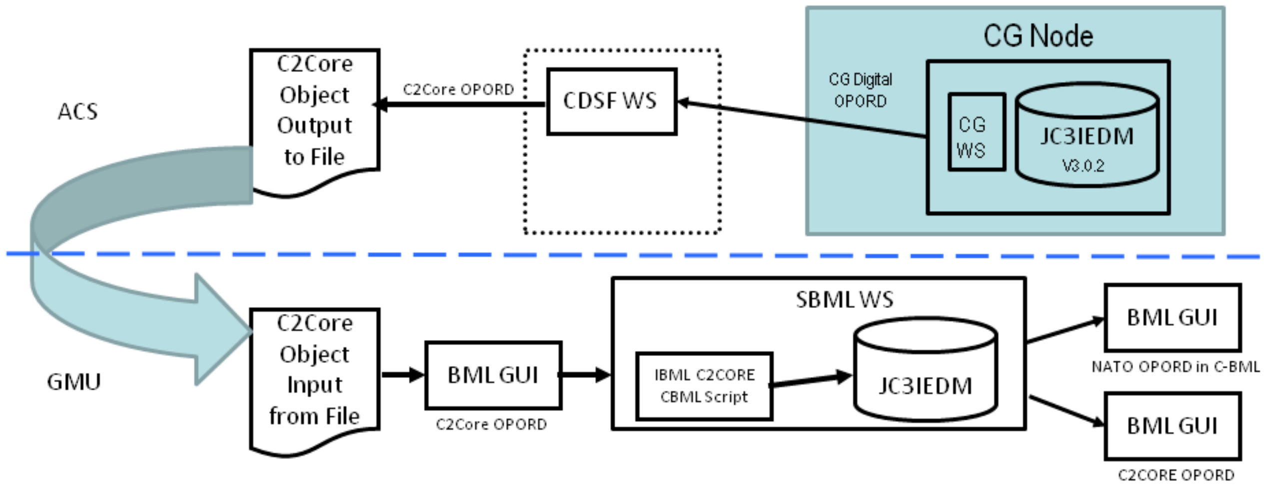

Figure 2. Demonstration Configuration

Appendix
Example of C2Core OPORD XML Text
BML Five Ws


```
<FiveWs xsi:type="ArrayFiveWsAndTextStatementType">
    <TaskName xmlns="http://c2core.jfcom.mil/ns/c2core/1.0"/>
    <TaskExecutionTime xmlns="http://c2core.jfcom.mil/ns/c2core/1.0">
        <StartDateTime>2010-08-16T00:00:00Z</StartDateTime>
        <DateTimeQualifierCode>As Soon As Possible</DateTimeQualifierCode>
    </TaskExecutionTime>
    <TaskExecutionTime xmlns="http://c2core.jfcom.mil/ns/c2core/1.0">
        <EndDateTime>2010-08-16T00:00:00Z</EndDateTime>
        <DateTimeQualifierCode>Until Further Notice</DateTimeQualifierCode>
    </TaskExecutionTime>
    <FiveWsWhat>CONDUCT COUNTERINSURGENCY OPERATIONS</FiveWsWhat>
        <FiveWsWhere>
            <Where>
                <WhereSymbol>
                    <SymbolCustomDataEntry/>
                    <SymbolName>OUA-1 1/3 SBCT AOR</SymbolName>
                    <SymbolCode>
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                            G-G*SAO---**--X
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eCollection&gt;&lt;/whereSymbol&gt;
                        </ReportComment>
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                        <ReportingOrganisationKey>
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                    <SymbolAddresses/>
                    <SymbolAliases/>
                    <SymbolStaffComments>
                        <CommentText xmlns="http://c2core.jfcom.mil/ns/c2core/c2core-u/1.0"/>
                    </SymbolStaffComments>
                </WhereSymbol>
                <TaskLocation xmlns="http://c2core.jfcom.mil/ns/c2core/1.0">
                    <LocationQualifierCode>In</LocationQualifierCode>
                </TaskLocation>
            </Where>
        </FiveWsWhere>
```

```
    <FiveWsWho>
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        <SymbolName>1-3 SBCT</SymbolName>
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